Institute of Safety
& Systems Management, Inc.



SEVENTH EDITION

CSP10 Examination Study Guide™

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Preparation review in all 9 domains of the new 2019 BCSP CSP10 Examination

- Advanced Science and Math
- Advanced Safety Concepts
- Environmental Management Systems
- Management Systems
- Emergency Preparedness, Fire Protection, and Security
- Training/Education
- Risk Management
- Occupational Health and Ergonomics
- Law and Ethics

CSP10 Examination Study Guide™

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Domain I: Advanced Science and Math

1.1 Engineering Mechanics

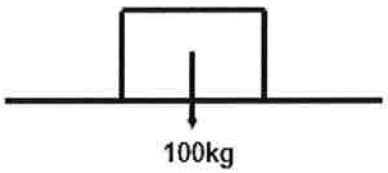
Friction

F = μN

Where F is the frictional force, μ is the coefficient of friction and N is the force *perpendicular* to the surface. It should be pointed out that frictional forces always OPPOSE the motion of an object.

Example 1

A rectangular box having a mass of 100 kilograms is resting on a horizontal surface having a coefficient of friction of 0.3. The amount of force required to set this box in motion must exceed:



a. 100 newtons

b. 300 newtons

c. 294 newtons

d. 60 newtons

Select (c)

$F = \mu N$

The unit of force in the SI system is the newton. In order to calculate N we proceed as follows:

$N = (100 \text{ kg})(9.8\frac{m}{\text{sec.}^2}) = 980$ *newtons*

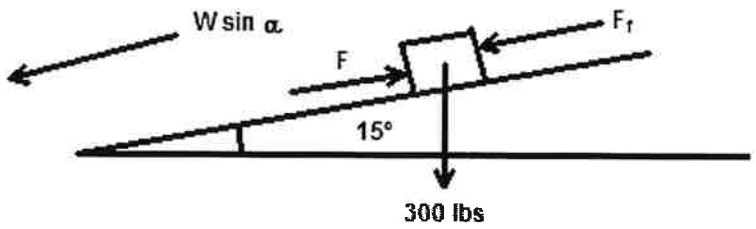
$N = mg =$ *weight of the box*

$F = (0.3)(980)$

$F = 294$ *newtons.*

Example 2

A box weighing 300 lb is resting on an inclined surface having a coefficient of friction of 0.4. The force necessary to set this box in motion up the inclined surface must exceed:



a. 50.0 lb

b. 193.5 lb

c. 140.0 lb

d. 77.6 lb

Select (b)

The force required to set the box in motion up the inclined surface must just overcome the frictional forces on the inclined surface (F_f) and the component of weight of the box on the inclined surface.

In order to calculate the frictional force using $F = \mu N$, we must note that N is the perpendicular force exerted by the box on the inclined surface. Since weight of any object is always perpendicular to the horizontal surface, the perpendicular force between the box and the inclined surface is

$N = (300) \cos 15 = 289.7\ lbs.$

$F_f = (0.4)(289.7) = 115.9$ lbs.

The component of weight of the box on the inclined surface is

$(300) \sin (15) = 77.6$ lbs.

The total force opposing the motion of the box up the inclined surface is:

$115.9 + 77.6 = 193.5$ lbs.

The force that would put the box in motion up the inclined surface must exceed 193.5 lbs.

Newton's Second Law of Motion

$$F = \frac{ma}{g_c}$$

Where:

F: is the resultant force (i.e. forces in the direction of motion minus forces opposing the motion).

m: is the mass of the object.

a: is acceleration of the object as a result of force F.

g_c: is a factor which has a value equal to 1 in the metric system and a value equal to 32.2 in the American Engineering System. In the American Engineering System the unit of force is lbf (pounds force), the unit of mass is lbm (pounds mass), the unit of length is ft. (foot).

It should be pointed out that the numerical value of mass and force on the surface of the earth where acceleration of gravity is 32.2 ft./sec.^{2} are equal. In order to better understand this concept, let us calculate the weight of a 100 lbm object on the surface of the earth using Newton's second law of motion:

$F = \frac{mg}{g_c}$

where g is acceleration of gravity which has a value of 32.2 ft./sec.2 on the surface of the earth,

$F = \frac{(100)(32.2)}{32.2} = 100$ lbf.

As can be noted from this example, in the American Engineering System, the numerical value of force and mass are equal on the surface of the earth. Also, note that if we had not used g_c in the above calculation, our answer would be wrong (by a factor of 32.2).

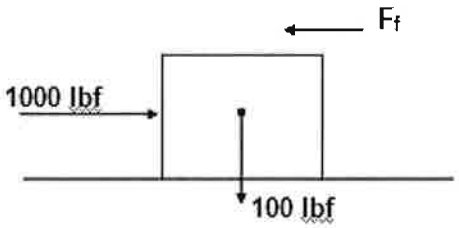
IT IS ALWAYS BEST TO INCLUDE THE FACTOR g_c IN THE ABOVE EQUATION. IN THE METRIC SYSTEM, THE VALUE OF g_c IS EQUAL TO 1. IN THE AMERICAN ENGINEERING SYSTEM, $g_c = 32.2$

Example 3

A box weighing 100 lbs. is acted upon by a force of 1,000 lbf. Assuming a coefficient of friction 0.3, what is the acceleration of the box?

Solution

Newton's second law of motion states that the *resultant* force in a given direction is equal to the mass of the object multiplied by its acceleration. In this case, the *resultant* force is:



1,000 lbf - frictional forces

F = 1,000 - (0.3)(100) = 970 lbf

$F = \frac{m\alpha}{g_c}$

$970 = \frac{(100)\alpha}{32.2}$

$\alpha = 312$ ft./sec.^{2}

Note: Since we are working in the American Engineering System, the numerical value of force and mass are equal. In other words, an object having a weight of 100 lbf has a mass of 100 lbm. Also, we have to use $g_c = 32.2$ because we work in the American Engineering System.

Linear Kinematics with Constant Acceleration

The study of motion of an object without concern for what caused the motion (force) is called linear kinematics. In linear kinematics, we are interested in relating distance, velocity, time, and acceleration. The CSP candidate must be familiar with linear kinematics relationships with constant acceleration. This means that the acceleration of the object has a constant value and does not change with time.

If an object with an initial velocity of V_0 (means velocity at time 0) and a constant acceleration α travels for a time t, its final velocity V and the distance covered can be obtained from the following relationships.

$V = V_0 + \alpha t$

$s = V_0 t + 1/2\ \alpha t^2$

$V^2 = V_0{}^2 + 2\ \alpha s$

In the above equations

V = Final velocity after time t

V_0 = Initial velocity at time zero

α = Acceleration

s = Distance covered in time t.

Example 4

A car is traveling with a speed of 65 miles per hour. The driver applies the brake and the car slows down with a constant deceleration (negative acceleration) of 10 ft./sec.^{2}. How long would it take for the car to come to a complete stop and what is the distance that the car travels before it comes to a complete stop?

Solution

First we list all known and unknown values:

$V_0 = 65$ miles/hr.

V = 0 (car comes to a complete stop)

α = -10 ft./sec.^{2}

t = ?

s = ?

We can use the following equation to find the time (t) for the car to come to a complete stop:

$V = V_0 + \alpha t.$

Before we can use the above equation, however, we must convert 65 miles per hour to feet per second to achieve consistency of units.

$65 \frac{\text{miles}}{\text{hr.}} \times \frac{5280 \text{ ft.}}{1 \text{ mile}} \times \frac{1 \text{ hr.}}{3600 \text{ sec.}}$

V_0 = 95.33 ft./sec.

$V = V_0 + \alpha t$

0 = 95.33 - 10 t

t = 9.5 seconds.

Note: Because the car is decelerating (not accelerating), we used -10 in the above equation.

In order to find the distance traveled by the car, we use the following equation:

$V^2 = v_0^2 + 2\,\alpha s$

$0 = (95.33)^2 + 2(-10)s$

$s = 454.2\ ft.$

Example 5

A worker weighing 200 lbs. slips on a 15 degree ramp and travels 10 feet before hitting a wall at the end of the ramp. If the coefficient of friction between the worker's shoes and the ramp is 0.1, the worker's velocity (assume constant acceleration) just when he hits the wall is:

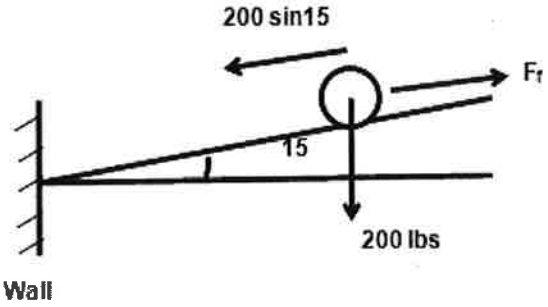
a. 50 ft./sec.

b. 100 ft./sec.

c. 70 ft./sec.

d. 10 ft./sec.

Select (d)



Solution

This example combines the Newton's second law of motion (discussed earlier) and the equations of linear kinematics. Let's take a step by step approach to solve this problem.

Step 1: First we list the known values and assign them the letters that we have used in the equations. The statement that the "worker weighs 200 lbs." means that the force exerted by the earth on the worker's mass is 200 lbs.:

F = 200 lbs.

The worker travels 10 ft. before hitting the wall. Since we have used "s" for distance, we can write:

s = 10 ft.

Coefficient of friction was shown with m

$\mu = 0.1$

and we are looking for the worker's velocity V

V = ?

Assuming that the worker was stationary before the slip indicates that the initial velocity V_0 is zero:

$V_0 = 0$

Step 2: Next we study the equations that were discussed earlier for linear kinematics. We notice that the equation relating the final velocity V to the initial velocity V_0 and the distance s is:

$V_2 = {V_0}^2 + 2\alpha s.$

However, in the above equation both V and α (acceleration) are unknown. In order to find V, we have to find the worker's acceleration.

Step 3: We use Newton's Second Law of Motion to find the acceleration

$F = \frac{m\alpha}{g_c}$

Important Note:

Remember that because we are working in the American Engineering System of units:

a. the numerical value of weight and mass on the surface of the earth are the same. In other words, the weight of this worker is 200 lbf and his mass is 200 lbm.

b. the value of g_c is 32.2.

Also note that in the equation:

$F = \frac{m\alpha}{g_c}$

F is the resultant force acting on the object (forces opposing the motion minus forces assisting the motion).

Step 4: Let's find the resultant force acting on this worker while slipping down the ramp.

a. Forces assisting the motion: the component of weight of the worker on the ramp is

$200 \sin 15 = 51.76$ lbf.

b. Forces opposing the motion: frictional forces always oppose the motion. In this case

$F_f = \mu N$.

Remember that N is the component of weight of worker perpendicular to the ramp or

$N = 200 \cos 15 = 193.18$.

Therefore

$F_f = (193.18)\ (0.1) = 19.31$.

The resultant force on the worker is:

F = 51.76 - 19.31 = 32.45 lbf.

Step 5: Let's use the Newton's second law of motion to calculate the worker's acceleration:

$F = \frac{m\alpha}{g_c}$

Or, $\alpha = \frac{Fg_c}{m} = \frac{(32.45)(32.2)}{200}$

$\alpha = 5.22 \frac{\text{ft.}}{\text{sec.}^2}$

Step 6: We can now use the following equation to find the worker's velocity at the end of the ramp:

$V^2 = V_0^2 + 2\alpha s$

$V^2 = 0 + 2(5.22)(10)$

V = 10.22 ft per second.

Free Fall and Acceleration of Gravity

When an object is falling under the force of gravity, the equations relating velocity, time, and distance are similar to those discussed earlier for linear kinematics. The only difference is that for objects under free fall the acceleration is the acceleration of gravity which is shown by the letter g. Therefore, in order to obtain the equations representing the free fall of an object, all that we have to do is to replace a by g in the equations developed earlier for linear kinematics. It must be pointed out that free fall assumes no air resistance.

$V = V_0 + gt$

$s = V_0t + 1/2\ gt^2$

$V^2 = V_0^2 + 2\ gs$

Where:

V = Velocity after time t

V_0 = Initial velocity

g = Acceleration of gravity

t = Time

s = Distance covered in time t.

Example 6

An object is dropped from the top of a building (no initial velocity). Assuming no air resistance (free fall), if it takes 2.5 seconds for this object to reach the ground, the height of the building is:

a. 225.7 ft.

b. 100.6 ft.

c. 58.2 ft.

d. 75.8 ft.

Select (b)

Solution

$s = V_0t + 1/2\ g\ t^2$

$s = 0 + 1/2\ (32.2)\ (2.5)^2$

s = 100.6 ft.

Kinetic and Potential Energy

Kinetic energy is the energy that an object has as a result of its motion. Therefore, any moving object has kinetic energy. If an object having a mass m is moving with a constant velocity V, its kinetic energy can be calculated from the following equation.

$$\text{K.E.} = \frac{mV^2}{2g_c}$$

Where:

m = Mass of the object

V = Velocity

g_c = A factor which has a value equal to 1 in the metric system, and a value equal to 32.2 in the American Engineering System.

Any object which is located above the surface of the earth has **potential energy**.

If an object with a mass equal to m is raised to a height h above the surface of the earth, its potential energy can be calculated from the following relationship

$\text{P.E.} = \frac{mgh}{g_c}$

Where:

m = Mass of the object

g = Acceleration of gravity

gc = 1 in metric system and 32.2 in the American Engineering System

P.E. = Potential energy

h = Height.

Example 7

Calculate the kinetic energy of an object which has a mass of 100 kg and traveling with a speed of 10 meters per second.

Solution

$\text{K.E.} = \frac{mV^2}{2g_c}$

$\text{K.E.} = \frac{(100)(10)^2}{2(1)}$

K.E. = 5000 joules.

Note: unit of energy is "joule" when mass is expressed in kilograms and velocity in meters per second. Because we are working in the metric system of units, the value of $g_c = 1$.

Example 8

The kinetic energy of a 100 lbm object moving with a velocity of 10 ft./sec. is:

a. 1,000 ft. lbf.

b. 5,000 ft. lbf.

c. 155 ft. lbf.

d. 310 ft. lbf.

Select (c)

Solution

$\text{K.E.} = \frac{mV^2}{2g_c}$

$\text{K.E.} = \frac{(100)(10)^2}{2(32.2)}$

$\text{K.E.} = 155 \text{ ft.} \times \text{lbf}$

Note: The value of g_c is 32.2 because we are working in the American Engineering System of units.

Example 9

A 100 lbm. object is dropped from the top of a 100 ft. tall building. How long would it take for this object to reach the ground? What is the velocity and kinetic energy of this object just before it hits the ground? What was its potential energy before release from the top of the building?

Solution

$s = 100$ ft.

$m = 100$ lbm

$V_0 = 0$

$V = ?$

$K.E. = ?$

$t = ?$

$P.E. = ?$

$V^2 = V_0{}^2 + 2\,gs$

$V^2 = 2(32.2)(100)$

$V = 80.24$ ft/sec.

$V = V_0 + gt$

$80.24 = 0 + (32.2)(t)$

$t = 24.9$ seconds

K.E. $= \frac{mV^2}{2g_c}$

K.E. $= \frac{(100)(80.24)^2}{2(32.2)}$

$K.E. = 10{,}000$ ft $\times$ lbf

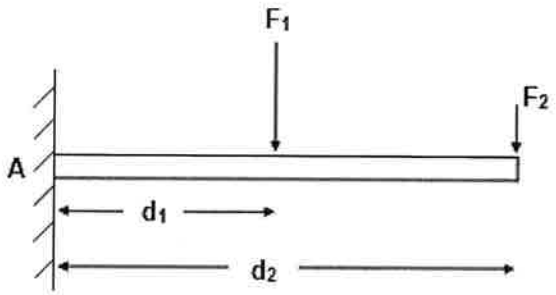
P.E. $= m\frac{g}{g_c}h$

P.E. $= 100\frac{32.2}{32.2}(100) = 10{,}000$ft $\times$ lbf.

Moment Generated by a Force

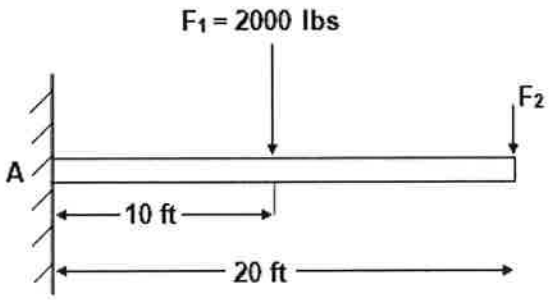
Let's consider a beam fixed in a wall (point A) as shown in the diagram. If a force F_1 is exerted on the beam at a distance d_1 from point A, the amount of moment generated at point A is $F_1.d_1$. Further, if a force F_2 is exerted on the beam at a distance d_2 from point A, the amount of moment generated at point A is $F_2.d_2$. If the moments generated by F_1 and F_2 at point A are equal, the following relationship applies.

$\mathbf{F_1 d_1 = F_2 d_2}$



Example 10

Calculate the value of force F_2 which would generate the same moment as the force F_1 around point A.



Solution

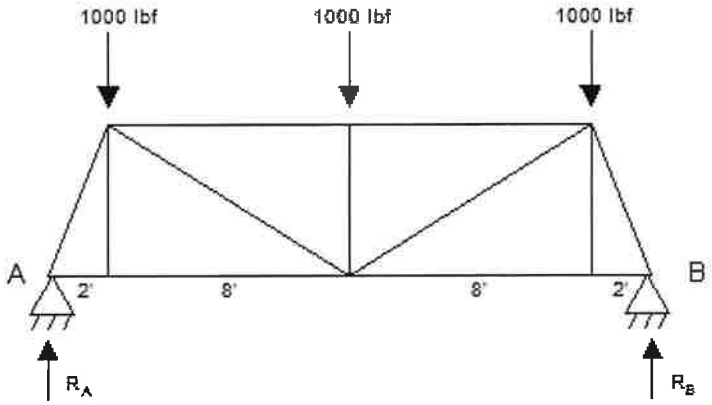
$F_1 d_1 = F_2 d2$

$2{,}000(10) = F_2(20)$

$F_2 = 1{,}000$ lb

Example 11

A truss system as shown in the diagram is supported at points A and B. Find the reaction forces RA and RB at points A and B respectively.



Solution

The sum of moments generated by all forces at points A and B must add to zero because the system is stationary (not rotating). Let's calculate the moment generated at point B.

1,000 (2) + 1,000 (10) + 1,000 (18) - R_A (20) = 0.

R_A = 1500 lbf.

Note: Since the direction of reaction force R_A is opposite to all three 1,000 lbf forces, the moments generated around point B must also be opposite to each other. That is why we used a negative value for the moment generated by R_A at point B.

In order to find the reaction force at point B, we note that the sum of moments generated at point A must add to zero.

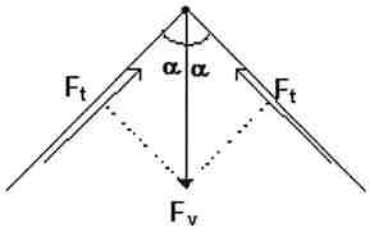
$1000\ (2) + 1{,}000\ (10) + 1{,}000\ (18) - R_B\ (20) = 0$

$R_B = 1{,}500$ lbf.

This result is expected due to the symmetrical nature of this problem.

1.2 Structural Systems

Analysis of Two-Leg Slings



Consider a two-leg sling with each leg making an angle α with the vertical as shown in the diagram. Assume that the sling is supporting a load F_v and that the tension in each leg of the sling is F_t. In order to obtain the relationship among F_V, F_t, and angle α, we note that since the sling is stationary, the algebraic sum of all forces in the vertical direction must add up to zero. The component of F_t in the vertical direction is F_t cos a for each leg (a total of 2 F_t cos α for the two-leg sling).

Therefore, we can write the relationship among vertical force F_v, tension in each leg of sling F_t and the angle of sling with the vertical:

Fv - 2Ft cos α = 0

Example 1

The maximum load rating for a two - leg sling having an operating tension rating in each leg equal to 3,000 lbs. and each leg making a 45 degrees angle with the vertical is:

a. 4,765 lb

b. 5,000 lb

c. 3,800 lb

d. 4,242 lb

Select (d)

The algebraic sum of all vertical forces must be equal to zero for equilibrium to be maintained.

F_V - 2 (3,000) cos 45 = 0

F_V = 4,242 lbs.

Example 2

The two main types of tubular scaffolds are:

a. Tube type and frame type.

b. Frame type and hanging type.

c. Hanging type and truss type.

d. Jointed and non-jointed.

Select (a)

Tubular scaffolds fall into frame type and tube type. The frame type has fewer connection points as compared to the tube type.

Example 3

A two-leg sling has a maximum operating tension of 2,500 lbs in each leg. The sling is used to hold a load of 4,000 lbs. What should the minimum angle of each leg with the vertical be to safely support this load?

a. 52.7 degrees.

b. 12.9 degrees.

c. 36.8 degrees.

d. 49.6 degrees.

Select (c)

$F_V = 2\ Ft \cos \alpha = 0$

4,000 - 2 (2,500) $\cos \alpha = 0$

$cos\ \alpha = \frac{4}{5} = 0.8$

$\alpha = 36.8$ degrees

Some of the More Common Terminology Related to Strength of Materials

Stress

The stress generated in an object as a result of application of a force is equal to the value of the force divided by the area upon which it acts. Mathematically, we can write:

$$S = \frac{F}{A}$$

where S is stress, F is the force , and A is the area. The safety engineer must ensure that the stress generated in an object does not exceed the value of the stress which can be tolerated by the object. For this reason, a factor of safety is generally introduced.

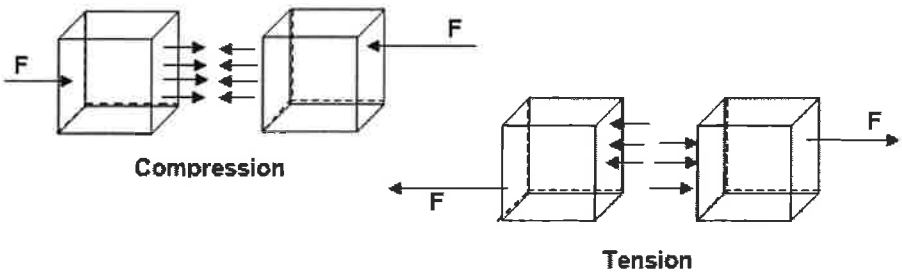
Factor of Safety

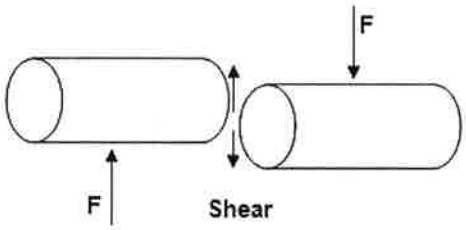
Factor of safety is the ratio of the stress which can produce failure in the material to its maximum allowable stress. For example, if the failure stress for a material is 50,000 lbs/in2, and its allowable stress is 20,000 lbs/in2, the factor of safety is:

factor of safety $= \frac{50{,}000}{20{,}000} = 2.5$

Different Types of Forces and Stresses

Stresses that are acting parallel to a plane are called **Shear Stresses**, and stresses that are perpendicular to a plane are called **Normal Stresses**. Normal stresses can be **Compression** stresses or **Tension** stresses.





Toughness

Toughness is referred to the ability of a material to resist impact forces.

Ductility

Ductility is a measure of the ability of a material to bend or deform.

Creep

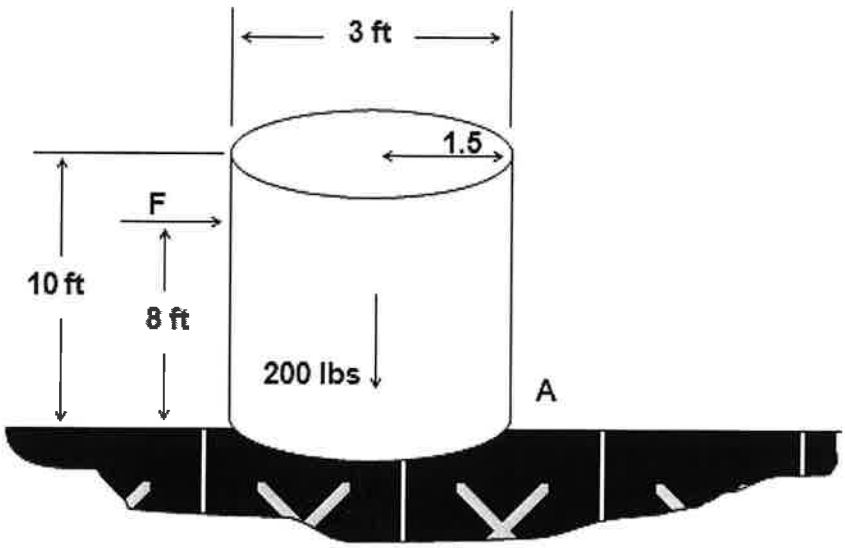
Creep is referred to as very slow but permanent deformation of a material that is under a given load.

Sliding Versus Tipping Over for an Object

If the amount of force on an object generates a moment greater than the moment generated by its weight, and the amount of force is less than the frictional forces, the object would tip over (rather than slide) as a result of the application of the force. Let's demonstrate this concept by an example.

Example

A cylindrical vessel 3 feet in diameter and 10 feet high is on a horizontal surface as shown in the diagram. If we apply a horizontal force F (see diagram) to this vessel trying to slide it on the surface, determine whether the vessel would tip over or slide. The weight of the vessel is 200 lbs. and the coefficient of friction is 0.7:



Solution

First we determine the value of the force F that if exceeded would tip over the vessel. We can do this by writing the sum of moments generated a point A and equating them to zero. Remember that moment around a given point is the product of force times distance. in this case, the moment generated at point A is due to the action of two forces, one is the force F, and the other is the weight of the vessel. Also, remember that the weight of an object is the force at its center of gravity, which in this case, has a distance of 1.5 feet from point A. finally, we notice that the sign of moments generated by F and by the weight of the vessel are different. In other words, force F is trying to rotate the vessel in one direction and the weight of the vessel is trying to rotate the vessel in the opposite direction. We can write:

$F \times 8 - 200 = 1.5 = 0$

$F = 37.5$ lbs

This means that if F is greater than 37.5 lbs. and has not overcome frictional forces, the vessel would tip over. Let's find out if a force of less than 37.5 lbs. is sufficient to over-come frictional forces. We know:

$F = \mu N$

where F is the frictional force, μ is the coefficient of friction, and N is the weight of the object. In this case, we can write:

$F = (0.7)(200)$

$F = 140$ lbs

This means that we need a force of at least 140 lbs. to slide the vessel. However, our results also indicate that if F exceeds 37.5 lbs., the vessel would tip over. Therefore, for this problem, we conclude that the vessel would tip over.

1.3 Electrical Systems

Electrical Resistance

The electrical resistance of a conductor (wire) can be calculated from the following relationship.

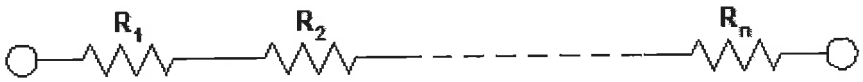
$$R = \rho \frac{L}{A}$$

Where R is the resistance, ρ is the resistivity, L is the length of the conductor, and A is the cross sectional area of the conductor.

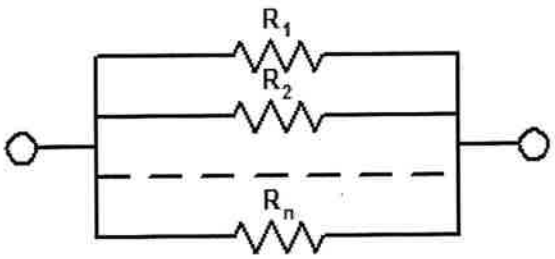
Combined Resistors

Electrical resistors can be connected in parallel, series, or combination of parallel and series as shown in the diagrams below.

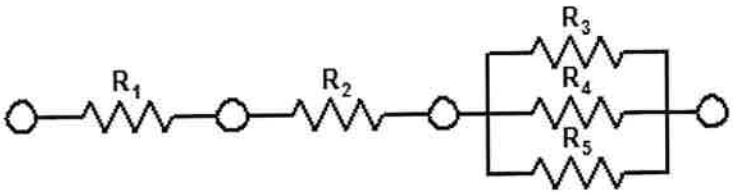
Series connection



Parallel connection



Combination of series and parallel connection



When resistors are connected in series or parallel, the equivalent resistance can be calculated from the following relationships.

$R = R_1 + R_2 + \cdots + R_n$ (Series)

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$ (Parallel)

Where R is the equivalent resistance.

Combined Capacitors

Capacitors are electrical devices that can store electrical energy (in contrast to resistors that consume electrical energy). Capacitors can also be connected in series, parallel, or a combination of series and parallel. The equivalent capacitance for these connections can be calculated from the following relationships.

$C = C_1 + C_2 + \cdots + C_n$ (Parallel)

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}$ (Series)

Where C is the equivalent capacitance.

Ohm's Law

If a resistor having a resistance equal to R is connected to a potential difference V, the electrical current I flows through the circuit. The relationship among V, R, and I is

$V = RI$

Which is called Ohm's law. When potential difference is expressed in volts and the resistance in ohms, the value of current has unit of ampere.

Example 1

A conductor 10 ft long with a circular cross section having a diameter of 1/8 of an inch, and a resistivity of 5×10^{-3} ohm-inch has an electrical resistance equal to

a. 83.2 ohms.

b. 48.9 ohms.

c. 72.6 ohms.

d. 28.7 ohms.

Select (b)

Solution

We use the formula

$R = \rho \frac{L}{A}$

Note: As in other problems, we have to be careful to be consistent with units. Since resistivity is given in ohm-inch, we use inch for length and inch squared for area:

$A = \frac{\pi D^2}{4}$ (D is the diameter)

$A = \frac{\pi\left(\frac{1}{8}\right)^2}{4} = 0.0122\ in^2$

$L = 10ft\frac{12in}{1ft} = 120\ inches$

$R = 5 \times 10^{-3}\frac{120}{0.0122} = 48.9\ ohms.$

Example 2

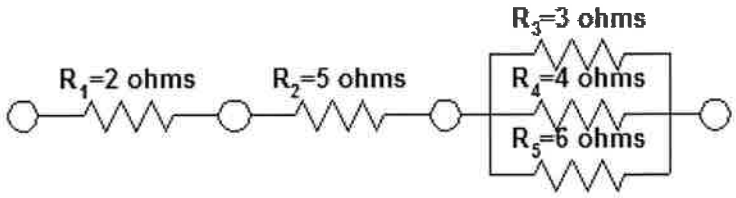
In the electrical circuit shown in the diagram below, all resistors can be replaced with a single resistor which has a resistance of

a. 20.00 ohms.

b. 13.67 ohms.

c. 8.33 ohms.

d. 0.05 ohms.



Select (c)

Solution

When we have a combination of series and parallel connection, first we find the equivalent resistor for the parallel connection.

Let's call the equivalent resistor for R_3, R_4, and R_5 to be R_6. We can write:

$\frac{1}{R_6} = \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$

$\frac{1}{R_6} = \frac{1}{3} + \frac{1}{4} + \frac{1}{6}$

$R_6 = 1.33\ ohms.$

Resistor R_6 is in series with resistors R_1 and R_2. Let's call the equivalent resistor for the circuit R.

$R = R_1 + R_2 + R_6$

$R = 2 + 5 + 1.33$

$R = 8.33$ ohms.

Example 3

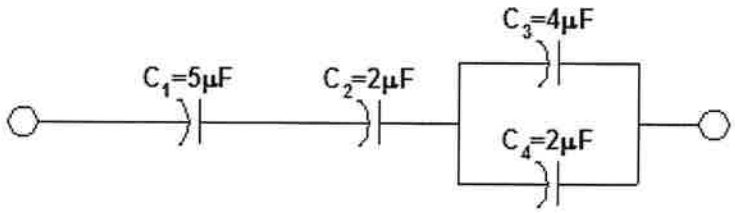
The equivalent capacitance for the circuit shown below is: (note: μF = microfarad).

a. 11.25 μF.

b. 1.15 μF.

c. 13.72 μF.

d. 26.72 μF.



Select (b)

Solution

First we find the equivalent capacitance for the parallel connection. This capacitor will then be in series with capacitors C_1 and C_2. Let's call the equivalent capacitance for the parallel connection C_5. We can write

$C_5 = C_3 + C_4$

$C_5 = 4 + 2 = 6\mu$F.

Let's call the equivalent capacitance for the circuit C:

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_5}$

$\frac{1}{C} = \frac{1}{5} + \frac{1}{2} + \frac{1}{6}$

$C = 1.15\mu$F.

Example 4

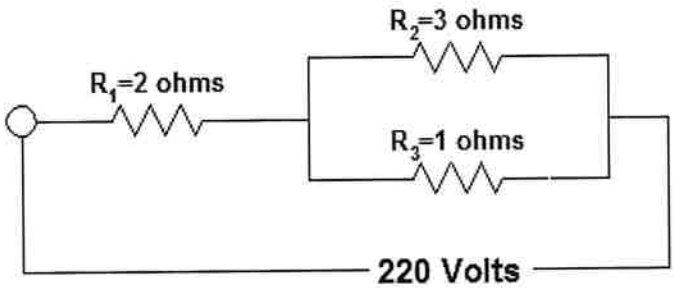
For the electrical circuit shown below, the amount of power consumed is:

a. 17,600 watts.

b. 34,200 watts.

c. 9,763 watts.

d. 23,562 watts.



Select (a)

Solution

Before calculating the power consumed, we have to find the amount of current flowing through the circuit. We can use Ohm's law:

V = R I.

R is the equivalent resistance for the circuit. In order to calculate R, we proceed as follows:

Resistors R_2 and R_3 are in parallel. We replace them with a single resistor R_4

R_4 is in series with R_1. Therefore, the value of the equivalent resistance for the circuit (R) is:

$\frac{1}{R_4} = \frac{1}{3} + \frac{1}{1}$

$R_4 = 0.75$ *ohms.*

We can now calculate the power consumed by this circuit using the following relationships:

R = 2 + 0.75 = 2.75 ohms

V = R I

$I = \frac{V}{R}$

$I = \frac{220}{2.75} = 80$ amperes.

We can now calculate the power consumed by this circuit using the following relationships:

$P = R\ I^2$

$P = (2.75)(80)^2$

P = 17,600 watts.

Or

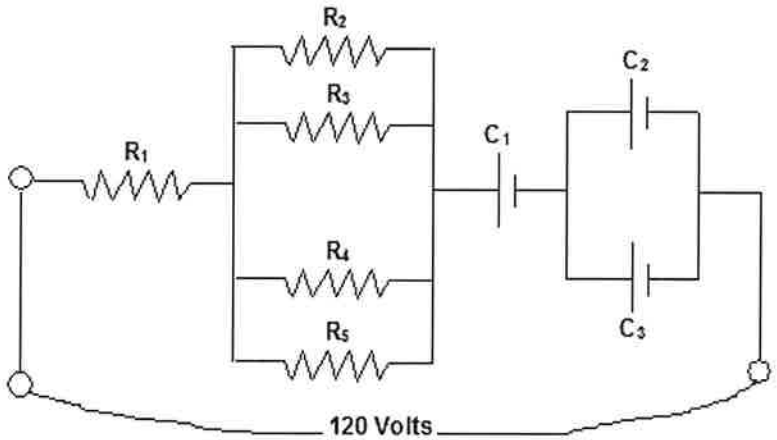
P = V I

P = (220) (80)

P = 17,600 watts.

Example 5

An electrical circuit connected to a potential difference of 120 volts is shown in the diagram. The resistor R_1 has a length of 1 inch and a diameter of ¼ inch and a resistivity of 20 ohm-inches. Resistors R_2, R_3, R_4, and R_5 have values of 20, 30, 40, and 50 ohms respectively. The capacitors C_1, C_2, and C_3 have values of 8, 15, and 20 microfarads, respectively. It has been decided to modify this circuit by replacing all resistors with a single resistor, and all capacitors with a single capacitor. The single resistor and capacitor have which of the following values:



1. 110.7 ohms, 43 microfarad.
2. 414.8 ohms, 6.5 microfarad.
3. 216.5 ohms, 92.7 microfarad.
4. 72.8 ohms, 12.7 microfarad.

Select (b)

Solution

First we replace resistors R_2, R_3, R_4, and R_5 that are connected in parallel with a single resistor R_6.

$$\frac{1}{R_6} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

$$\frac{1}{R_6} = \frac{1}{20} + \frac{1}{30} + \frac{1}{40} + \frac{1}{50}$$

$R_6 = 7.79$ ohms.

Now, resistors R_1 and R_6 are connected in series, but we must first calculate the value of resistor R_1 from the following equation:

$$R_1 = \rho\frac{L}{A}$$

where R_1 is the resistance in ohms, ρ is the resistivity, L is the length of the resistor and A is its cross sectional area:

$$R_1 = 20\frac{1\times4}{3.14(0.25)^2}$$

$R_1 = 407$ ohms.

Note: the area of a circle is $\pi D^2/4$ where D is the diameter.

Now we replace the resistors R_1 and R_6 which are connected in series with a single resistor R_7:

$R_7 = R_6 + R_1$

$R_7 = 407 + 7.8$

$R_7 = 414.8$ ohms.

Capacitors C_2 and C_3 are connected in parallel; we replace them with a single capacitor C_4:

$C_4 = C_2 + C_3$

$C_4 = 15 + 20 = 35$ microfarad.

Now capacitors C_4 and C_1 are connected in series, we replace them with a single capacitor C_5

$\frac{1}{C_5} = \frac{1}{C_1} + \frac{1}{C_4}$

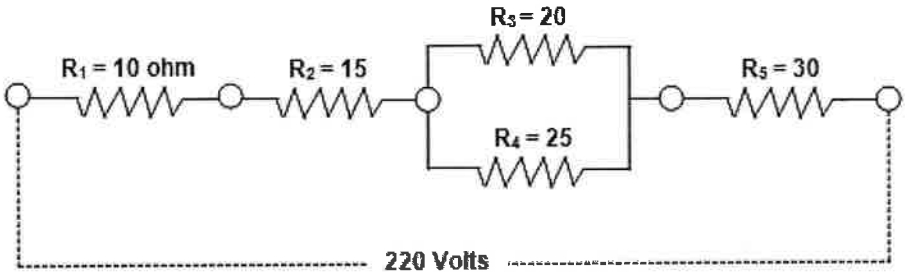
$\frac{1}{C_5} = \frac{1}{8} + \frac{1}{35}$

$C_5 = 6.5$ microfarad.

The resistors and capacitors in the circuit can be replaced with a single resistor of 414.8 ohms and a single capacitor of 6.5 microfarads.

Example 6

An electrical circuit consists of 5 resistors connected as shown in the diagram.



The amount of power consumed by resistor R_1 is:

a. 2,200 watts.

b. 10 watts.

c. 110 watts.

d. 220 watts.

Select (c)

Solution

Replace resistors R_3 and R_4 which are connected in parallel with a single resistor R_6:

$\frac{1}{R_6} = \frac{1}{R_3} + \frac{1}{R_4}$

$\frac{1}{R_6} = \frac{1}{20} + \frac{1}{25}$

$R_6 = 11.11$ ohms.

Replace resistors R_1, R_2, R_6, and R_5 which are connected in series with a single resistor R_7:

$R_7 = R_1 + R_2 + R_6 + R_5$

$R_7 = 10 + 15 + 11.11 + 30 = 66.11$ ohms

$V = RI$ Ohm's law.

where V is the potential difference in volts, R is the resistance in ohms, and I is the current in amperes.

$220 = 66.11\ I$

$I = 3.327$ amperes.

Since the resistors are connected in series, the same current of 3.3 amperes flows through all of them. The amount of power consumed in resistor R1 can be calculated from the following equation:

$P = R_1 I^2$

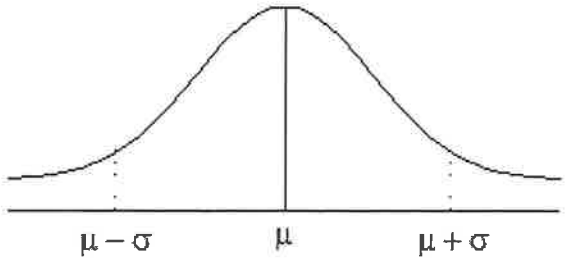
$P = 10\ (3.327)^2$

$P = 110.73$ watts.

1.4 Inferential Statistics

The Normal Probability Distribution

A large number of random variables observed in everyday life and nature form a frequency distribution which is approximated by a bell-shape curve called the normal probability distribution.



The equation representing a normal probability distribution is:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

Where x is the value of a random variable in a population.

For example if the height of people in a given city is normally distributed, then x in the above equation represents a given height and f(x) represents the proportion of people with that height. Let's assume that the height of people in a small city of 10,000 people is normally distributed, and let's further assume that 500 people are 6 feet tall. This means that for a value of x equal to 6, f(x) is equal to 500/10,000.

In the equation representing the normal distribution, μ is the population mean and s is the population standard deviation.

Although in solving the CSP examination problems dealing with normal distribution we do not use the above equation directly (as will be discussed later), we do need to understand how to calculate the mean (μ) and the standard deviation (s) for a given population. These can be calculated from the following relationships:

$$\mu = \frac{\sum_{i=1}^{n} x_i}{n}$$

where n is the sample size and x_i represents the values of the random variable.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \mu)^2}{n-1}}$$

s is called the **standard deviation** and s^2 is called the **variance** of the sample distribution.

Example 1

Calculate the mean and the standard deviation for the following sample of x?:

x_i	x_i - μ	$(x_i - \mu)^2$
3	1.33	1.77
5	0.67	0.45
2	-2.33	5.43
7	2.67	7.13
6	1.67	2.79
3	-1.33	1.77
$\mu = 4.33$		**sum = 19.34**

our sample size is 6, we can write:

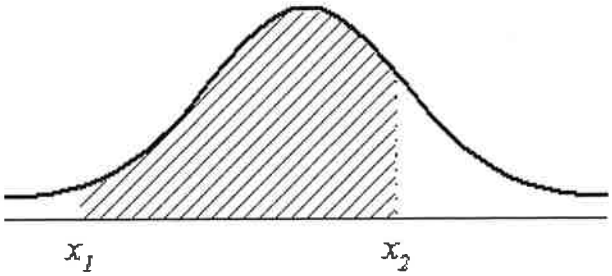
standard deviation $= \sigma = \sqrt{\frac{19.34}{6-1}}$

or

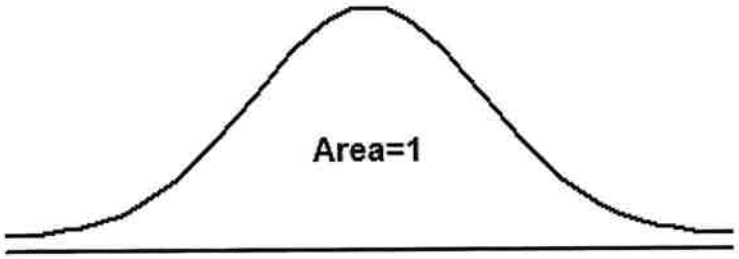
s = 1.966.

Characteristics of the Normal Probability Distribution

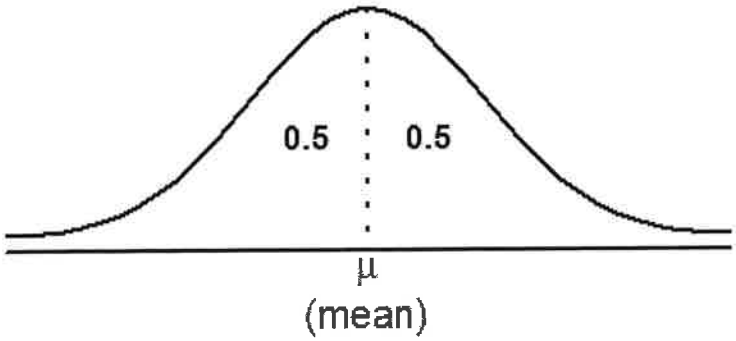
1. The area under the normal probability distribution curve between two values x_1 and x_2 represents the probability that a randomly selected value would fall between x_1 and x_2. For example, the shaded area under the curve in the following diagram is the probability that a randomly selected variable would fall between x_1 and x_2.



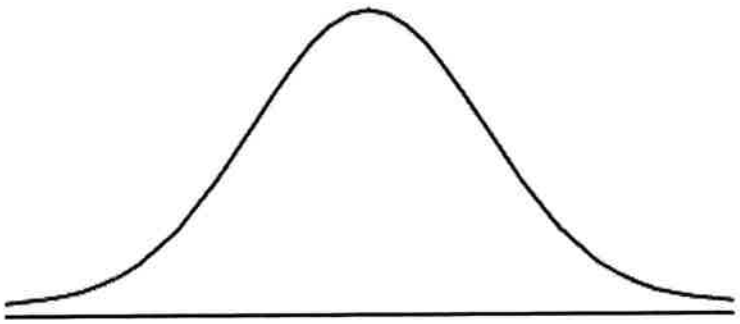
2. The area under the normal probability curve represents probability. The maximum value that a probability function can assume is 1 (which means the event will certainly happen). Therefore, the total area under the normal probability distribution curve is equal to 1.



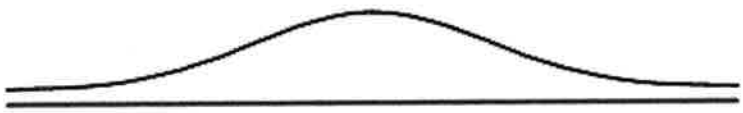
3. The normal probability distribution curve is symmetrical around its mean. This indicates that half of the total area under the curve (0.5) is to the right of the mean and the other half is to the left of the mean.



4. The shape of the normal distribution is determined by the value of its standard deviation. Large values of standard deviation reduce the height of the curve and increase its spread while small values of standard deviation increase the height of the curve and decrease its spread.

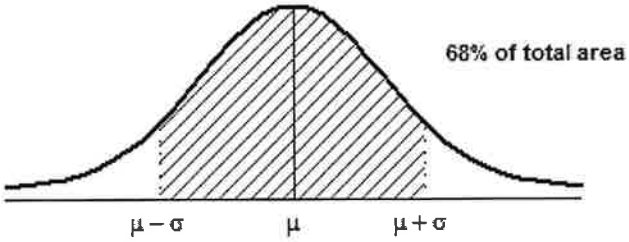


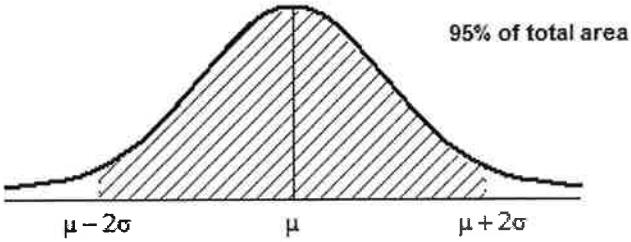
Small value of Standard Deviation

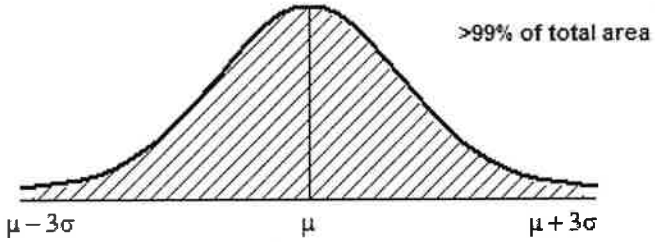


Large value of Standard Deviation

5. Approximately 68% of the area under the normal distribution curve lies within ?one standard deviation of the mean. About 95% of the area under the curve falls within ?two standard deviations of the mean and almost all within ?three standard deviations of the mean.







Types of Problems Dealing With the Normal Probability Distribution

- One type of problem dealing with normal probability distribution is to find the probability that a randomly selected variable from the population (with known values of mean and standard deviation) assumes a value between x_1 and x_2.

  In order to solve this type of problem we proceed as follows:

  Step 1:

  Calculate the value of Z_1 from

  $Z_1 = \frac{x_1 - \mu}{\sigma}$

Step 2:

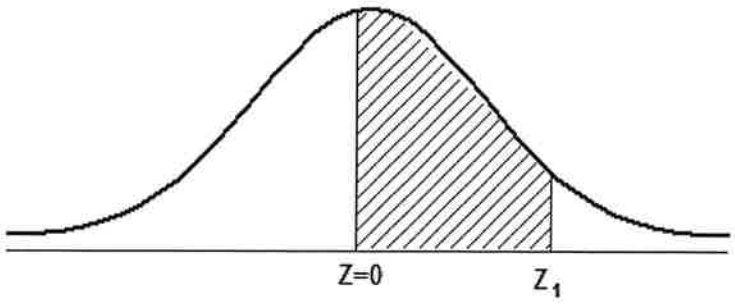
Calculate the value of Z_2 from

$$Z_2 = \frac{x_2 - \mu}{\sigma}$$

Step 3:

Table 3 which is the table of areas for the normal probability distribution provides the areas (probabilities) under the curve between Z = 0 and a given value of Z_1.

Important Note: The areas under the normal distribution curve listed in Table 3 are the areas under the curve between Z = 0 and a given value of Z_1.



Obtain the area between Z = 0, Z_1 and Z_2 from Table 3. This table will be provided by the BCSP at the time of the examination.

Step 4:

Since for the problem at hand we are interested in the area under the curve between Z_1 and Z_2, subtract the area obtained for Z_1 from that obtained for Z_2 if both Z_1 and Z_2 are positive or they are both negative. This value represents the area under the curve between Z_1 and Z_2 or the probability that a randomly selected variable would assume a value between x_1 and x_2 (remember Z_1 and Z_2 were calculated form x_1 and x_2). If Z_1 and Z_2 have opposite signs (i.e.: one is positive and the other is negative) add the areas obtained for Z_1 and Z_2. Due to symmetry, the area for a negative value of Z_1 is the same as the positive value of Z_1 except that a negative Z_1 has its area to the left of Z = 0.

Example 2

A population is normally distributed with a mean of 50 and a standard deviation of 10. What is the probability that a randomly selected variable from this population falls between 35 and 40?

Step 1:

$Z_1 = \frac{35-50}{10} = -1.5$

Step 2:

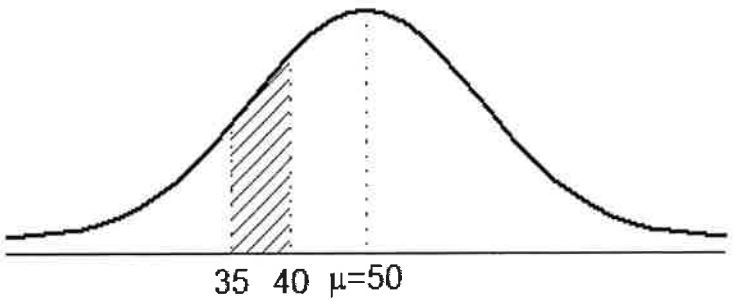
$Z_2 = \frac{40-50}{10} = -1.0$

Step 3:

From Table 3, the area between Z = 0 and Z_1 = -1.5 is 0.4332 and the area between Z = 0 and Z_2 = -1.0 is 0.3413. Therefore the area under the curve between above values of Z_1 and Z_2 is:

0.4332 - 0.3413 = 0.0919

or the probability that a randomly selected variable from this population falls between 35 and 40 is 0.0919 or 9.19 per cent. This problem can be demonstrated graphically as follows.



- Another type of problem dealing with normal probability distribution is to find the probability that a randomly selected variable would assume a value larger or smaller than a given value x_1. In order to solve this type of problem, we proceed as follows:

  Step 1:

  Calculate the value of Z_1 from

  $Z_1 = \frac{x_1-\mu}{\sigma}$

  Step 2:

  If Z_1 has a positive value two situations may arise:

The problem asks for probability of a randomly selected variable being greater than Z_1. In this case subtract the area obtained from 0.5 Probability of a randomly selected variable being smaller than Z_1. Add 0.5 to the area obtained from the table.

If Z_1 has a negative value:

For probability of the random variable being greater than Z_1, add 0.5 to the area obtained from the table. For probability of random variable being smaller than Z_1, subtract the area obtained form 0.5.

- The problem asks for probability of a randomly selected variable being greater than Z_1. In this case subtract the area obtained from 0.5
- Probability of a randomly selected variable being smaller than Z_1. Add 0.5 to the area obtained from the table.
- For probability of the random variable being greater than Z_1, add 0.5 to the area obtained from the table.
- For probability of random variable being smaller than Z_1, subtract the area obtained form 0.5.

Example 3

For a population with a mean of 200 and a standard deviation of 30, what is the probability that a randomly selected variable assumes a value less than 250?

Solution

$Z_1 = \frac{250-200}{30} = 1.66$

From the table of normal distribution (Table 3) the area between Z_0 and $Z_1 = 1.66$ is 0.4515. Therefore, the probability that a randomly selected variable from this population assumes a value less than 250 is 0.5 plus 0.4515 or 95.15 per cent.

Example 4

A population has a mean of 500 and a standard deviation of 50. What is the probability that a randomly selected variable from this population has a value larger than 600?

Solution

$Z_1 = \frac{600-500}{50} = 2.0$

From the table of normal distribution the area between Z_0 and $Z_1 = 2.0$ is 0.4772. However, for this problem we need the area to the right of Z_1 which is:

0.5 - 0.4772 = 0.0228

which means that the probability that a randomly selected variable has a value larger than 600 is 0.0228 or 2.28 percent.

How to use Table 3:

The left column lists values of Z with one decimal point. The second decimal for Z is selected from the top row. For example, the area between Z = 0 and $Z_1 = 1.23$ is equal to 0.3907.

z		0	1	2	3	4	5	6	7	8	9
0.0		.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1		.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2		.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3		.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4		.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5		.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6		.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7		.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8		.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9		.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0		.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1		.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2		.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3		.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4		.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5		.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6		.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7		.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8		.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9		.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0		.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1		.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2		.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3		.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4		.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5		.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6		.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7		.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8		.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9		.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0		.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Table 3. Table of The Normal Distribution; source: BCSP Candidate Handbook

Student T-Distribution

The Student t-distribution is used to make inferences about a large population when the sample size is small (less than 30). This is done by stating a null hypothesis and an alternative hypothesis. The table of t-distribution (Table 4) can then be used to reject or accept the null hypothesis at an assumed confidence level. The steps involved in solving problems are summarized below.

Let's assume that a new process makes steel rings for automotive industry. Six rings which have been generated by the new process have diameters of 0.46, 0.61, 0.52, 0.48, 0.57, and 0.54 inches. A study of this process has indicated that the new process can only be profitable if the average diameter of all rings produced is larger than 0.5 inches.

In this case, we wish to test the null hypothesis that μ (mean) = 0.5 against the alternative hypothesis that $\mu > 0.5$. The null hypothesis is shown with H_0 and the alternative hypothesis with H_a. For this example:

$H_0 : \mu = 0.5$

$H_a : \mu > 0.5$

Note that μ is the population mean i.e. for this example μ is the average diameter of all rings which is produced by the process (not just the six which is being studied). In order to solve this problem, we proceed as follows:

1. Calculate the value of the test statistic t:

   $$t = \frac{\bar{X} - \mu}{s \div \sqrt{n}}$$

   where X is the sample mean, μ is the population mean, s is the sample standard deviation and n is the sample size. In this example, $X = 0.53$ and $s = 0.0559$ (verify that the sample mean and standard deviation are indeed 0.53 and 0.0559 respectively), $\mu = 0.5$, $n = 6$

   $$t = \frac{0.53 - 0.5}{0.0559 \div \sqrt{6}} = 1.32$$

2. Calculate the degrees of freedom: N = n - 1 N = 6 - 1 = 5
3. The null hypothesis can be rejected or accepted at a given confidence level P (see Table 4). Let's assume that in this example we are interested in a confidence level of 0.95 (or 95 percent).
4. Determine the value listed in Table 4 (t-distribution) for N degrees of freedom and a confidence level of P. In this example, N = 5, P = 0.95, and the table value is 2.015

5. Reject the null hypothesis H_0 in favor of the alternative hypothesis H_a if the calculated value of the t - statistic is greater than the value obtained from the table. In this example since the calculated value of t, which is 1.32, is less than the table value (2.015), we can not reject the null hypothesis H_0. In other words, we can not say with 95 percent confidence that the average diameter of all rings produced by the new process is more than 0.5 inches.

Important Note:

In the above example, we decided that we would reject the null hypothesis H_0 in favor of the alternative hypothesis H_a if the calculated value of the t-statistic *exceeds* the value listed in the table of t-distribution (Table 4). This was because the alternative hypothesis Ha stated that the population mean is *greater* than a given value (0.5 inches in the example). If our alternative hypothesis had stated that the population mean be *less* than a given value, we would reject the null hypothesis (H_0) in favor of the alternative hypothesis (H_a) only if the calculated value of the t-statistic was *less* than the value listed in Table 4 for a given number of degrees of freedom and confidence level. In order to demonstrate this concept, let's rework the example dealing with the average diameter of rings with only one change.

THE PROCESS WOULD BE PROFITABLE ONLY IF THE AVERAGE DIAMETER OF ALL RINGS PRODUCED IS LESS THAN 0.5 INCHES.

Null hypothesis $H_0 : \mu = 0.5$

Alternative hypothesis $H_a : \mu < 0.5$

Sample mean $X = 0.53$

Sample standard deviation $s = 0.0559$

Calculated value of t = 1.32

Table value with 5 degrees of freedom and at 95 percent confidence level = 2.015

In this case since the alternative hypothesis H_a requires the population mean (μ) to be less than 0.5 inches, we reject the null hypothesis in favor of the alternative hypothesis (H_a) only if the calculated value of the t-statistic (1.32) is less than the value obtained from the table of t-distribution (2.015). Since this is the case in this example: We reject the null hypothesis H_0 that the average diameter of all rings produced is equal to 0.5 inches (H_0: m = 0.5) in favor of the alternative hypothesis Ha that the average diameter of all rings produced is less than 0.5 inches (H_a: $\mu < 0.5$). In other words, we can say at 95 percent confidence level that the average diameter of all rings which is produced by the new process is less than 0.5 inches. This conclusion is, of course, based on our study of only 6 rings.

Students-t distribution is, therefore, used to draw inferences about a large population based on statistical analysis of a small sample (less than 30).

Summary Of Small-Sample Test Of An Hypothesis Concerning A Population Mean (Student-t distribution)

1. State the null hypothesis $H_0 : \mu = \mu_0$
2. State the alternative hypothesis $H_a : \mu > \mu_0$ (or H_a: $\mu < \mu_0$)
3. Calculate the value of test statistic t

$$t = \frac{\bar{X} - \mu}{s \div \sqrt{n}}$$

Where:

X = the sample mean

μ = the population mean

s = sample standard deviation

n = the sample size.

4. Obtain the table value (Table 4) corresponding to N = n - 1 degrees of freedom and confidence level P.
5. Reject the null hypothesis in favor of the alternative hypothesis if the calculated value of t is greater than the table value if the alternative hypothesis is:

$H_a : \mu > \mu_0$

or

Reject the null hypothesis and accept the alternative hypothesis if the calculated value of t is less than the table value if alternative hypothesis is:

$H_a : \mu < \mu_0$.

Sample Size (N)	Confidence Level (P)			
	0.750	**0.900**	**0.950**	**0.990**
1	1.000	3.078	6.314	31.821
2	0.816	1.886	2.920	6.965
3	0.765	1.638	2.353	4.541
4	0.741	1.533	2.132	3.747
5	0.727	1.476	2.015	3.365
6	0.718	1.440	1.943	3.143
7	0.711	1.415	1.895	2.998
8	0.706	1.397	1.860	2.896
9	0.703	1.383	1.833	2.821
10	0.700	1.372	1.812	2.764
15	0.691	1.341	1.753	2.602
20	0.687	1.325	1.725	2.528
25	0.684	1.316	1.708	2.485
30	0.683	1.310	1.697	2.457
∞	0.674	1.282	1.645	2.326

Table 4. Table of Percentage Points of the t Distribution

Example 5

Let x be a normally distributed random variable with a mean of 30 and a standard deviation of 4. What is the probability that a randomly selected value of x lies between 25 and 32?

a. 68%

b. 26%

c. 58%

d. 73%

Select (c)

Solution

$\mu = 30$

$s = 4$

$x_1 = 25$

$x_2 = 30$

$Z_1 = \frac{x_1 - \mu}{\sigma}; Z_2 = \frac{x_2 - \mu}{\sigma}$

$Z_{25} = \frac{25-30}{4} = \frac{-5}{4} = -1.25$

$Area_{25}$ = 0.10595 (average area for Z = -1.2 and Z = -1.3)

$Z_{32} = \frac{32-30}{4} = \frac{2}{4} = 0.5$

$Area_{32}$ = 0.6915 (table 3)

Probability for a value to fall between 25 and 32 is

0.6915 - 0.1059 = 0.5856 or approximately 58 percent.

Example 6

You have just completed a HAZCOM training for 300 employees at your workplace and have tabulated the results of their tests. The mean is 75 and the standard deviation is 4. What percentage of your students scored 81 or better?

a. 8.9%

b. 6.7%

c. 11.3%

d. 14.6%

Select (b)

Solution

$Z_{81} = \frac{81-75}{4} = \frac{6}{4} = 1.5$

$Area_{Z\,=\,1.50}$ = 0.4332, percentage of people with a score of 81 or better is 0.5 - 0.4332 = 0.067 or 6.7 %. Note that the area obtained from Table 3 for Z = 1.5 is the area to the left of Z. We are looking for the area to the right of Z = 1.5, i.e. people who scored more than 81.

Example 7

The average diameter of steel rings produced by a machine must be greater than 0.30 inches. Six sample rings were tested and found to have the diameters of 0.28, 0.34, 0.31, 0.27, 0.31, and 0.29 inches.

Based on the data available, we can say with a confidence level of 95% that the average diameter of all rings produced by this machine is greater than 0.30 inches.

a. True

b. False

Select (b)

Solution

State the null hypothesis

$H_0 : \mu = 0.30$ inches

State the alternative hypothesis

$H_a : \mu > 0.30$ inches

Calculate the mean and the standard deviation for the sample

$\bar{X} = \frac{0.28+0.34+0.31+0.27+0.31+0.29}{6}$

$X = 0.30$

$S = \sqrt{\frac{(0.02)^2+(0.04)^2+(0.01)^2+(0.03)^2+(0.01)^2+(0.01)^2}{6-1}}$

$S = 0.025$

$t = \frac{0.30-0.30}{0.025 \div \sqrt{6}} = 0$

From Table 4 with 5 degrees of freedom (6 - 1), and a confidence level of 0.95, we obtain a value equal to 2.015. Since the calculated value of the t-statistic (0) is less than the table value (2.015), we can not reject the null hypothesis $H_0 : \mu = 0.30$. In other words, we can not say with a confidence level of 95 percent that the average diameter of all rings produced by this machine is more than 0.30 inches. Note that if our alternative hypothesis was $H_a : \mu < 0.30$, then with the above results (calculated t being less than the table value), we could reject the null hypothesis $H_0 : \mu = 0.30$ and accept the alternative hypothesis $\mu < 0.30$ inches. In other words, we could say, in this case, that the average diameter of all rings produced by this machine is less than 0.30 inches (at a confidence level of 95 percent).

1.5 Gas Laws

Introduction

The chemistry portion of the applied sciences section deals with the application of knowledge of the composition and transformations of matter for the assessment and control of hazards.

Although a comprehensive coverage of chemical principles and chemistry of matter is beyond the scope of this workbook, the candidate for the CSP designation is expected to have some familiarity with these areas.

Gas laws are an important part of the "chemistry" portion of the examination and find widespread applications in safety. Since the candidate may not be familiar with the principles governing the changes in the state of a gas, we have devoted the following section to a brief review of the basic principles and terminology used in this area.

Gas Laws: Basic Definitions and Relationships

Density

Density is mass per unit volume:

$$\rho = \frac{m}{v}$$

Where:

ρ is density

m is mass

v is volume.

Compressible fluid

The volume changes significantly with changes in pressure. Air is an example of a compressible fluid.

Incompressible fluid

The volume does not change significantly with changes in pressure. Water is an example of an incompressible fluid.

Mole

Mass divided by the molecular weight. For example 32 lb of methane (molecular weight = 16) is equal to 2 lb moles of methane.

Mixture density

$$\frac{1}{\rho} = \sum_{i=1}^{n} \frac{x_i}{\rho_i}$$

Where:

n is number of components in mixture

ρ_i is the density of component i

x_i is the mass fraction of component i.

Ideal gas law

PV = nRT

Where:

p is the absolute pressure (gauge pressure plus atmospheric pressure)

v is the volume occupied by the gas

n is number of moles of gas

R is the universal gas constant

T is the absolute temperature (degrees Fahrenheit plus 460 or degrees centigrade plus 273).

Standard conditions

Reference temperatures of 0°C and pressure of 1 atm are commonly referred to as standard temperature and pressure (STP).

Mole fraction

The number of moles of a component in a mixture divided by the total number of moles

$$y_A = \frac{n_A}{n_t}$$

Where:

y_A is mole fraction of component A in a mixture

n_A is number of moles of component A

n_t is total number of moles.

Partial pressure

The pressure exerted by a component of a mixture ALONE at the same volume and temperature as that of the mixture.

The partial pressure of a component in an ideal gas mixture is equal to its mole fraction multiplied by the total pressure

$$\mathbf{P_A = y_A P_t}$$

Where:

P_A is partial pressure of component A in the gas mixture

y_A is mole fraction of A in the mixture

P_t is total pressure.

Partial volume

The volume that would be occupied by a component of a mixture ALONE at the pressure and temperature of the mixture.

The partial volume of a component of an ideal gas mixture equals its mole fraction in the mixture multiplied by the total mixture volume:

$$\mathbf{V_A = y_A V_t}$$

Where:

V_A is the partial volume of component A

y_A is mole fraction of component A in the mixture

V_t is the total mixture volume.

Isothermal changes in an ideal gas

When an ideal gas undergoes a change at constant temperature its pressure and volume are related by:

$$\mathbf{P_1 V_1 = P_2 V_2}$$

Where:

P_1 and V_1 are pressure and volume under conditions 1

P_2 and V_2 are pressure and volume under conditions 2.

Isobaric changes in an ideal gas

When an ideal gas undergoes changes at constant pressure, its volume and temperature are related by:

$$\mathbf{V_1T_2 = V_2T_1}$$

Isometric changes in an ideal gas

When an ideal gas undergoes changes at constant volume conditions, its temperature and pressure are related by:

$$\mathbf{P_1T_2 = P_2T_1}$$

Combined gas law

When the state of an ideal gas is changed from conditions 1 to 2, the relationship between pressure, temperature, and volume is given by:

$$\mathbf{P_1V_1T_2 = P_2V_2T_1}$$

Absolute pressure and temperature scales

Absolute pressure = gauge pressure + atmospheric pressure

There are two absolute temperature scales used in solving gas law problems:

°K (degrees Kelvin) = °C + 273

°R (degrees Rankine) = °F + 460.

The gas constant

The value of the gas constant in the ideal gas law depends on the units chosen for pressure, temperature, number of moles, and volume. The following values of the gas constant are more commonly used in solving gas law problems.

The gas constant

8.314 m^3 • Pa/mol • °K

0.08314 liter • bar/mol • °K

0.08206 liter • atm/mol • °K

62.36 liter • mmHg/mol • °K

0.7302 ft^3 • atm/lb-mole • °R

10.73 ft^3 • psia/lb-mole • °R

8.314 J/mol • °K

1.987 cal/mol • °K

1.987 Btu/lb.$^{-mole}$ • °R

Standard conditions for gases

The PVT values for standard conditions in different system of units are tabulated below:

Standard conditions for gases

Standard conditions for gases				
System	$\mathbf{T_s}$	$\mathbf{P_s}$	$\mathbf{V_s}$	$\mathbf{n_s}$
SI	273°K	1 atm	0.02415 m^3	1 kg mole
CGS	273°K	1 atm	22.415 liters	1 gram mole
American Engineering	492°R	1 atm	359.05 ft.3	1 lb.-mole

1.6 Life Sciences

Cell theory

1. All living organisms are composed of one or more compartments called "cells."
2. Each cell has and can maintain its unique vitality.
3. Most cells can reproduce themselves.

Cellular Functions

The seven major cellular functions are:

Movement

Muscle cells can generate forces that produce motion.

Conductivity

Conduction as a result of response to a stimulus is manifested by a wave excitation, and an electrical potential that passes from the surface of the cell to its other parts. For example, conductivity is the principal function of the nerve cells.

Metabolic absorption

All cells are capable of absorbing nutrients and other substances from their surroundings.

Secretion

Certain cells are capable of converting the absorbed materials into other substances that may be needed elsewhere. The mucous gland cells serve as a good example.

Excretion

The process of waste elimination by cells that results from its metabolic function.

Respiration

All cells are capable of absorbing oxygen that is used to convert nutrients into energy.

Reproduction

Most cells are capable of reproducing themselves. Some cells, such as nerve cells, can not reproduce.

Structure and Function of Cellular Components

A typical cell is composed of three major components: an **outer membrane** called "plasma membrane" or "plasma lemma," a **fluid** called "cytoplasm," and **cell organs** including the "nucleus."

The nucleus

The nucleus, which is located in the center of cell, is surrounded by the cytoplasm. The primary function of the nucleus is cell division and control of genetic information. The nucleus consists of chromosomes surrounded by a nuclear membrane.

Chromosomes

Human cells can be categorized into two general types: sperm and egg cells that are also called "gametes," and "somatic cells" respectively.

Each somatic cell has 46 chromosomes in its nucleus. Since the chromosomes occur in pairs, each human somatic cell contains **23 pairs** of chromosomes. One member of each chromosome pair comes from the female parent, and the other is contributed by the male parent. The sperm and egg cells, on the other hand, have only one member of each chromosome pair, giving them a **total complement of 23 chromosomes**.

In 22 of the 23 pairs of chromosomes contained in the nucleus, somatic cells of the two members are identical in microscopic structure and are said to be "homologous" to one another. These 22 chromosome pairs are homologous in both male and female. The remaining chromosome pair, also known as "sex chromosomes" consists of two homologous X chromosomes in females and a nonhomologous pair, X and Y, in males.

Genetics

Genes are located along the chromosomes. Genes are responsible for controlling the development of the body, physical characteristics, and metabolic process of the cells. Defective genes may cause physical abnormalities and certain diseases.

Cellular metabolism

All of the chemical tasks of maintaining cellular functions are called cellular metabolism. This process converts nutrients into energy and building blocks which the cell needs to produce cellular structures and conduct functions.

Cellular reproduction

Cellular reproduction is necessary for the maintenance of life. The somatic body cells reproduce through a two-step process:

1. Nuclear division or "**mitosis**"
2. Cytoplasmic division

Before a cell can divide, it usually doubles its mass and duplicates all of its contents. Sperm and egg cell reproduction occurs by a process called **meiosis**. This process ensures that each gamete has only 23 chromosomes and not 46 as in the somatic cell.

Cellular Injury

The stimuli which can cause cellular injury include chemical agents, radiation, lack of sufficient oxygen (hypoxia), infectious agents, physical and mechanical factors, genetic factors, and nutritional imbalances.

Hypoxic cellular injury

Hypoxia, or lack of sufficient oxygen is the most common type of cellular injury. Hypoxia can be caused by reduced concentration of oxygen in air, loss of hemoglobin or hemoglobin function, decreased production of red blood cells, or disease of the respiratory and cardiovascular systems.

Chemical injury

Chemical injury is usually initiated by the interaction between a toxic chemical agent and the cell's plasma membrane. As a result of this biochemical interaction, the cell's plasma membrane becomes damaged, leading to its loss of permeability. Severe damage (e.g. exposure to corrosives) may disrupt the cell entirely.

Infectious Injury

Bacteria

A microorganism has the potential to cause injury by 1) invasion and destruction of cells, 2) production of toxic materials, 3) producing damaging hypersensitivity reactions.

Viruses

Viruses do not have their own nucleus or cell structure and survive as intracellular parasites that can take over the metabolic functions of host cells and use them for their own survival and reproduction. Unlike bacteria, viruses can not reproduce independently; their replication is completely dependent on their ability to infect a permissive host cell. This is also the reason that viruses are hard to destroy because one must kill the host cell in order to kill the virus. This is in contrast to the destruction of bacteria where a wide range of antibiotics are effective.

Injurious genetic factors

Genetic factors can alter the DNA within a cell's nucleus resulting in damage to the cells.

Nutritional imbalances

In order to function normally, cells require adequate amounts of nutrients such as minerals, vitamins, carbohydrates, proteins, etc. Any imbalance of these essential nutrients can cause adverse cellular effects.

Injurious Physical Agents

Physical agents such as temperature extremes, pressure changes, radiation, mechanical factors, noise, and vibration can cause cellular injuries.

Temperature extremes

Exposure of cells to extremely low temperatures causes **hypothermic** injury. Slow chilling of cells can cause changes in small blood vessels resulting in cellular and tissue swelling. Cryogenic liquids, such as liquid nitrogen, will cause severe **hypothermic** injury.

Cell exposure to high temperatures causes **hyperthermic** injury. The extent depends on the temperature and length of time of exposure. A **full thickness burn** is an open

wound involving all skin layers; cellular regeneration is not possible and skin must be grafted to the site from a donor. **A partial thickness burn**, on the other hand, causes reddening of the area as a result of dilation of small blood vessels and increased permeability of cellular membranes, and a loss of protein rich fluid, resulting in the typical "burn blister."

Pressure changes

Injury to the body cells can be caused as a result of sudden increase or decrease in atmospheric pressure. This is more commonly known as **blast injury**. In air blast or explosive injuries, tissue injury is often caused by compressive force of air impinging on the body, followed by a sudden wave of decreased pressure. These pressure changes are capable of rupturing the internal organs.

Cellular damage by radiation

Ionizing radiation refers to any type of radiation capable of removing orbital electrons from the atom and thereby forming ions. Typical forms of ionizing radiation are X-rays, beta particles, alpha particles, and gamma rays. Ionizing radiation can affect the cellular structure either directly or indirectly. The direct effect of ionizing radiation on cells is by ionizing the macromolecules within the cell and in particular the DNA molecule. The indirect effect of ionizing radiation on the cellular structure is ultimately ionization of the DNA molecule which may affect later generations of cells.

Non-ionizing radiation such as ultraviolet, infrared, and microwave radiation, can adversely affect surface or internal cells.

Mechanical Stress

Repetitive Motion

Mechanical injury is caused by physical impact or constant irritation. The response of tissue to mechanical stress is the focus of occupational biomechanics.

Noise

Noise is defined as a sound wave that has the potential for causing bodily harm. Two types of hearing losses are associated with noise.

1. **Acoustic trauma** results from an instantaneous noise.
2. **Noise Induced Hearing Loss (NIHL)** results from prolonged exposure to noise.

Acoustic trauma can rupture the ear drum, displace the small bones (ossicles) in the middle ear, and damage the inner ear.

When the noise has not been too loud and the hearing returns to normal, the hearing loss is called a **Temporary Threshold Shift**. When the hearing does not return to normal, the hearing loss is called a **Permanent Threshold Shift**.

Epidemiology

Epidemiology

Epidemiology is the study of the occurrence of disease in human populations.

The major emphasis of the science of epidemiology is to focus on the prevention of disease through the reduction of factors that may increase the likelihood that an individual or group will suffer a given disease.

Descriptive epidemiological studies

Descriptive epidemiological studies usually focus on the number of cases of a disease in a given time period. This type of study provides information on the distribution of the disease as well as the risk factors for an individual to contract the disease.

Descriptive studies in epidemiology are helpful in the formation of hypotheses regarding the relationships between exposure and disease. Analytic studies are studies seeking to prove or disprove specific hypotheses.

Prevalence

Prevalence refers to the number of cases with the disease to the total number of cases in the study.

Incidence rate

Incidence rate refers to the number of new cases of disease during a given time period divided by the total number at risk.

1.7 General Topics in Facility Design

Engineering Design Methods

Example 1

Incorporation of safety at the design stage of a potentially hazardous industrial process is important because:

a. OSHA regulations require a place of employment free of all hazards.

b. It has an economic advantage to the company.

c. It decreases management liability before facility construction.

d. Safety is the most important consideration in design of potentially hazardous industrial processes.

Select (b)

Incorporation of safety at the design stage has a clear economic advantage. It is much less expensive to make changes at this stage compared to changes made after construction of a facility.

Example 2

A pump is sending cooling water to a reactor. Loss of cooling water to this reactor would cause the reactor to explode. A fail-safe design for the system is best portrayed by:

a. Activation of a spare pump upon failure of the cooling water pump.

b. Automatic shutdown of the process upon failure of the cooling water pump.

c. Relieve pressure in the reactor to prevent explosion.

d. All of the above.

Select (a)

The best example of a fail-safe design is depicted in statement (a). This would allow the plant to operate safely and efficiently when the cooling water pump fails. The statement in (b) would result in loss of production and additional cost for startup.

Example 3

The concept of "Energy Theory" in the safe design of processing facilities states that the severity of an accident is related to:

a. Amount of energy release.

b. Rate of energy release.

c. Means of energy transfer.

d. All of the above.

Select (d) The energy theory relates the type and severity of injuries in an accident to statements (a), (b), and (c).

Geotechnics/Soil Mechanics

Example 1

Shoring is required for all trenches more than 4 feet deep unless:

a. They are sloped to the angle of repose.

b. The trench is in stable rock.

c. A ladder is provided.

d. Only (a) and (b) above.

Select (d)

No shoring is required for situations stated in (a) and (b).

Example 2

A trench is:

a. A narrow excavation.

b. Deeper than it is wide.

c. Never wider than 15 feet.

d. All of the above.

Select (d) Situations presented in statements a, b, and c are correct about trenches.

Example 3

OSHA regulations require adequate bracing and shoring or a sloped trench when the depth of excavation is more than:

a. 3 ft.

b. 5 ft.

c. 10 ft.

d. 4 ft.

Select (b)

When the depth of excavation is more than 5 ft (1.5 m), adequate bracing and shoring is required or the trench must be sloped.

Example 4

A trench _____ ft. or deeper must be provided with ladders to facilitate safe entrance and exit.

a. 4

b. 6

c. 10

d. 15

Select (a)

A trench which has a depth of 4 ft. or more must be provided with ladders to facilitate safe entrance into and safe exit out of the trench. The ladders must be distributed in such a way that no worker, at any time, is more than 25 ft. away from a ladder. The ladders must extend to at least 3 ft. above the surface of the ground.

Mechanical Systems

Example 1

The guard on a grinding wheel must:

a. Completely enclose the wheel.

b. Cover the wheel as completely as the nature of the work permits.

c. Be adjustable.

d. Only (b) and (c) above

Select (d)

It is impossible to fully enclose the grinding wheel as some portion of the wheel must be exposed to perform grinding on the part. Guards on grinding wheels must be adjustable to provide adequate protection when the diameter of the wheel decreases.

Example 2

Two cranes that are operated on the same runway should be separated by a distance of at least:

a. 50 feet.

b. 30 feet.

c. 20 feet.

d. 10 feet.

Select (b) Per National Safety Council recommendation, at least 30 feet (9 meters) separation must be maintained where possible.

Example 3

Which of the following organizations has the most number of standards for unfired pressure vessels?

a. ANSI.

b. NFPA.

c. ASME.

d. OSHA.

Select (c) Unfired pressure vessels such as compressed air tanks, steam-jacketed kettles, etc. must follow the ASME code, section VIII, division 1 and 2.

Example 4

The recommended maximum allowable slope for a ramp is:

a. 45 degrees.

b. 25 degrees.

c. 20 degrees.

d. 15 degrees.

Select (d) Ramps should be constructed using the minimum possible slope. The recommended maximum value for the slope of a ramp is 15 degrees. However, the slope should never exceed 20 degrees.

Example 5

In indoor warehousing operations, the preferred type of powered truck is:

a. Liquefied petroleum gas trucks.

b. Electric trucks.

c. Diesel trucks.

d. Gasoline trucks.

Select (b) Electric trucks do not generate carbon monoxide and are preferred over other types for indoor operations. LPG powered trucks generate considerably less carbon monoxide compared to gasoline trucks.

Example 6

Fuel containers for LPG powered trucks must conform to the specifications of:

a. DOT.

b. NIOSH.

c. ASME.

d. Only (a) and (c) above.

Select (d) Fuel containers for LPG trucks must conform to both DOT and ASME specifications. These containers should only be filled outdoors and the storage areas for the fuel containers must conform to NFPA 58.

Example 7

According to OSHA requirements, all powered industrial trucks must meet the design and construction requirements of:

a. DOT.

b. NEC.

c. ANSI.

d. All of the above.

Select (c) According to OSHA standard 29 CFR 1910.178 for powered industrial trucks, the design and construction of these trucks must meet ANSI B56.1-1969.

Materials Handling

Example 1

In handling bulging drums of hazardous chemicals or wastes:

a. The pressure must be relieved using a knife, chisel, or similar tools.

b. The pressure must be relieved in an area which is away from the drum using appropriate PPE.

c. The drum must be isolated with a barricade.

d. Only (b) and (c) above.

Select (d) Bulging drums are under pressure and may explode during handling.

Example 2

When lifting a load, the load must be kept:

a. As far away from the body as possible.

b. As low as possible.

c. As close to the body as possible.

d. The line through the center of gravity of the load must make an angle of 80 degrees with the hands.

Select (c) The load must be kept as close to the body as possible. This would minimize the moment created by the load on the back muscles.

Example 3

The most common occupational injuries resulting from manual materials handling are injuries to the

a. Foot.

b. Hand.

c. Eyes.

d. Back.

Select (d)

Injuries to the back are the most common type of injuries resulting from manual materials handling. Many studies indicate that about 25 percent of all workers' compensation claims account for injuries to the lower back.

Example 4

Many powered materials handling vehicles have a high center of gravity. This means that:

a. The maximum load rating of the vehicle is increased compared to an identical low center of gravity vehicle.

b. The pressure exerted on tires is less than an identical vehicle with a low center of gravity.

c. The gravitational force exerted on the center of the vehicle is less than that of an identical vehicle with a low center of gravity.

d. When the vehicle operated in a turn, it has a greater potential for roll over compared to an identical vehicle with a low center of gravity.

Select (d)

The higher the center of gravity, there is more potential for roll over during a turn.

Inspection and Control Procedures

Example 1

One of the problems associated with safety inspections is:

a. Regulations may not be updated.

b. Control methods may not be economical.

c. Hazards are allowed to accumulate between inspections.

d. Lost time cases cannot be detected.

Select (c)

A safety inspection usually causes a surge in safety and health activities. However, after a period of time hazards are allowed to accumulate until the next inspection.

Example 2

One of the disadvantages of an external safety inspection is:

a. Its objectivity.

b. High cost.

c. Several follow-up inspections.

d. All of the above.

Select (b)

An external safety audit is normally conducted by outside consultants hired by the organization. The major advantage of an external audit is its "objectivity." The disadvantages include lack of familiarity of the auditor with the facility and the personnel, high cost, and the possibility of no or minimum follow-up.

Example 3

During a safety inspection of your facility, you have discovered an unsafe act being committed by an employee. Your best course of action is:

a. To stop the unsafe act and instruct the employee how the job can be done safely.

b. To report the unsafe act to employee's supervisor.

c. Provide adequate training.

d. All of the above.

Select (d)

A sound safety management program sets forth provisions to stop unsafe acts as soon as they are discovered and to provide adequate training.

Example 4

Accident causes can be classified into "basic," "indirect," and "direct" causes. An unsafe act by an employee which results in an accident is an example of which of the following accident causes?

a. Basic.

b. Indirect.

c. Direct.

d. Basic and direct.

Select (b)

Poor management is an example of basic causes of accidents. Unsafe acts or unsafe conditions are indirect causes of accidents. These can lead to direct causes of an accident such as unplanned release of energy which can result in fatality, injury, or property damage.

Facilities Planning and Layout

Example 1

In new chemical plant layout where most processing equipment is located outdoors, which of the items listed below should be the first consideration?

a. To group similar equipment in one location

b. To determine the direction of the prevailing wind

c. To provide room for maintenance

d. To minimize piping and pumping costs

Select (b)

The direction of prevailing wind will determine the location of much equipment.

Example 2

The areas for containment of spills of liquefied petroleum gases should always be constructed below grade because:

a. These gases have a vapor density which is greater than one.

b. A person in the surrounding area will not be asphyxiated.

c. Spilled material can flow to these areas by gravity.

d. Only (a) and (b) above.

Select (d)

These gases have a vapor density greater than one and thus they will collect at low points resulting in less contaminated air at grade level. This results in less hazard to people in the area and for emergency vehicles which may enter the area. Liquefied petroleum gases immediately vaporize when released and do not flow as conventional liquids.

Example 3

The advantage of "flow line layout" as opposed to "grouped equipment layout" for processing facilities is:

a. Minimization of the length of transfer lines.

b. Minimization of the energy requirement for transport of materials.

c. Minimization of the number of people required to operate the facility.

d. Only (a) and (b) above.

Select (d) "Flow line layout" results in minimum length of transfer lines and reduces material transport and energy requirements. "Grouped equipment layout," where all similar equipment placed in the same area, usually requires fewer operators.

1.8 Example Questions

1. 400° K is equal to:
   a. 127° F
   b. 273° F
   c. 160° F
   d. 260.6° F
2. 900° R is equal to:
   a. 226.6° C
   b. 440° C
   c. 460° C
   d. 273° C
3. Which of the following chemical equations is not balanced?
   a. $SO_3 + H_2O \rightarrow H_2SO_4$
   b. $N_2 + 3H_2 \rightarrow 2NH_3$
   c. $C_6H_5Cl + SiCl_4 + Na \rightarrow (C_6H_5)_4Si + NaCl$
   d. $C_2H_6 + 3O_2 \rightarrow CO_2 + CO + 3H_2O$
4. 20 cubic feet of air at 70° F and 1.0 atm is heated to 610° F and compressed to 2.5 atm. The volume of air in its new state is:
   a. 16.15 ft^3
   b. 28.13 ft^3
   c. 15.70 ft^3
   d. 32.18 ft^3
5. The volume occupied by 1 lb.-mole of an ideal gas under STP conditions is:
   a. 65 liters
   b. 359 ft^3
   c. 22.4 ft^3
   d. 359 liters
6. A gas mixture contains 32 lbs. of methane (molecular weight = 16); 6 lbs. of hydrogen (molecular weight = 2), and 44 lbs. of carbon dioxide (molecular weight = 44). The mole fraction of hydrogen in the gas mixture is:
   a. 3.0

b. 0.5.

c. 2.0

d. 0.8

7. A gas tank which is under 2,000 psig pressure contains 30 mole per cent hydrogen 40 mole per cent nitrogen, and the balance helium. The partial pressure of helium expressed in psig is:

   a. 600

   b. 1,200

   c. 1,400

   d. 900

8. In chemistry, the term *sorption* is used to cover which of the following processes?

   a. Adsorption

   b. Absorption

   c. Ion exchange

   d. All of the above

9. Which of the following statements is NOT true in regard to a cathode in an electric cell?

   a. The cathode is negatively charged.

   b. The cathode attracts anions.

   c. The cathode is the source of electrons.

   d. The cathode accepts positive charges.

10. The number of chromosomes in a somatic cell is:

    a. 46 pairs

    b. 2 pairs

    c. 23 pairs

    d. 1 pair

11. In somatic cells, the members of a given chromosome pair are:

    a. One from the female and one from the male

    b. Both able to come from either the female or the male

    c. Both generated by the cell nucleus

    d. All of the above

12. Chromosomes are responsible for:

a. Production of red blood cells

b. Cell reproduction

c. Production of bone marrow

d. Carrying genetic information

13. A bacteria can cause injury to the human body by:

a. Invasion and destruction of cells

b. Production of toxic materials

c. Producing damaging hypersensitivity reactions

d. All of the above·

14. A virus can adversely affect the human body by:

a. Taking over the metabolic function of the cells

b. Attacking the cell nucleus

c. Reducing the number of red blood cells

d. All of the above

15. Body cell exposure to extremely low temperature causes:

a. Hyperthermic injury

b. Hypothermic injury

c. Cryothermic injury

d. Epithermo injury

16. The major emphasis of the science of epidemiology as relates to diseases is:

a. Cure

b. Prevention

c. Research

d. Data collection

17. Which of the following statements BEST describes *bioconcentration*?

a. Accumulation of substances or other organic chemicals in an organism from all sources (water, food, air, and so on)

b. Bioconcentration occurs when an organism absorbs a toxic substance at a rate greater than at which the substance is lost from all sources (water, food, air, and so on)

c. Bioconcentration refers to the uptake and accumulation of a substance from water alone

d. All of the above

18. The science that studies the patterns, causes, and effects of health and disease conditions in defined populations is called:

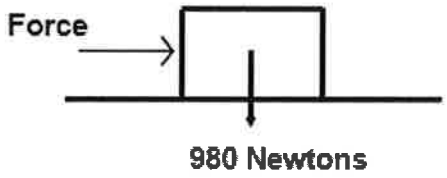
    a. Biology

    b. Etiology

    c. Epidemiology

    d. Endemology

19. A rectangular box having a mass of 100 kilograms is resting on a horizontal surface having a coefficient of friction of 0.3. The amount of horizontal force required to set this box in motion must exceed:



    a. 100 newtons

    b. 390 newtons

    c. 294 newtons

    d. 60 newtons

20. A box having a mass 100 kilograms and resting on a horizontal surface with a coefficient of friction of 0.3 is acted upon by a horizontal force of 350 newtons, the box would move with an acceleration equal to:

    a. 1 m/sec^2

    b. 100 cm/sec^2

    c. 0.56 m/sec^2

    d. 50 cm/sec^2

21. A box accelerates from rest with an acceleration equal to 0.56 m/sec^2. In 10 seconds the box will travel a distance which is equal to:

    a. 50 meters

    b. 100 meters

    c. 10 meters

    d. 28 meters

22. A box with an acceleration of 0.56 m/sec^2 starts from rest and travels a distance of 28 meters. The final velocity of this box is equal to:

a. 10 m/sec

b. 49 m/sec

c. 5.6 m/sec

d. 3.5 m/sec

23. A box weighing 200 lbf has a mass equal to:

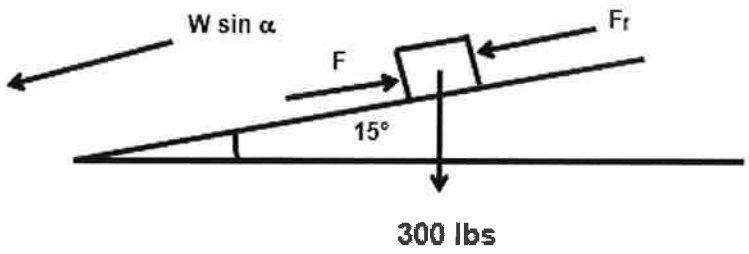
a. 50 lbm

b. 200 lbm

c. 80 lbm

d. 40 lbm

24. A box weighing 300 lb is resting on an inclined surface having a coefficient of friction of 0.4 as shown in the diagram. The minimum force necessary to set this box in motion up the inclined surface must exceed:



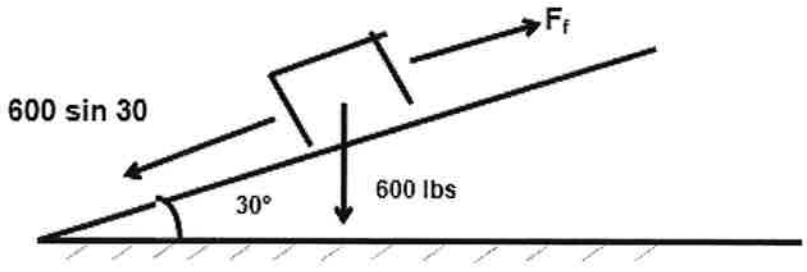
a. 50 lb

b. 194 lb

c. 140 lb

d. 77 lb

25. An object is resting on a inclined surface as shown in the diagram. In order to prevent the object from sliding downward, the coefficient of friction must be at least:



a. 0.57

b. 0.81

c. 0.77

d. 0.42

26. A 600 lb object is on a ramp making an angle of 30 degrees with horizontal. What distance would the object cover after 1 second starting from rest assuming that the coefficient of friction is 0.2?

    a. 8.5 feet

    b. 5.2 feet

    c. 2.5 feet

    d. 7.6 feet

27. An object is on a ramp and starts its motion from rest and accelerates at the rate of 10.5 ft/sec^2. What would the velocity of the object be at the end of the ramp which is 20 feet long?

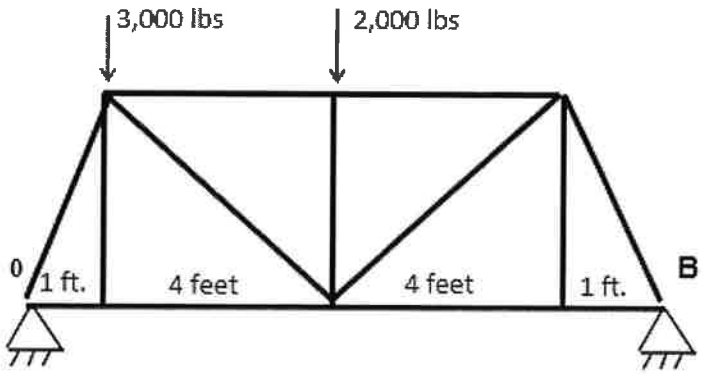
    a. 40.0 ft/sec

    b. 20.5 ft/sec

    c. 6.2 ft/sec

    d. 12.5 ft/sec

28. The reaction force at point 0 for the truss shown below is:



    a. 3,700 lb

    b. 2,000 lb

    c. 5,000 lb

    d. 7,500 lb

29. A worker weighing 200 lbs. slips on a 15 degree ramp and travels 10 feet before hitting a wall at the end of the ramp. If the coefficient of friction between the worker's shoes and the ramp is 0.1, the worker's velocity just when he hits the wall is:

    a. 50 ft/sec

    b. 100 ft/sec

c. 70 ft/sec

d. 10 ft/sec

30. A cylindrical drum having a diameter of 2 feet and height of 4 feet is half filled with a liquid having a density of 60 lbm per cubic foot. The weight of liquid inside the drum is:

a. 600 lb

b. 250 lb

c. 376 lb

d. 862 lb

31. A two-leg sling with each leg making an angle of 45 degrees with the vertical is holding a load of 5,000 lb. The tension in each leg of the sling is:

a. 3,535 lb

b. 2,500 lb

c. 2,525 lb

d. 4,200 lb

32. A two-leg sling is to hold a weight of 10,000 lb. The maximum tension in each leg of the sling can not exceed 7,000 lb. The angle of the sling with the vertical must not exceed:

a. 60 degrees

b. 44 degrees

c. 35 degrees

d. 55 degrees

33. The maximum load which can be supported by a two-leg sling having an operating tension rating in each leg equal to 3,000 lbs. and each leg making a 45 degrees angle with the vertical is:

a. 4,765 lb

b. 5,000 lb

c. 3,800 lb

d. 4,242 lb

34. Four cylindrical storage tanks having diameter of 20 feet and height of 30 feet each are to be constructed on a rectangular piece of land having dimensions of 50 by 300 feet. The volume of liquid that can be stored in each tank is:

a. 9,000 liters

b. 266,761 liters

c. 306,702 liters

d. 80,675 liters

35. Four cylindrical storage tanks having diameter of 20 feet and height of 30 feet each are to be constructed on a rectangular piece of land having dimensions of 50 by 300 feet. The amount of land that is not occupied by the tanks is:

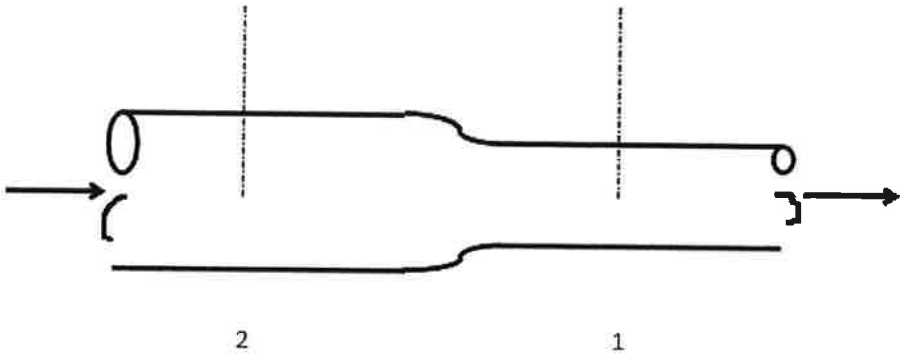
a. 13,744 ft^2

b. 9,674 ft^2

c. 5,622 ft^2

d. 11,676 ft^2

36. A liquid is flowing through two sections of a circular piping system having diameters of 2 and 1 inches, respectively. If the volumetric flow rate of the liquid in the larger pipe is 200 cubic feet per minute, the velocity of the liquid in the smaller pipe is:



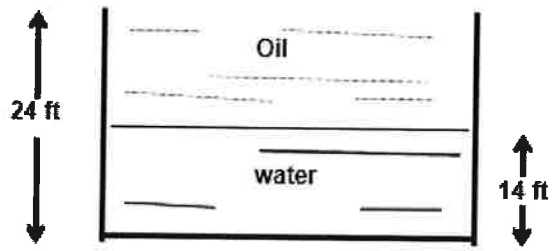
a. 200 ft/sec

b. 611 ft/sec

c. 506 ft/sec

d. 309 ft/sec

37. A large open tank contains oil and water as shown in the diagram. The height of the tank is 24 feet and the water level is 14 feet. Oil has a specific gravity of 0.7 and the density of water is 62 lbm per cubic foot. The gauge pressure at the bottom of the tank is:



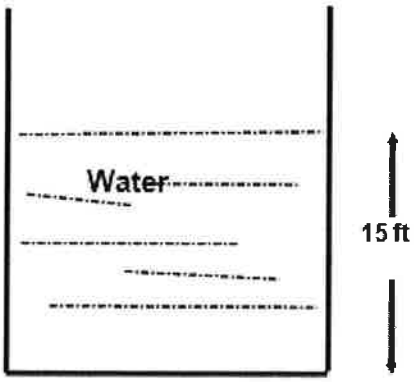
a. 15 psi

b. 17 psi

c. 9.0 psi

d. 20 psi

38. The gauge pressure at the bottom of the tank shown in the diagram is (density of water is 62 lbm/ft^3):



a. 20 feet of water

b. 15 feet of water

c. 30 feet of water

d. 10 feet of water

39. A containment berm 80 feet long and 4 feet wide is to be constructed in a drum storage area that stores no more than 100 55-gallon drums. The depth of the berm must be at least: (Note: The berm must contain the entire volume of liquid stored.)

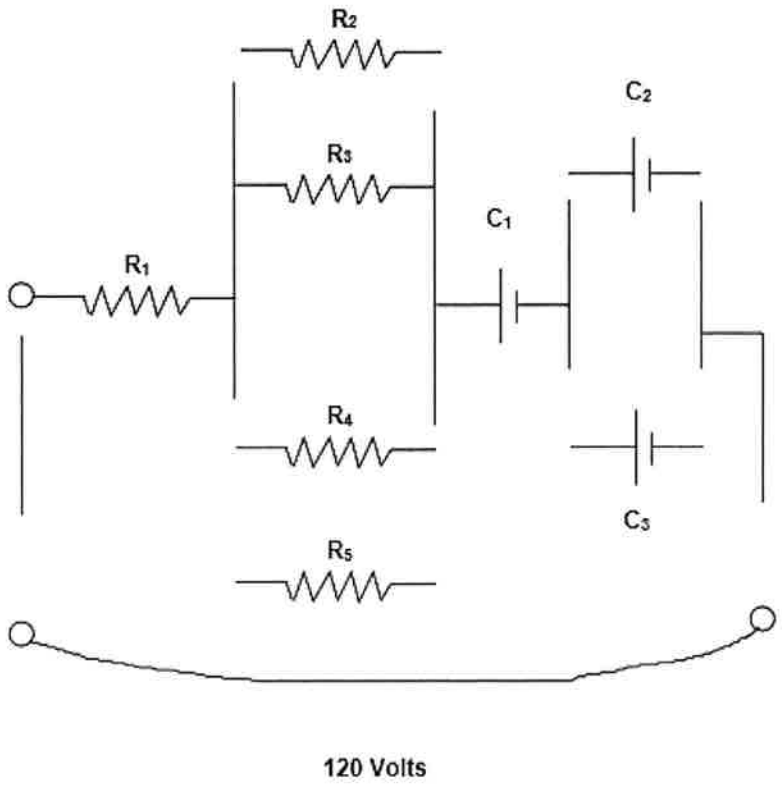
a. 4.5 ft

b. 6.2 ft

c. 5.7 ft

d. 2.3 ft

40. An electrical circuit is connected to a potential difference of 120 volts as shown in the diagram. The resistor R_1 has a length of 1 inch, a diameter of ¼ inch and a resistivity of 20 ohm-inches. Resistors R_2, R_3, R_4, and R_5 have values of 20, 30, 40, and 50 ohms respectively. The capacitors C_1, C_2, and C_3 have values of 8, 15, and 20 microfarad respectively. It has been decided to modify this circuit by replacing all resistors with a single resistor, and all capacitors with a single capacitor. The single resistor and capacitor have which one of the following values?



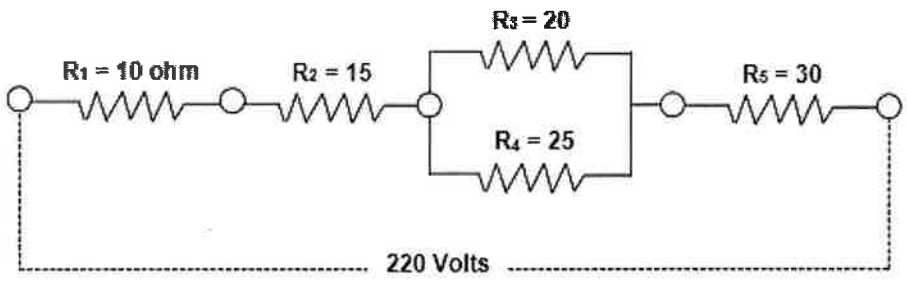
a. 110.7 ohms, 43 microfarads

b. 414.8 ohms, 6.5 microfarads

c. 216.5 ohms, 92.7 microfarads

d. 72.8 ohms, 12.7 microfarads

41. An electrical circuit consists of 5 resistors connected as shown in the diagram.



The amount of power consumed by resistor R1 is:

a. 2,200 watts

b. 10 watts

c. 109 watts

d. 220 watts

42. The potential difference across a resistor of 10 ohms with a current flow of 3.3 ampere is:

    a. 10.3 volts

    b. 20.6 volts

    c. 33.0 volts

    d. 60.7 volts

43. The amount of current flowing through a resistor having a resistance of 66.11 ohms and connected to a potential difference of 220 volts is:

    a. 8.5 amperes

    b. 7.3 amperes

    c. 2.9 amperes

    d. 3.3 amperes

44. The amount of current flowing through a resistor of 20 ohms with a potential difference of 36.66 volts is:

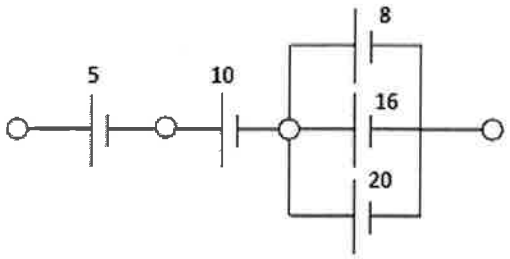
    a. 1.833 amperes

    b. 2.472 amperes

    c. 3.310 amperes

    d. 3.720 amperes

45. An electrical circuit has 5 capacitors connected as shown in the diagram. The capacity of each capacitor is expressed in microfarads. This circuit is equivalent to a single capacitor circuit having a value of:



    a. 44 microfarads

    b. 24 microfarads

    c. 59 microfarads

    d. 3 microfarads

46. The electrical resistivity of a copper wire 100 foot long and ¼ inch in diameter with a resistance of 100 ohms in ft-ohm is:

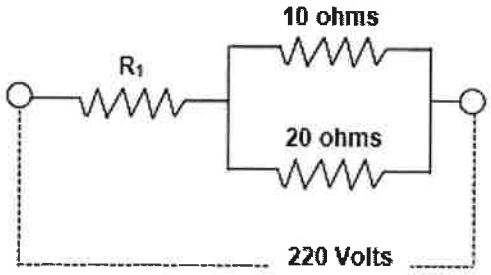
a. 6.2×10^{-3}

b. 3.4×10^{-4}

c. 6.7×10^{-4}

d. 2.7×10^{-2}

47. A resistor R1 is used in the circuit shown in the diagram. The current flow is 1 ampere. The resistance of this resistor is:



a. 30.0 ohms

b. 213.0 ohms

c. 6.6 ohms

d. 73.0 ohms

48. A power plant delivers electricity to a transformer station through 10,000 feet of a 10 gauge copper wire having a cross sectional area of 1.44 in^2 and a resistivity of 0.9989×10^{-5} ft-ohms. If the circuit potential difference is 500 volts, the amount of power consumed by the copper wiring is:

a. 10 kilowatts

b. 15 kilowatts

c. 5 kilowatts

d. 25 kilowatts

49. A power plant delivers electricity to a transformer station through 10,000 feet of a 10 gauge copper wire having a cross sectional area of 1.44 in^2 and a resistivity of 0.9989×10^{-5} ohms . feet. If the circuit potential difference is 1,000 volts, the amount of power consumed by the copper wiring is:

a. 20 kilowatts

b. 100 kilowatts

c. 50 kilowatts

d. 75 kilowatts

50. An electrical circuit has a resistance of R and a potential difference of V. If the voltage is increased to 3V, the amount of power consumption in the circuit will:

a. Decrease by a factor of 3

b. Increase by a factor of 6

c. Decrease by a factor of 6

d. Increase by a factor of 9

51. A worker having a skin resistance of 70,000 ohms accidentally comes into contact with an energized line having a voltage of 110 volts. Referring to the following table, what kind of effect would be produced in this worker?

Current, MAs (milliamperes)	**Effect**
3	mild shock
5	painful shock
10	muscular paralysis
80	asphyxiation
100	fibrillation

a. Painful shock

b. Fibrillation

c. Mild shock

d. Muscular paralysis

52. An electric device consumes 500 watts of energy when connected to a 110 volt line. The resistance of this device is:

a. 4.5 ohms

b. 24 ohms

c. 55,000 ohms

d. 2.3 ohms

53. You are traveling on an interstate highway at 60 miles per hour. Suddenly you see a pedestrian crossing the road. Your reaction time is one second to apply full, four-wheel braking. Assuming that the coefficient of friction between the tires and the road is 0.75, how far would your car travel before it comes to a complete stop?

a. 108 feet

b. 73 feet

c. 248 feet

d. 146 feet

54. The output of a light source measured at a given distance from the source was 4 lumens. The output at 2 feet away from the source is measured to be 1 lumens. At what distance from the source was the original measurement made?

a. 2 feet

b. 1 foot

c. 4 feet

d. 3 feet

55. A worker with a mass of 150 lbm falls from a scaffold 20 feet high. His velocity at the time of impact with the ground is:

a. 75 ft/sec

b. 7.5 ft/sec

c. 35.9 ft/sec

d. 72 ft/sec

56. A sample size of 500 has a mean of 20 and a standard deviation of 4. What is the probability that a randomly selected variable from this population has a value smaller than 18? (Assume normal frequency distribution.)

a. 20%

b. 30%

c. 60%

d. 75%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

57. In the normal probability distribution, the probability that Z has a value falling between the Z value for the mean and 2 is:

a. 47%

b. 68%

c. 99%

d. 73%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

58. Let x be a normally distributed random variable with a mean of 30 and a standard deviation of 4. What is the probability that a randomly selected value of x lies between 25 and 32?

    a. 68%

    b. 26%

    c. 58%

    d. 73%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

59. Assuming that the number of miles per gallon of gasoline for all midsize cars sold in the United States is normally distributed with a mean of 18 and a standard deviation of 3 miles per gallon, what percentage of midsize cars obtain less than 16 miles per gallon?

a. 32%

b. 7%

c. 18%

d. 25%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

60. You have just completed a HAZCOM training for 300 employees at your workplace and have tabulated the results of their tests. The mean is 75 and the standard deviation is 4. What percentage of your students scored 81 or better? (Assume normal distribution.)

    a. 8.9%

    b. 6.8%

    c. 11.3%

    d. 14.6%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

61. A bottling machine must put more than an average of 50 ounces of a beverage into bottles for wholesale distribution. 6 bottles were found to have 46, 61, 52, 48, 57, and 54 ounces. The six bottles provide sufficient evidence to indicate that the average of all bottles produced by this machine contains more than 50 ounces. (Use a confidence level of 95%.)

    a. True

    b. False

Sample Size (N)	Confidence Level (P)			
	0.750	**0.900**	**0.950**	**0.990**
1	1.000	3.078	6.314	31.821
2	0.816	1.886	2.920	6.965
3	0.765	1.638	2.353	4.541
4	0.741	1.533	2.132	3.747
5	0.727	1.476	2.015	3.365
6	0.718	1.440	1.943	3.143
7	0.711	1.415	1.895	2.998
8	0.706	1.397	1.860	2.896
9	0.703	1.383	1.833	2.821
10	0.700	1.372	1.812	2.764
15	0.691	1.341	1.753	2.602
20	0.687	1.325	1.725	2.528
25	0.684	1.316	1.708	2.485
30	0.683	1.310	1.697	2.457
∞	0.674	1.282	1.645	2.326

62. The average diameter of steel rings produced by a machine must be more than 0.30 inches. Six sample rings were tested and found to have diameters of 0.28, 0.34, 0.31, 0.27, 0.31, and 0.29 inches. Based on this data, we can say with 95% confidence that the average diameter of all steel rings produced by this machine is more than 0.30 inches.

    a. True

    b. False

Sample Size (N)	Confidence Level (P)			
	0.750	**0.900**	**0.950**	**0.990**
1	1.000	3.078	6.314	31.821
2	0.816	1.886	2.920	6.965
3	0.765	1.638	2.353	4.541
4	0.741	1.533	2.132	3.747
5	0.727	1.476	2.015	3.365
6	0.718	1.440	1.943	3.143
7	0.711	1.415	1.895	2.998
8	0.706	1.397	1.860	2.896
9	0.703	1.383	1.833	2.821
10	0.700	1.372	1.812	2.764
15	0.691	1.341	1.753	2.602
20	0.687	1.325	1.725	2.528
25	0.684	1.316	1.708	2.485
30	0.683	1.310	1.697	2.457
∞	0.674	1.282	1.645	2.326

63. The equivalent inductance for a circuit which has a 15 mH inductor in parallel with a 30 mH inductor and the combination in series with a 5 mH inductor is:

    a. 20 mH

    b. 50 mH

    c. 15 mH

    d. 45 mH

64. The momentum of an object having a mass of 10 lbm and a velocity of 10 ft./sec is:

    a. 100 lb-ft/sec

    b. 10 lb-ft/sec

    c. 20 lb-ft/sec

    d. 50 lb-ft/sec

65. The velocity of an object having a mass of 100 lbs and a momentum of 2000 lb-ft/sec is:

    a. 200 ft/sec

    b. 20 ft/sec

    c. 50 ft/sec

    d. 100 ft/sec

66. A cylindrical bar 6 inches in diameter supports a load of 6,000 lb. The amount of stress on this bar is equal to:

a. 360 psi

b. 212 psi

c. 75 psi

d. 62 psi

67. The stress on a beam with a rectangular cross sectional area having a length of 8 inches and a width of 4 inches is equal to 40 psi. The amount of load on this beam is equal to:

a. 160 lbs

b. 320 lbs

c. 650 lbs

d. 1280 lb

68. A cylindrical bar supports a load of 2,000 lb. If the stress is equal to 50 psi, the diameter of this bar is approximately equal to:

a. 4 inches

b. 12 inches

c. 7 inches

d. 2 inches

69. A cylindrical tank is filled with a liquid which has a density of 90 lbm/ft^3. If the gauge pressure at the bottom is 30 psi, and the tank has a diameter of 10 ft., the volume of the tank is:

a. 4,271 ft^3

b. 3,768 ft^3

c. 6,351 ft^3

d. 2,168 ft^3

70. The pressure reading at the bottom of a cylindrical tank 10 ft. high and 2 ft. in diameter filled with a liquid having a density of 70 lbm/ft^3 is:

a. 14.72 psi

b. 20.00 psi

c. 14.00 psi

d. 4.86 psi

71. A cylindrical tank 30 ft high and 10ft in diameter is filled to 50% of its height with a liquid of unknown density. The pressure gauge at the bottom of the tank reads 3 psi. The density of the liquid in the tank is:

a. 62.4 lbm/ft^3

b. 52.7 lbm/ft^3

c. 28.8 lbm/ft^3

d. 68.3 lbm/ft^3

72. A spring with a K-value of 1,500 lbf/in is compressed 2 inches from its equilibrium position. The potential energy stored in the spring is:

a. 3,000 lbf-in

b. 750 lbf-in

c. 6,000 lbf-in

d. 4,500 lbf-in

73. A box weighing 100 lbs. is acted upon by a force of 1,000 lbf. Assuming a coefficient of friction 0.3, the acceleration of the box is:

a. 300 ft./sec^2

b. 10 ft./sec^2

c. 312 ft/sec^2

d. 30 ft/sec^2

74. A car is traveling with a speed of 65 miles an hour. The driver applies the brake and the car slows down with a constant deceleration (negative acceleration) of 10 ft./sec^2. The time it would take for the car to come to a complete stop and the distance that the car travels before it comes to a complete stop is:

a. 9.5 seconds and 454.2 ft

b. 20.5 seconds and 653.5 ft

c. 5.3 seconds and 262.3 ft

d. 3.5 seconds and 63.4 ft

75. An object is dropped from the top of a building (no initial velocity). Assuming no air resistance (free fall), if it takes 2.5 seconds for this object to reach the ground, the height of the building is:

a. 225.7 ft

b. 100.6 ft

c. 58.2 ft

d. 75.8 ft

76. The kinetic energy of an object which has a mass of 100 kg and traveling with a speed of 10 meters per second is:

a. 1,000 joules

b. 5,000 joules

c. 100 joules

d. 500 joules

77. The kinetic energy of a 100 lbm object moving with a velocity of 10 ft/sec is:

a. 1,000 ft. lbf

b. 5,000 ft. lbf

c. 155 ft. lbf

d. 310 ft. lbf

78. A 20-foot long beam is inserted into a wall at point A. A force $F_1 = 2{,}000$ lb is exerted at the center of the beam. The value of force F_2 exerted at the end of the beam that would generate the same moment as force F_1 (around point A) is:

a. 1,000 lb

b. 200 lb

c. 4,000 lb

d. 20,000 lb

79. A 20-foot long beam is supported at both ends (points A and B). A force equal to 1,000 lb is applied to the beam 2 feet away from point A. Another 1,000 lb force is applied to the beam at 10 feet away from point A and another 1,000 lb force at 18 feet away from point A. The value of reaction force at point A is equal to:

a. 2,000 lb

b. 8,000 lb

c. 3,000 lb

d. 1,500 lb

80. A two-leg sling has a maximum operating tension of 2,500 lbs in each leg. The sling is used to hold a load of 4,000 lbs. What should the maximum angle of each leg with the vertical be to safely support this load?

a. 52.7 degrees

b. 12.9 degrees

c. 36.8 degrees

d. 49.6 degrees

81. A tackle consisting of two double blocks (four sheaves) is to be used to lift a weight of 2 tons. What should be the proper breaking strength of a manila rope to safely lift this load? (Use a factor safety of 10 and 10 percent friction per rope part.)

a. 18,000 lbs

b. 23,000 lbs

c. 28,000 lbs

d. 14,000 lbs

82. A conductor 10 ft long with a circular cross section having a diameter of 1/8 of an inch, and a resistivity of 5×10^{-3} ohm- inch has an electrical resistance equal to:

a. 83.2 ohms

b. 48.9 ohms

c. 72.6 ohms

d. 28.7 ohms

83. Three resistors $R_3 = 3$ ohms, $R_4 = 4$ ohms, and $R_5 = 6$ ohms are arranged in parallel. Two resistors $R_1 = 2$ ohms, and $R_2 = 5$ ohms are arranged in series and connected in series to the above parallel arrangement. All resistors can be replaced with a single resistor which has a resistance equal to:

a. 20.00 ohms

b. 13.67 ohms

c. 8.33 ohms

d. 0.05 ohms

84. Capacitors C_3 and C_4 with capacitances equal to 4 and 2 microfarad respectively are arranged in parallel. Capacitors C_1 and C_2 with capacitances equal to 5 and 2 microfarad respectively are arranged in series and connected to the above parallel arrangement. The equivalent capacitance for this circuit is: (Note: μF = microfarad)

a. 11.25 μF

b. 1.15 μF

c. 13.72 μF

d. 26.72 μF

85. Resistors $R_2 = 3$ ohms and $R_3 = 1$ ohm are arranged in parallel. This arrangement is connected to resistor $R_1 = 2$ ohms in series. The above arrangement is connected to a potential difference of 220 volts. The amount of power consumed by this electrical circuit is:

a. 17,600 watts

b. 34,200 watts

c. 9,763 watts

d. 23,562 watts

86. A population is normally distributed with a mean of 50 and a standard deviation of 10, the probability that a randomly selected variable from this population falls between 35 and 40 is:

a. 0.90

b. 0.09

c. 0.62

d. 0.12

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

87. For a population with a mean of 200 and a standard deviation of 30, the probability that a randomly selected variable assumes a value less than 250 is:

a. 95%

b. 86%

c. 72%

d. 65%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

88. A population has a mean of 500 and a standard deviation of 50. The probability that a randomly selected variable from this population has a larger than 600 is:

a. 6.72%

b. 9.80%

c. 2.28%

d. 7.53%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

89. A billiard ball moving at a constant velocity of 20 m/s hits another stationary billiard ball of the same mass. After the impact, the first ball slows down to 5 m/s. Assuming that the second ball moves in the same direction as the first ball and that the mass of each ball is 100 grams, what is the velocity of the second ball after impact? Ignore frictional forces.

a. 10 m/s

b. 15 m/s

c. 5 m/s

d. 12 m/s

90. Two above-ground cylindrical storage tanks are to be built on a rectangular area that has a length of 70 meters. The larger tank has a diameter of 20 meters and a height of 10 meters, and the smaller tank has a diameter of 5 meters and a height of 8 meters. The containment area must be designed in such a way to contain all of the liquid stored in the larger tank. Allow a factor of safety of 20% for rainfall. Assuming that the height of the containment is 2 meters, the width of the rectangular area is:

a. 45.3 m

b. 65.2 m

c. 31.7 m

d. 53.1 m

91. A cooling water pump on a reactor with an exothermic reaction has failed 6 times in the past 3 years. What is the probability that this pump would fail twice in the next 6 months?

a. 18.39%

b. 8.36%

c. 12.93%

d. 32.72%

92. Using the following table from 29 CFR 1926, which of the following is the acceptable size of cross braces for a trench in Type A soil 13 feet deep and 5 feet wide? The cross braces are to be spaced at 6 feet horizontally and 4 feet vertically.

a. 4×6

b. 4×4

c. 6×6

d. 6×8

Timber Trench Shoring—Minimum Timber Requirements							
Soil Type A							
P(a) = 25 × H + 72 psf (2-ft Surcharge)							
	Size (Actual) and Spacing of Members						
	Cross Braces						
	Horiz. Spacing (Ft)	Width of Trench (Feet)					Vert. Spacing (Ft)
Depth of Trench (Ft)		up to 4	up to 6	up to 9	up to 12	up to 15	
5 to 10	up to 6	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4
5 to 10	up to 8	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4
5 to 10	up to 10	4 × 6	4 × 6	4 × 6	6 × 6	6 × 6	4
5 to 10	up to 12	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	4
10 to 15	up to 6	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4
10 to 15	up to 8	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	4
10 to 15	up to 10	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4
10 to 15	up to 12	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4

93. Using the following table from 29 CFR 1926, which of the following is the acceptable size of cross braces for a trench in Type A soil 13 feet deep and 5 feet wide? The cross braces are to be spaced at 8 feet horizontally and 4 feet vertically.

a. 4 × 6

b. 4 × 4

c. 6 × 6

d. 6 × 8

Timber Trench Shoring—Minimum Timber Requirements							
Soil Type A							
P(a) = 25 × H + 72 psf (2-ft Surcharge)							
	Size (Actual) and Spacing of Members						
	Cross Braces						
	Horiz. Spacing (Ft)	Width of Trench (Feet)					Vert. Spacing (Ft)
Depth of Trench (Ft)		up to 4	up to 6	up to 9	up to 12	up to 15	
5 to 10	up to 6	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4
5 to 10	up to 8	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4
5 to 10	up to 10	4 × 6	4 × 6	4 × 6	6 × 6	6 × 6	4
5 to 10	up to 12	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	4
10 to 15	up to 6	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4
10 to 15	up to 8	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	4
10 to 15	up to 10	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4
10 to 15	up to 12	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4

94. The standard deviation for the following sample of x's is:

a. 2.674

b. 1.966

c. 3.147

d. 4.365

x_i	$x_i - \mu$	$(x_i - \mu)^2$
3	–1.33	1.77
5	0.67	0.45
2	–2.33	5.43
7	2.67	7.13
6	1.67	2.79
3	–1.33	1.77
$\mu = 4.33$		sum = 19.34

95. Which of the following statements is correct in regard to Avogadro's number?

    a. It is the number of atoms per gram mole of a substance.

    b. It is used in calculating the number of electrons to determine electrical current.

    c. It is used in Fick's Law for calculating diffusion through a membrane.

    d. It is used in calculating the number of atoms in a vapor and liquid phase that are at equilibrium.

96. Your company is planning to build a dike around a tank containing a hazardous chemical. The dike must be capable of containing 300,000 gallons and cannot exceed 3 ft in depth and 150 ft in length. The width of this dike is:

    a. 109 ft

    b. 160 ft

    c. 59 ft

    d. 89 ft

97. A rectangular cement block 4 ft × 4 ft × 10 ft is dropped into a cylindrical tank containing water. The tank diameter is 15 ft and its height is 30 ft. The tank is half full prior to dropping the cement block in it. The height of water in the tank after the cement block has been dropped is:

    a. 4.5 ft

    b. 8.2 ft

    c. 32.1 ft

    d. 15.9 ft

98. The 2 g-force for an object weighing 300 lbs is:

    a. 600 lbs

    b. 800 lbs

    c. 900 lbs

    d. 150 lbs

99. *Flocculation* is the process wherein colloids come out of suspension in the form of floc or flake, either spontaneously or due to the addition of a clarifying agent. Which of the following statements BEST describes the difference between flocculation and precipitation?

    a. Prior to flocculation, the colloids are suspended in a liquid. However, prior to precipitation, the colloids are actually dissolved in a solution.

    b. Flocculation takes place first, followed by precipitation.

    c. Flocculation takes place by attractive and repulsive electrical forces while precipitation takes place by gravity.

    d. Precipitation must be followed by filtration, while flocculation is always followed by a dewatering process.

100. The probability of getting a head in one flip of a coin is:

    a. 0.2

    b. 0.5

    c. 0.6

    d. 0.7

101. The probability of drawing an ace of hearts or a king of spades or a 4 of diamonds from a 52 deck of cards is:

    a. 10%

    b. 5%

    c. 15%

    d. 20%

102. What is the probability that two cards drawn from two separate decks of cards are both aces?

    a. 6%

    b. 0.6%

    c. 8%

    d. 0.8%

103. What is the probability of tossing a coin 4 times and getting 4 tails in a row?

    a. 6%

    b. 16%

    c. 8%

    d. 10%

104. During a given calendar quarter a facility had 15 accidents of which 5 resulted in lost time from work. What is the probability that the next accident is a lost time injury accident?

a. 15%

b. 33.3%

c. 66.6%

d. 25%

105. A game of chance consists of flipping a coin and rolling a pair of dice. What is the probability of getting a tail on the coin and a pair of 2 on the dice?

a. $\frac{1}{2}$

b. $\frac{1}{36}$

c. $\frac{1}{18}$

d. $\frac{1}{72}$

106. If we draw one card from two separate decks of cards (total of two cards), what is the probability that both cards would be an ace of hearts?

a. 3.6×10^{-4}

b. 2.6×10^{-3}

c. 5.2×10^{-4}

d. 6.8×10^{-3}

107. Getting a 3 and 6 on one roll of a pair of dice is considered to be an occurrence of:

a. Mutually inclusive events

b. Rational events

c. Mutually exclusive events

d. Mutually contradicting events

108. A game of chance consists of tossing a coin and rolling a die. What is the probability of getting the event (tail, 3)? i.e. a 3 on the die and a tail on the coin?

a. $\frac{3}{6}$

b. $\frac{1}{12}$

c. $\frac{2}{36}$

d. $\frac{3}{24}$

109. A box contains 15 red balls and 12 white balls. What is the probability of picking a red ball on two consecutive draws from the box? Assume that the first ball is not replaced back into the box.

a. 0.299

b. 0.467

c. 0.162

d. 0.568

110. The passageways by which air passes through the nose or mouth to the "alveoli" of the lungs which allows the oxygen to pass freely through the membrane is called:

a. Conducting zone

b. Cartilage

c. Bronchioles

d. Respiratory glands

111. When the route of entry of a chemical into the body is through the skin, one way of expressing dose-response relationship is:

a. LC_{50}

b. LD_{50}

c. LI_{50}

d. All of the above

112. Which of the following is the best description of "histograms"?

a. They display frequency distribution

b. They are the same as normal probability distribution

c. They are also called "bar charts"

d. The area enclosed by the graph represents the probability of an event.

113. All organic compounds have one or more atoms of:

a. Nitrogen

b. Oxygen

c. Carbon

d. Halogen

114. The value that appears most often in a data set is called:

a. Mean

b. Median

c. Range

d. Mode

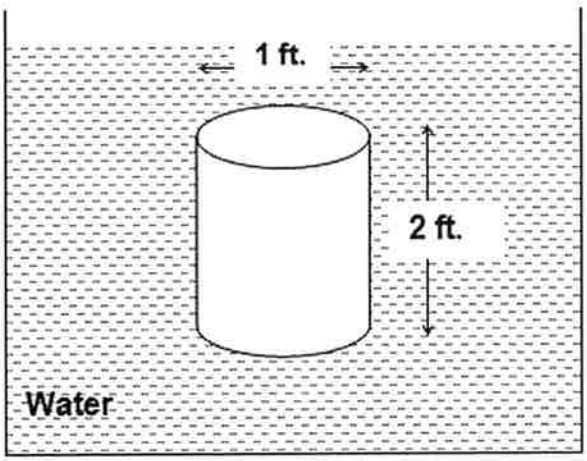
115. A cylindrical object having a diameter of 1 foot and a length of 2 feet is completely submerged in water, which has a density of 62.4 lbm/ft^3. The buoyant force exerted on this object is:

a. 154.2 lb

b. 97.97 lb

c. 45.63 lb

d. 62.4 lb



116. A block and tackle consisting of four rope section is used to lift a load which has a mass of 100 kg. The amount of force required to lift the load ignoring frictional losses is:

a. 245 newtons

b. 25 newtons

c. 980 newtons

d. 100 newtons

117. The number of rope sections in a block and tackle system which requires a 25 dynes force to lift a weight of 200 dynes is equal to:

a. 4

b. 8

c. 6

d. 2

118. Which of the following statements is correct about the Coefficient of Variation (CV)?

a. CV is a measure of how the dependent variable can be plotted against independent variable.

b. CV is used to determine the slope of linear data.

c. CV determines type I error for a set of measured data.

d. CV is a measure of relative variability of a set of data.

119. Which of the following statements is correct regarding nanotechnologies?

a. Nanotechnologies are new approaches to research and development that aim to control the fundamental structure and behavior of matter at the level of atoms and molecules.

b. They offer the possibility of furthering our understanding of phenomena at the atomic level.

c. Nanotechnologies make possible the development of materials and devices with novel properties, functions and performance.

d. All the above.

120. Waterborne pathogens can be divided into three main categories. Which of the following does not belong to these categories?

a. Viruses

b. Bacteria

c. Parasite

d. Mold

121. Which of the following is not among several ways to prevent diseases caused by waterborne pathogens?

a. Use good environmental management.

b. Take sufficient amount of vitamin D3.

c. Practice good personal hygiene.

d. Take food safety precautions to learn about the fundamentals of food safety.

122. Which of the following is not an example of bloodborne pathogens?

a. Malaria

b. Syphilis

c. Brucellosis

d. Cancer

123. Which of the following is not among different ways that bloodborne pathogens can be transmitted?

a. Needle stick

b. Broken skin

c. Inhalation

d. Infected body fluids

124. Which of the following enforces the bloodborne pathogens standard?

a. Center for disease control

b. OSHA

c. Department of Health and Human Services

d. EPA under Toxic Substances Control Act (TSCA)

1.9 Example Answers

1. Select (d)

   400°K - 273 = 127°C

   $\frac{F-32}{1.8} = 127$

   F = 260.6°F

2. Select (a)

   900°R - 460 = 440°F

   $\frac{F-32}{1.8} = C$

   $\frac{440-32}{1.8} = 226.6°C$

3. Select (c)

   Number of atoms of carbon in the reactant is 6 and the product is 24.

4. Select (a)

   $\frac{p_2V_2}{p_1V_1} = \frac{T_2}{T_1}$

   $V_2 = V_1\left(\frac{p_1}{p_2}\right)\left(\frac{T_2}{T_1}\right)$

   $V_2 = \frac{20\ \text{ft}^3|1.00\ \text{atm}|1070°\text{R}}{|2.50\ \text{atm}|530°\text{R}} = 16.15\ \text{ft}^3$

5. Select (b)

   $P_sV_s = n_sRT_s$

   $V_s = \frac{n_sRT_s}{P_s}$

   $V_s = \frac{1\ \text{lb-mole}(0.7302\text{ft}^3\times\text{atm})492°\text{R}}{1\ \text{atm(lb-mole°R)}} = 359\ \text{ft}^3$

6. Select (b)

   Pound moles of methane = $\frac{32}{16} = 2$

   Pound moles of hydrogen = $\frac{6}{2} = 3$

   Pound moles of carbon dioxide = $\frac{44}{44} = 1$

   Total number of moles = 2 + 3 + 1 = 6

   Mole fraction of hydrogen = $\frac{3}{6} = 0.5$

7. Select (a)

   We note that the sum of mole fractions of components of a mixture must be equal to 1.

   Mole fraction of helium = 1 - 0.3 - 0.4 = 0.3

Partial pressure of helium = (2,000) (0.3) = 600 psig

Note: See definition of partial pressure in the text.

8. Select (d)

   Absorption is the incorporation of a substance in one state into another of a different state (for example, a liquid being absorbed by a solid). Adsorption is the physical adherence or bonding of ions onto the surface of another phase (for example, reagents adsorbed to a solid catalyst surface). Ion exchange is an exchange of ions between two electrolytes or between an electrolyte solution and a complex.

9. Select (b)

   Anions are negatively charged and are rejected by the cathode, which is also negatively charged. Cations, which are positively charged, are attracted by the cathode.

   On the other hand, the anode in an electric cell is positively charged and accepts anions or negatively charged particles. This concept is widely used in electroplating, where positively charged metal ions migrate from anode to cathode and cover the cathode.

10. Select (c)

    See description in text.

11. Select (a)

    See description in text.

12. Select (d)

    See description in text.

13. Select (d)

    See description in text.

14. Select (a)

    See description in text.

15. Select (b)

    See description in text.

16. Select (b)

    See description in text.

17. Select (c)

    Statements (a) and (b) refer to *bioaccumulation.*

18. Select (c)

    Epidemiology is the cornerstone of public health. It identifies the risk factors for disease and targets for preventive medicine.

19. Select (c)

First we have to find the normal force exerted on the surface. Since the box is resting on a horizontal surface, this force is equal to the weight of the box. We use Newton's second law of motion to find the weight of the box:

$F = m\frac{g}{g_c}$

Where:

F = force (weight)

m = mass of the box

g = acceleration of gravity (9.8 meters per second squared)

g_c = 1 (because we are working in the metric system).

$F = \frac{(100)(9.8)}{1} = 980$ Newtons

To calculate the frictional force between the box and surface, we use:

$F = \mu N$

F = (0.3)(980) = 294 newtons.

In order to put this box in motion, we have to exert a force that exceeds the frictional forces.

20. Select (c)

In order to find the acceleration of the box, we use Newton's second law of motion:

$F = \frac{ma}{g_c}$

g_c = 1 (metric system)

In the above equation F is the resultant force. For the problem at hand F is the force exerted on the box (350 newtons) minus the frictional forces (294 newtons) that oppose the motion of the box.

F = 350 - 294 = 56 newtons

$56 = (100)(\alpha)$

$\alpha = 0.56\frac{\text{meters}}{\text{second}^2}$

21. Select (d)

$s = 1/2\ \alpha t^2$

s = 1/2 (0.56)(100)

s = 28 meters

22. Select (c)

$V^2 - V_0{}^2 = 2\alpha s$

$V^2 = 2\ (0.56)\ (28)$

$V^2 = 31.36$

$V = 5.6$ m/sec.

23. Select (b)

$F = m\frac{g}{g_c}$

g = acceleration of gravity = 32.2 ft/sec^2

g_c = 32.2 (American Engineering System)

$200 = m\frac{32.2}{32.2}$

m = 200 lbm

24. Select (b)

The force required to set the box in motion up the inclined surface must just overcome the frictional forces on the inclined surface (Ff), and the component of weight of the box on the inclined surface.

The component of frictional force on the inclined surface is:

$F_f = (0.4)\ (300) \cos 15$

$F_f = 115.9$ lb

The component of weight of the box on the inclined surface is

$(300) \sin (15) = 77.6$ lb

$77.6 + 115.9 = 193.5$

The force that would put the box up the inclined surface must exceed 193 lb.

25. Select (a)

The frictional forces (F_f) must exceed the component of the weight of the object on the inclined surface (600 sin 15).

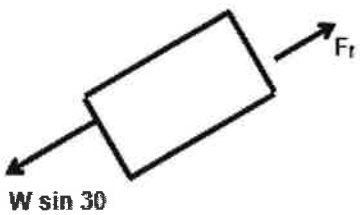
Frictional forces = $\mu\ (600) \cos 30$

Weight component = $(600) \sin 30 = 300$ lbs

$300 = \mu\ (600) \cos 30$

$\mu = 0.577$

26. Select (b)



The resultant force on the object is the difference between the weight component of force and the frictional forces (F_F) on the inclined surface:

$F_f = (0.2)\ (600) \cos 30\ F_f = 104$ lbs.

The weight component of the object acting downward is:

$(600) \sin 30 = 300$ lbs.

The resultant force on the object is $300 - 104 = 196$ lbs.

Using Newton's second law of motion

$F = \frac{m\alpha}{g_c}$

The force generates an acceleration equal to:

$\alpha = \frac{Fg_c}{m}$

$\alpha = \frac{(196)(32.2)}{600\text{lbs}} = 10.5 \frac{\text{ft}}{\text{sec}^2}$

The relationship between distance, time, and acceleration is

$s = ½\ \alpha t^2 + V_0 t\ s = ½\ (10.5)\ (1)\ s = 5.25$ ft.

Also note that in metric system the value of gc is 1 while in the American Engineering System the value of

$g_c = 32.2 \frac{\text{ft} \times \text{lbm}}{\text{lbf} \times \text{sec}^2}$

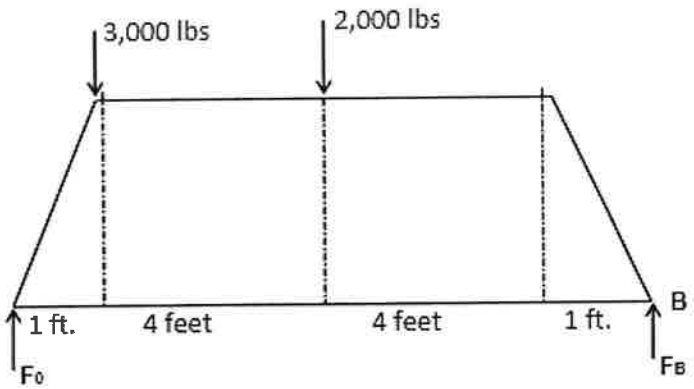
27. Select (b)

$V^2 - V_0^2 = 2\ \alpha s$

$V^2 - 0 = 2\ (10.5)\ (20)$

$V = 20.5$ ft/sec

28. Select (a)

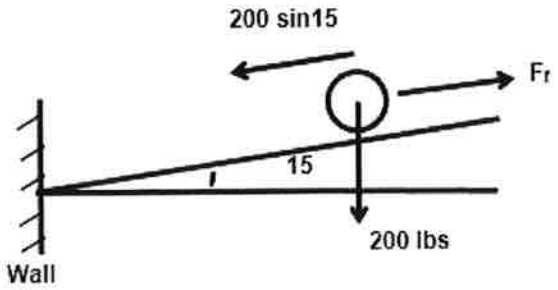


Because the truss system is at equilibrium (that is, no motion or rotation), the sum of moments taken around point B must equal zero. Note that moment around a given point is force multiplied by the distance. For the problem at hand we can write:

(3,000) (9) + (2,000) (5) – F_0 (10) = 0 F_0 = 3,700 lbf

Also note that because the direction of force F0 is opposite to the other forces, the moment that F0 generates around point B is also opposite to the moment generated by the other forces. That is why we used a negative sign for the moment generated by F0 around point B.

29. Select (d)



F_f = (200) (0.1) cos 15 = 19 lbs. (component of frictional force)

(200) sin 15 = 52 (component of worker's weight)

52 – 19 = 33 net force on the worker. Using Newton's 2nd law:

$F = \frac{ma}{g_c}$

$33 = \frac{200a}{32.2}$

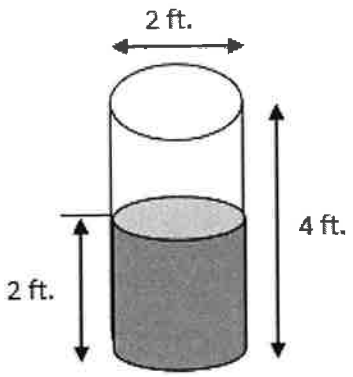
$a = 5.3$ ft/sec^2

$V^2 - V_0^2 = 2\ as$

$V^2 - 0 = 2(5.3)(10)$

$V = 10.3$ ft/sec

30. Select (c)



First we have to find the volume of the cylindrical drum:

volume = π R^2 H

where R is the radius and H is the height of the cylinder

volume = (3.14) $(1)^2$ (4) = 12.56 ft^3

volume of liquid inside the drum = $\frac{12.56}{2}$ = 6.28ft^3

Mass = (density) (volume)

Mass of liquid = (60) (6.28) = 376.8 lbm

$W = \frac{mg}{g_c}$

$W = \frac{(376.8)(32.2)}{32.2}$

W = 376.8 lbf

31. Select (a)

The vertical component of force in each leg of the sling is

F_v cos 45

Since the system is stationary, the sum of all forces in the vertical direction must add up to zero.

5,000 - $2F_v$ cos 45 = 0

F_v = 3,535 lbs.

32. Select (b)

10,000 - 2(7,000) cos α = 0

cos $\alpha = \frac{10{,}000}{14{,}000}$

α = 44 degrees

33. Select (d)

The sum of all the vertical forces must be equal to zero for equilibrium to be maintained.

W - 2 (3,000) cos 45 = 0

W = 4,242 lbs.

34. Select (b)

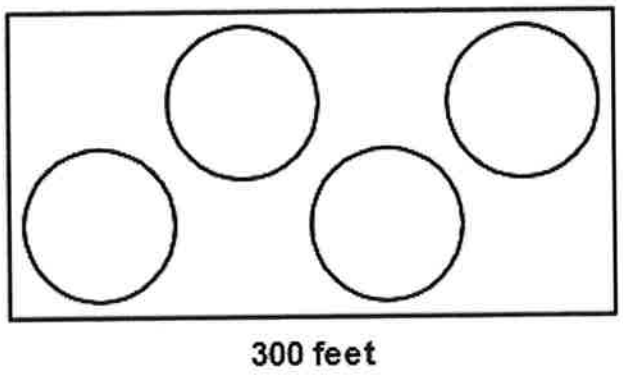
$V = \frac{\pi D^2 L}{4} = \frac{(3.14)(400)(30)}{4}$

V = 9,420ft^3

9,420$ft^3 \times \frac{(12)^3 in^3}{1 ft^3} \times \frac{1 \text{ liter}}{61.02 in^3}$

V = 266,761 liters.

35. Select (a)



The area not occupied by the tanks is equal to the total area of the land minus the area covered by the base of the cylindrical tanks.

Total area $= 50 \times 300 = 15{,}000$ ft^2

Area occupied by tanks $= 4 \times \frac{(3.14)(400)}{4}$

15,000 - (3.14) (400) = 13,744 ft^2

36. Select (b)

The continuity equation states that the volumetric flow rate in sections 1 and 2 are equal:

$Q_1 = V_1A_1$ $Q_2 = V_2A_2 = 200$ ft^3/min

Where:

Q = volumetric flow rate

V = velocity

A = area of flow

$A_1 = \frac{\pi D^2}{4} = \frac{(3.14)(1)^2}{4} = 0.785\text{in}^2$

Convert area (A_1) to ft^2

$0.785\text{in}^2 = \frac{1\text{ft}^2}{144\text{in}^2} = \frac{0.785}{144}\text{ft}^2$

$Q_1 = 200 = V_1A_1$

$200 = V_1\frac{0.785}{144}$

$V_1 = 36{,}687$ ft / min

$V_1 = 36{,}687$ ft/min $\times \frac{1 \text{ min}}{60 \text{ seconds}}$

$V_1 = 611$ ft/sec

37. Select (c)

$P = d_{\text{water}}\frac{g}{g_c}h_{\text{water}} + d_{\text{oil}}\frac{g}{g_c}h_{\text{oil}}$

$P = 62\frac{32.2}{32.2}(14) + (0.7)(62)\frac{32.2}{32.2}(10)$

$P = 1{,}302\frac{\text{lbf}}{\text{ft}^2} \times \frac{1\text{ft}^2}{144\text{in}^2}$

P = 9 psi

Where:

P = pressure

d = density

g = acceleration of gravity (32.2 ft/sec^2)

g_c = 32.2 in American Engineering System and 1 in metric system

h = the height of liquid

Note that density of oil is obtained by multiplying its specific gravity by the density of water.

38. Select (b)

Since the tank contains water to a height of 15 ft., the pressure at the bottom of the tank is 15ft. of water.

39. Select (d)

Total volume of liquid = 100 × 55 = 5,500 gallons

From conversion tables, each 7.4805 gallons is 1 ft^3

The volume of liquid in ft^3 = $\frac{5500}{7.4805}$ = 735 ft^3

The volume of the containment berm must be at least 735 ft^3

(depth) (80) (4) = 735

Depth = 2.3 ft.

40. Select (b)

First we replace resistors R_2, R_3, R_4, and R_5 that are connected in parallel with a single resistor R_6.

$\frac{1}{R_6} = \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$

$\frac{1}{R_6} = \frac{1}{20} + \frac{1}{30} + \frac{1}{40} + \frac{1}{50}$

$R_6 = 7.79\ ohms$

Now, resistors R_1 and R_6 are connected in series, but we must first calculate the value of resistor R_1 from the following equation

$R_1 = \rho\frac{L}{A}$

Where: R_1 is the resistance in ohms, ρ is the resistivity, L is the length of the resistor, and A is its cross sectional area.

$R_1 = 20\frac{1\times4}{3.15(0.25)^2}$

$R_1 = 407.6$ ohms

Now we replace the resistors R_1 and R_6 which are connected in series with a single resistor R_7:

$R_7 = R_6 + R_1$

$R_7 = 407.6 + 7.8$

$R_7 = 415$ ohms.

Capacitors C_2 and C_3 are connected in parallel; we replace them with a single capacitor C_4:

$C_4 = C_2 + C_3$

$C_4 = 15 + 20 = 35$ microfarads.

Now capacitors C_4 and C_1 are connected in series; we replace them with a single capacitor C_5:

$\frac{1}{C_5} = \frac{1}{C_1} + \frac{1}{C_4}$

$\frac{1}{C_5} = \frac{1}{8} + \frac{1}{35}$

$C_5 = 6.5$ microfarads

The circuit can be replaced with a single resistor of 415 ohms and a single capacitor of 6.5 microfarads.

41. Select (c)

Replace resistors R_3 and R_4 which are connected in parallel with a single resistor R_6

$\frac{1}{R_6} = \frac{1}{R_3} + \frac{1}{R_4}$

$\frac{1}{R_6} = \frac{1}{20} + \frac{1}{25}$

$R_6 = 11.11$ ohms

replace resistors R_1, R_2, R_6, and R_5 which are connected in series with a single resistor R_7.

$R_7 = R_1 + R_2 + R_6 + R_5$

$R_7 = 10 + 15 + 11.11 + 30 = 66.11$ ohms

$V = RI$ (Ohm's law)

Where V is the potential difference in volts, R is the resistance in ohms, and I is the current in amperes.

$220 = (66.11)I$

$I = 3.3$ amperes

Since the resistors are connected in series, the same current of 3.3 amperes flows through all of them. The amount of power consumed by resistor R_1 can be calculated from the following equation:

$P = R_1 I^2$

$P = 10\ (3.3)^2$

$P = 109$ watts.

42. Select (c)

We use Ohm's law:

$V = RI$

$V = (10)\ (3.3) = 33$ volts.

43. Select (d)

$V = RI$

$220 = 66.11I$

$I = 3.3$ amperes

44. Select (a)

$V = RI$

$36.66 = 20I$

$I = 1.833$ amperes

45. Select (d)

The three parallel capacitors can be replaced with a single capacitor C_1:

$C_1 = 8 + 16 + 20 = 44$ microfarads.

The equivalent capacitor is:

$\frac{1}{C} = \frac{1}{5} + \frac{1}{10} + \frac{1}{44}$

$C = 3$ microfarads.

46. Select (b)

$R = \rho \frac{L}{A}$

$A = \frac{3.14(0.25)^2}{4 \times 144} = 3.4 \times 10^{-4} \text{ft}^2$

$100 = \rho \frac{100}{3.4 \times 10^{-4}}$

$\rho = 3.4 \times 10^{-4}$ ft-ohms

47. Select (b)

First we get the equivalent resistor R_2 for the parallel circuit:

$\frac{1}{R_2} = \frac{1}{10} + \frac{1}{20}$

$R_2 = 6.66$

The total resistance of the circuit is:

$R_1 + 6.66$

$V = (R_1 + 6.66)\ (I)$

$220 = (R_1 + 6.66)\ (1)$

$R_1 = 213.3$ ohms.

48. Select (d)

First we calculate the resistance of the copper wire

$R = \rho \frac{L}{A}$

$R = 0.9989 \times 10^{-5} \frac{10{,}000 \text{ ft}}{1.44 \text{ in}^2} \times \frac{144 \text{ in}^2}{1 \text{ ft}^2}$

$R = 9.989$ ohms

Next, we calculate the amount of current flow using Ohm's law:

$V = R\ I$

$500 = (9.989)I$

$I = 50.05$ amperes

Power can be calculated from $P = VI$ or $P = RI^2$

$P = (500)\ (50.05) = 25{,}027$ watts $= 25$ kilowatts

or

$P = (9.989)\ (50.05)^2 = 25$ kilowatts.

49. Select (b)

The resistance is the same, i.e. $R = 9.989$ ohms.

The current flow is $V = RI$

$1{,}000 = (9.989)\ (I)$

$I = 100$ amperes (approximately)

$P = VI$

$P = (100)\ (1{,}000) = 100{,}000$ watts $= 100$ kilowatts.

It is interesting to note that when the potential difference is doubled, the power consumption has increased by a factor of four.

50. Select (d)

The power consumption in a circuit can be calculated from

$P = VI = RI^2$

First calculate the current flow:

$V_1 = RI_1$

$I_1 = \frac{V_1}{R}$

$I_2 = \frac{V_2}{R} = \frac{3V_1}{R}$

$P_1 = RI_1^2 = R\frac{V_1^2}{R^2} = \frac{V_1^2}{R}$

$P_2 = RI_2^2 = R\frac{V_2^2}{R^2} = \frac{9V_1^2}{R}$

divide:

$\frac{P_2}{P_1} = \frac{9V_1^2}{V_1^2} = 9$

The power consumption in the circuit will increase by a factor of 9.

51. Select (c)

The current flow through the worker's body must be calculated and be compared to the values given in the table. Use Ohm's law

$V = RI$

$I = \frac{110 \times 1000}{70{,}000} = 1.57$ milliamperes (1 ampere = 1000 milliamperes)

The worker would most likely experience a mild shock.

52. Select (b)

First we calculate the current flow through this device.

$P = VI$

$I = \frac{500}{110} = 4.5$ amperes

The resistance can be calculated from:

$P = RI^2$

$500 = R\ (4.5)^2$

$R = 24$ ohms

53. Select (c)

Pre-braking distance:

$60 \frac{\text{miles}}{\text{hr.}} \times \frac{5280 \text{ feet}}{1 \text{ mile}} \times \frac{1 \text{ hr}}{3600 \text{ seconds}}$

= 88 feet in one second.

The braking distance:

$S = \frac{V^2}{(30)K}$

$S = \frac{(60)^2}{(30)(0.75)} = 160$ feet

total distance = pre-braking distance + braking distance

total distance = 88 + 160 = 248 feet

54. Select (b)

Illumination intensity follows the inverse square law $\mathbf{I_1 D_1^2 = I_2 D_2^2}$ where I_1, I_2 are light intensity at distances D_1 and D_2 from the source respectively.

$D_1^2 \times 4 = 1 \times 2^2$

$D_1 = 1$ ft.

55. Select (c)

$V^2 - V_0^2 = 2gs$

Where V is the final velocity, V_0, is the initial velocity, g is the acceleration of gravity = 32.2 ft/sec^2 and s is the distance traveled.

$V^2 = 2(32.2) \times 20$

$V = 35.9$ ft/sec

56. Select (b)

$Z_{18} = \frac{18-20}{4} = -0.5$

From the table below: area for Z equal to 0.5 is 0.1915. This is the area between Z = 0 and Z_{18}. However, due to symmetry, this is also the area between Z = 0 and Z_{18} = – 0.5. Therefore, The probability that a randomly selected value from the population has a value of less than 18 is 0.5 minus 0.1915, which is equal to 0.3085 or approximately 30 percent.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

57. Select (a)

The mean has a Z value equal to zero:

$Z = \frac{\mu - \mu}{\sigma} = 0$

From the table below, the area for $Z_0 = 0.0$ and the area for $Z_2 = 0.4772$. Therefore, the probability that Z has a value between 0 and 2 is 0.4772.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

58. Select (c)

$Z_{25} = \frac{25-30}{4} = \frac{-5}{4} = -1.25$

Area $= 0.3944$

$Z_{32} = \frac{32-30}{4} = \frac{2}{4} = 0.5$

Area $= 0.1915$

(For areas, see the table below.)

The probability for a value to fall between 25 and 32 is:

$0.3944 + 0.1915 = 0.5859$ or 58 percent.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

59. Select (d)

$Z_{16} = \frac{16-18}{3} = -0.666$

Area for Z = – 0.66 is equal to 0.2454 which means approximately 25% of midsize cars obtain less than 16 miles per gallon of gasoline (0.5 – 0.2454). Areas are obtained from the table below.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

60. Select (b)

$Z_{81} = \frac{81-75}{4} = \frac{6}{4} = 1.5$

Area for Z = 1.50 is equal to 0.4332, percentage of people with a score of 81 or better is 0.5 – 0.4332 = 0.068 or 6.8 %. Areas are obtained from the table below.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

61. Select (b)

First, we have to calculate the sample mean, and the sample standard deviation:

$\bar{X} = \frac{46+61+52+48+57+54}{6} = 53$

S = 5.59

null hypothesis: H_0; $\mu = 50$

alternative hypothesis H_a; $\mu > 50$

t statistic = $\frac{\bar{X}-\mu}{S/\sqrt{N}}$

$t = \frac{53-50}{5.59/\sqrt{6}} = 1.31$

The rejection region for P = 0.95 and N = 5 from Table 4 is 2.015.

Since the calculated value of t (1.31) does not fall in the rejection region, we can not reject the null hypothesis. In other words, we can not say with 95% confidence that the average volume of bottles is more than 50 ounces.

Sample Size (N)	Confidence Level (P)			
	0.750	**0.900**	**0.950**	**0.990**
1	1.000	3.078	6.314	31.821
2	0.816	1.886	2.920	6.965
3	0.765	1.638	2.353	4.541
4	0.741	1.533	2.132	3.747
5	0.727	1.476	2.015	3.365
6	0.718	1.440	1.943	3.143
7	0.711	1.415	1.895	2.998
8	0.706	1.397	1.860	2.896
9	0.703	1.383	1.833	2.821
10	0.700	1.372	1.812	2.764
15	0.691	1.341	1.753	2.602
20	0.687	1.325	1.725	2.528
25	0.684	1.316	1.708	2.485
30	0.683	1.310	1.697	2.457
∞	0.674	1.282	1.645	2.326

62. Select (b)

H_0:$\mu = \mu_0$ or $\mu = 0.30$ inches

H_α:$\mu > \mu_0$ or $\mu > 0.30$ inches

Calculate mean and standard deviation for the sample:

$\bar{X} = \frac{0.28+0.34+0.31+0.27+0.31+0.29}{6}$

$\bar{X} = 0.30$

$S = \sqrt{\frac{(0.02)^2+(0.04)^2+(0.01)^2+(0.03)^2+(0.01)^2+(0.01)^2}{6-1}}$

S = 0.025

$t = \frac{0.30-0.30}{0.025/\sqrt{6}}$

The rejection region for P = 0.95, N = 5 from Table 4 is 2.015. Since the calculated value of t (0) is less than the value from table, we can not reject the null hypothesis. This means that we can not say with 95% confidence that the average diameter of all rings produced by this machine is more than 0.30 inches.

Sample Size (N)	Confidence Level (P)			
	0.750	**0.900**	**0.950**	**0.990**
1	1.000	3.078	6.314	31.821
2	0.816	1.886	2.920	6.965
3	0.765	1.638	2.353	4.541
4	0.741	1.533	2.132	3.747
5	0.727	1.476	2.015	3.365
6	0.718	1.440	1.943	3.143
7	0.711	1.415	1.895	2.998
8	0.706	1.397	1.860	2.896
9	0.703	1.383	1.833	2.821
10	0.700	1.372	1.812	2.764
15	0.691	1.341	1.753	2.602
20	0.687	1.325	1.725	2.528
25	0.684	1.316	1.708	2.485
30	0.683	1.310	1.697	2.457
∞	0.674	1.282	1.645	2.326

63. Select (c)

The formulas for series and parallel arrangements of inductances are:

$L_{\text{series}} = L_1 + L_2 + \cdots + L_R$

$\frac{1}{L_{\text{parallel}}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}$

Where:

L_{series} and L_{parallel} are equivalent inductances. For the problem at hand first replace the parallel inductances with an equivalent inductance which becomes in series in arrangement with L3. Inductance is expressed in units of Henry.

$\frac{1}{L_4} = \frac{1}{15} + \frac{1}{30}$

$L_4 = 10$

$L = 10 + 5 = 15$ mH

64. Select (a)

The formula for momentum is:

$P = mV$

Where:

P is momentum

m is mass

V is velocity

For the problem at hand we have:

$P = mV$

$P = 10 \times 10 = 100$ lb-ft/sec

65. Select (b)

$P = mV$

$V = \frac{P}{m} = \frac{2000}{100} = 20$ ft/sec

66. Select (b)

The relationship between stress (force per unit area), area, and force is:

$$\boxed{\frac{P}{A} = \sigma}$$

where:

σ = stress

P = load

A = cross sectional area

For the problem at hand, we have:

P = 6,000 lbs

$A = \frac{\pi d^2}{4} = \frac{\pi(6)^2}{4 \times 144} = 0.1962$ ft^2

$\sigma = \frac{6000}{0.1962} = 30{,}573$ psf or $\sigma = \frac{30{,}573}{144} = 212$ psi

67. Select (d)

$\frac{P}{A} = \sigma$

$P = A\sigma$

$P = (4 \times 8)(40)$

P = 1,280 lbs

68. Select (c)

$\frac{P}{A} = \sigma$

$A = \frac{P}{\sigma} = \frac{2000}{50} = 40$ in^2

$A = \frac{\pi D^2}{4}$

$D^2 = \frac{4A}{\pi}$

$D = \sqrt{4A/\pi} = \sqrt{\frac{4 \times 40}{\pi}} = 7.13$ inches

69. Select (b)

The relationship between height of fluid, density, and pressure is:

$$\boxed{h_p = \frac{P}{W}}$$

h_p is the height of fluid

P is the hydrostatic pressure

W is the density

For the problem at hand, we have:

W = 90 lbm/ft^3

P = 30 psi

$h_p = \frac{30 \times 144}{90} = 48$ ft

Volume = area × height

volume $= \frac{\pi D^2}{4} \times 48 = \frac{\pi \times 10^2}{4} \times 48$

Volume = 3,768 ft^3

70. Select (d)

$h_p = \frac{P}{W}$

$P = h_p W$

P = 10 × 70 = 700 psf

$P = \frac{700}{144} = 4.86$ psi

71. Select (c)

$h_p = \frac{P}{W}$

$W = \frac{P}{h_p}$

P = 3 × 144 = 432 psf

$W = \frac{432}{15} = 28.8$ lbm/ft^3

72. Select (a)

The relationship between potential energy and spring deflection is

$$\boxed{\text{P.E.} = \frac{Kx^2}{2}}$$

where:

P.E. is potential energy

x is distance spring is deflected from its equilibrium position

K is spring constant which has units of force divided by distance

For the problem at hand

P.E. $= \frac{(1500)(2)^2}{2} = 3,000$ lbf/in

73. Select (c)

Newton's Second Law of Motion states that the resultant force in a given direction is equal to the mass of the object multiplied by its acceleration. In this case, the resultant force is:

1,000 lbf – frictional forces

F = 1,000 – (0.3)(100) = 970 lbf

$F = \frac{ma}{g_c}$

$970 = \frac{(100)\alpha}{32.2}$

$\alpha = 312$ ft./sec.^{2}

Note: Since we are working in the American Engineering System, the numerical value of force and mass are equal. In other words, an object having weight of 100 lbf has a mass of 100 lbm.

Also, we have to use

$g_c = 32.2$ because we work in the American Engineering System.

74. Select (a)

First we list all known and unknown values

$V_0 = 65$ miles/hr

V = 0 (car comes to a complete stop)

$\alpha = -10$ ft./sec.^{2}

t = ?

s = ?

We can use the following equation to find the time (t) for the car to come to a complete stop:

$V = V_0 + \alpha t$

Before we can use the above equation, however, we must convert 65 miles per hour to feet per second to achieve consistency of units.

$65 \frac{miles}{hr.} \times \frac{5280 \text{ ft}}{1 \text{ mile}} \times \frac{1 \text{ hr}}{3600 \text{ sec.}}$

$V_0 = 95.33$ ft./sec.

$V = V_0 + \alpha t$

$0 = 95.33 - 10\ t$

$t = 9.5$ sec.

Note: Because the car is decelerating (not accelerating), we used –10 in the above equation.

In order to find the distance traveled by the car, we use the following equation:

$V^2 = V_0{}^2 + 2\alpha s$

$0 = (95.33)^2 + 2\ (-10)s$

$s = 454.2$ ft.

75. Select (b)

$s = V_0 t + 1/2\ g\ t^2$

$s = 0 + 1/2\ (32.2)(2.5)^2$

$s = 100.6$ ft.

76. Select (b)

$\text{K.E.} = \frac{mV^2}{2g_c}$

$\text{K.E.} = \frac{(100)(10)^2}{2(1)}$

K.E. = 5,000 joules

Note: unit of energy is "joule" when mass is expressed in kilograms and velocity in meters per second. Because we are working in the metric system of units, the value of $g_c = 1$.

77. Select (c)

$\text{K.E.} = \frac{mV^2}{2g_c}$

$\text{K.E.} = \frac{(100)(10)^2}{2(32.2)}$

K.E. = 155 ft. × lbf

Note: the value of g_c is 32.2 because we are working in the American Engineering System of units.

78. Select (a)

$F_1 d_1 = F_2 d_2$

$(2{,}000)(10) = F_2(20)$

$F_2 = 1{,}000$ lbs.

79. Select (d)

The sum of moments generated by all forces at points A and B must add to zero because the system is stationary (not rotating). Let's calculate the moment generated at point B.

$1{,}000(2) + 1{,}000\ (10) + 1{,}000\ (18) - R_A(20) = 0.$

$R_A = 1{,}500$ lbf.

Note: Since the direction of reaction force R_A is opposite to all three 1,000 lbf forces, the moments generated around point B must also be opposite to each other. That is why we used a negative value for the moment generated by R_A at point B.

In order to find the reaction force at point B, we note that the sum of moments generated at point A must add to zero.

$1{,}000(2) + 1{,}000(10) + 1{,}000(18) - R_B(20) = 0$

$R_B = 1{,}500$ lbf.

This result is expected due to the symmetrical nature of this problem.

80. Select (c)

$F_v - 2F_1 \cos \alpha = 0$

$4{,}000 - 2(2{,}500) \cos \alpha = 0$

$\cos \alpha = \frac{4}{5} = 0.8$

$\alpha = 36.8$ degrees

81. Select (d)

$S = 4$

$W = 2 \times 2{,}000 = 4{,}000$ lbs

$B = ?$

$F = 10$

$P = \frac{10}{100} = 0.1$

$B = \left(\frac{W+PWS}{S}\right) F$

$B = \left(\frac{4000+0.1(4000)(4)}{4}\right) 10$

$B = 14{,}000$ lbs

82. Select (b)

We use the formula:

$R = \rho \frac{L}{A}$

Note: As in other problems, we have to be careful to be consistent with units. Since resistivity is given in ohm-inch, we use inch for length and inch squared for area:

$A = \frac{\pi D^2}{4}$ (D is the diameter)

$A = \frac{\pi\left(\frac{1}{8}\right)^2}{4} = 0.0122 \text{ in}^2$

$L = 10\text{ft}\frac{12\text{in}}{1\text{ft.}} = 120$ inches

$R = 5 \times 10^{-3} \frac{120}{0.0122} = 48.9$ ohms

83. Select (c)

When we have a combination of series and parallel connection, first we find the equivalent resistor for the parallel connection.

Let's call the equivalent resistor for R_3, R_4, and R_5 to be R_6. We can write:

$\frac{1}{R_6} = \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$

$\frac{1}{R_6} = \frac{1}{3} + \frac{1}{4} + \frac{1}{6}$

$R_6 = 1.33$ ohms

Resistor R_6 is in series with resistors R_1 and R_2. Let's call the equivalent resistor for the circuit R.

$R = R_1 + R_2 + R_6$

$R = 2 + 5 + 1.33$

$R = 8.33$ ohms.

84. Select (b)

First we find the equivalent capacitance for the parallel connection. This capacitor will then be in series with capacitors C_1 and C_2. Let's call the equivalent capacitance for the parallel connection C_5. We can write:

$C_5 = C_3 + C_4$

$C_5 = 4 + 2 = 6\mu$F.

Let's call the equivalent capacitance for the circuit C:

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_5}$

$\frac{1}{C} = \frac{1}{5} + \frac{1}{2} + \frac{1}{6}$

$C = 1.15\ \mu$F.

85. Select (a)

Before calculating the power consumed, we have to find the amount of current flowing through the circuit. We can use Ohm's law:

$V = RI$

R is the equivalent resistance for the circuit. In order to calculate R, we proceed as follows:

Resistors R_2 and R_3 are in parallel. We replace them with a single resistor R_4.

$\frac{1}{R_4} = \frac{1}{3} + \frac{1}{1}$

$R_4 = 0.75$ ohms

R_4 is in series with R_1. Therefore, the value of the equivalent resistance for the circuit (R) is:

$R = 2 + 0.75 = 2.75$ ohms

$V = RI$

$I = \frac{V}{R}$

$I = \frac{220}{2.75} = 80$ amperes

We can now calculate the power consumed by this circuit using the following relationships:

$P = RI^2$

$P = (2.75)(80)^2$

$P = 17{,}600$ watts.

Or:

$P = VI$

$P = (220)(80)$

$P = 17{,}600$ watts.

86. Select (b)

From Table below, the Normal Probability Distribution, the area between $Z = 0$, and $Z_1 = -1.5$ is 0.4332 and the area between $Z = 0$ and $Z_2 = -1.0$ is 0.3413. Therefore the area under the curve between above values of Z_1 and Z_2 is:

$0.4332 - 0.3413 = 0.0919$

or the probability that a randomly selected variable from this population falls between 35 and 40 is 0.0919 or 9.19 per cent.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

87. Select (a)

$Z_1 = \frac{250-200}{30} = 1.66$

From Table below, Normal Probability Distribution, the area between Z = 0 and Z_1 = 1.66 is 0.4515. Therefore, the probability that a randomly selected variable from this population assumes a value less than 250 is 0.5 plus 0.4515 or 95.15 percent.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

88. Select (c)

From Table below, the area between Z = 0 and $Z_1 = 2.0$ is 0.4772. However, for this problem we need the area to the right of Z_1 which is:

0.5 – 0.4772 = 0.0228

which means that the probability that a randomly selected variable has a value larger than 600 is 0.0228 or 2.28 percent.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

89. Select (b)

This problem deals with the principle of conservation of momentum. Momentum is defined as mass multiplied by the velocity.

$MV_{11} + M_2V_{21} = M_1V_{12} + M_2V_{22}$

Where:

M_1 = mass of the first ball

V_{11} = initial velocity of the first ball

M_2 = Mass of the second ball

V_{21} = initial velocity of the second ball

V_{12} = final velocity of the first ball

V_{22} = final velocity of second ball

100 gr = 0.1 kg

(0.1) (20) + (0.1) (0.0) = (0.1) (5) + (0.1) (V_{22})

V_{22} = 15 m/s

90. Select (c)

Volume of the larger tank = $\frac{(3.14\times20^2)}{4} \times 3,140m^3$

Volume of containment = 3,140 × 1.2 = 3,768 m^3

Available area = 70 W – area occupied by the large tank – area occupied by the small tank. W is the width of the rectangular area.

Available area = 70W – 314 – 19.6

Volume of containment = (70W – 314 – 19.6) × 2

This volume must equal 3,768 m^3

W = 31.7 m

91. Select (a)

We use the Poisson distribution equation:

$P_{(r)} = \frac{[(\lambda t)^r e^{-\lambda t}]}{r!}$

Where:

$P_{(r)}$ is the probability of r events. In this case, r is equal to 2 failures.

λ is the expected number of events in a given time interval. In this case, it is equal to 1 because if 6 failures occurred in 36 months, we expect one failure in 6 months.

t is the time interval. In this case, we set 6 months as 1 time interval, which means t is equal to 1.

$P_{(2)} = \frac{[(1)^2 e^{-1}]}{1\times2} = 0.1839$ or 18.39%

92. Select (b)

From the table, the acceptable size for cross braces is 4 × 4.

93. Select (a)

From the table, the acceptable size for cross braces is 4 × 6.

94. Select (b)

$\sigma = \sqrt{\frac{\sum(x_i-\mu)^2}{n-1}}$ where n is the sample size

$$\sigma = \sqrt{\frac{19.34}{6-1}} = 1.966$$

95. Select (a)

Avogadro's number (6.024×10^{23}) is the number of atoms in one gram mole. For example, one kilogram mole contains 1,000 times Avogadro's number of atoms because one kilogram mole is equal to 1,000 gram moles.

96. Select (d)

First we convert gallons to cubic feet:

$300{,}000 \div 7.48 = 40{,}106.95$

Dike volume $= 150 \times 3 \times$ width

$40{,}106.95 = 150 \times 3 \times$ width

Width $= 89$ ft

97. Select (d)

The volume of the block $= 4 \times 4 \times 10 = 160$ ft^3

This volume of displaced water must distribute itself in a cylinder having a diameter of 15 ft.

$V = \frac{\pi d^2}{4} \times h$

where V is the volume of displayed water, d is the tank diameter, and h is the height.

$160 = \frac{\pi(15)^2}{4} \times h$

$h = 0.9$ ft

Final height $= 15 + 0.9 = 15.9$ ft

98. Select (a)

One g-force is equal to the weight of the object on the surface of the earth, where the acceleration of gravity is equal to 32.2 ft/sec^2. In this case, since 1 g-force is equal to 300 lbs, then 2 g-force is equal to 600 lbs.

99. Select (a)

This statement best describes the difference between flocculation and precipitation.

100. Select (b)

First we have to find out how many simple events our sample space has. Remember that sample space, by definition, is the set of all possible outcomes of an experiment. In this case, our sample space S has only 2 elements:

S: head, tail

Next we have to find out how many simple events there are in our event of interest. In this case our event of interest (head) has only one element:

A: head

$$\text{Probability of event A} = \frac{\text{Number of simple events in event A}}{\text{Number of simple events in sample space}}$$

In this case:

Probability of getting a head = ½ = 0.5 or 50 percent

101. Select (b)

These events are obviously mutually exclusive because if one event occurs, the other events can not occur. The probabilities are, therefore, additive. In this case the probability is:

$\frac{1}{52} + \frac{1}{52} + \frac{1}{52} = \frac{3}{52} = 0.05$ or 5 percent

102. Select (b)

The events getting an ace from the first deck and an ace from the second deck are independent. Let's focus on the first deck of cards. Our sample space has 52 elements and our event has 4 elements (there are 4 aces in a deck of cards). The probability of drawing an ace from the first deck is:

$\frac{4}{52}$

Similarly, the probability of drawing an ace from the second deck is:

$\frac{4}{52}$

Since these two events are independent, the probability that both cards are aces is:

$\frac{4}{52} \times \frac{4}{52} = 0.0059$ or 0.6 percent

A probability of 0.5 percent means that we should expect the event to occur 0.5 times in 100 tries or 1 time in 200 tries. In other words, the result obtained above means that if we draw 200 times from two separate decks of cards, we could EXPECT that one of these draws would be two aces.

103. Select (a)

Getting a head or tail on each toss of a coin comprise independent events. For each toss of a coin our sample space has 2 elements and our event (getting a tail) has only one element. Therefore, the provability of getting a tail 4 times in a row is:

$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{16} = 0.06$ or 6 percent

104. Select (b)

Sample = 15

Number of events = 5

Probability = $\frac{5}{15} = 33.3\%$

105. Select (d)

All events are mutually exclusive, and therefore, the probabilities are multiplied.

Probability of getting a tail $= \frac{1}{2}$

Probability of getting a 2 on one die $= \frac{1}{6}$

Probability of getting a tail, (2, 2) is $= \frac{1}{2} \times \frac{1}{6} \times \frac{1}{6} = \frac{1}{72}$

106. Select (a)

The drawings from two separate decks of cards represent mutually exclusive events and probabilities are multiplied.

The probability of drawing an ace of hearts from the first deck is $\frac{1}{52}$; and the probability of drawing an ace of hearts from the second deck is also $\frac{1}{52}$. Therefore, the probability that both cards drawn will be aces of hearts is:

$\frac{1}{52} \times \frac{1}{52} = 3.69 \times 10^{-4}$

107. Select (c)

Events 3 and 6 on one roll of a pair of dice is considered to be mutually exclusive events. In other words they do not affect the outcome of each other.

108. Select (b)

Probability of getting a tail $= \frac{1}{2}$

Probability of getting a 3 $= \frac{1}{6}$

Probability of getting a tail and a 3 is equal to $\frac{1}{2} \times \frac{1}{6} = \frac{1}{12}$

109. Select (a)

First draw:

All possible events $= 12 + 15 = 27$

Red balls $= 15$

Probability of red ball on first draw $= \frac{15}{27}$

Second draw:

All possible events $= 14 + 12 = 26$

Red balls $= 14$

Probability of red ball $= \frac{14}{26}$

The first and second drawings from the box are mutually exclusive events, and therefore, the probability of getting a red ball on two consecutive draws is:

$\frac{14}{26} \times \frac{15}{27} = 0.299$

110. Select (c)

The bronchioles or bronchiole allow the air to pass through the nose or mouth and reach the air sacs of the lungs called "alveoli."

111. Select (b)

The rate of absorption of a chemical through the skin depends on the physical as well as chemical properties of the substance involved. Absorption is a diffusional process of mass transfer. Lethal dose 50 (LD_{50}) is the amount of a chemical that causes death in 50% of the laboratory animals under study.

112. Select (a)

Histograms display frequency distribution. For example, histograms can be used to displays the frequency of incidents for different months or years.

113. Select (c)

All organic compounds have one or more atoms of carbon in their molecules. Hydrocarbons are organic compounds which contain only carbon and hydrogen atoms in their molecules.

114. Select (d)

For example, number 4 is the mode for the following data set.

4, 2, 6, 5, 2, 4, 3, 9, 4

115. Select (b)

Solution

According to the Archimedes' Principle, the buoyant force is equal to the weight of the water that is displaced by the cylinder.

Step 1: Calculate the volume of the cylinder.

$V = \frac{\pi D^2}{4} \times H$

Where V is the volume, D is the diameter, and H is the height of the cylinder.

$V = \frac{(3.14)\times(1)^2}{4} \times 2$

V = 1.57 ft^3

Step 2: Calculate the weight of the water that has a volume equal to 1.57 ft^3. We know that weight (force) is equal to mass multiplied by the acceleration of gravity.

W = mg

Where:

W = weight of an object

m = mass

g = acceleration of gravity

We also know that mass is equal to density multiplied by volume:

$m = \rho V$

Where:

m = mass

ρ = density

V = volume

Therefore, we can write:

$W = \rho Vg$

In this case:

$\rho = 62.4$ lbm/ft^3

V = 1.57 ft^3

g = 32.2 ft/sec^2

Before we use the above equations, we have to remember that since we are working in the American Engineering System, mass (ρV) must be divided by 32.2.

$W = \frac{62.4 \times 1.57 \times 32.2}{32.2}$

W = 97.97 lbs or approximately 100 lbs

116. Select (a)

The mechanical advantage of block and tackle (pulley) systems is equal to the weight of the load being lifted divided by the number of rope sections in the tackle.

$Weight\ of\ load = mg = 100 \times 9.8 = 980\ newtons$

With a mechanical advantage of 4, the amount of force needed to lift this load is:

$\frac{980}{4} = 245\ newtons$

117. Select (b)

The mechanical advantage which is equal to the number of rope sections is equal to the force required to lift a load divided by the actual weight of the load. In this case, the number of rope sections is equal to:

$\frac{200}{25} = 8$

118. Select (d)

CV is a measure of relative variability of data. It is obtained by dividing the standard deviation of a sample or population by the mean of the sample or population. If we multiply the result by 100, CV is expressed in percent. Using the standard deviations of different sets of data alone to express variability can be misleading if there is significant difference in the values of the means. For example, one might conclude that two sets of data with standard deviations of 8 and 8.3 represent the same variability. However, if the first of data has a mean of 72 and the second set of data has a mean of 41.5, the coefficient of variations are as follows:

CV for the first set of data = 8/72 = 0.11 or 11%

CV for the second set of data = 0.20 or 20%

119. Select (d)

Nanotechnologies are pervasive enabling technologies with far-reaching effects. They are expected to help address many problems facing today's society.

120. Select (d)

The parasites are comprised of protozoa and helminths. Such pathogens reach water sources when infected people or animals shed microbes in feces.

121. Select (b)

Also, drink properly treated water. E. coli and fecal coliform are bacteria whose presence can indicate water contaminated by human or animal wastes, causing short-term health effects, including: cramps, nausea, diarrhea, headaches and more; they may also pose a greater risk for people with severely weak immune systems.

122. Select (d)

Bloodborne pathogens are microorganisms such as viruses or bacteria that are carried in blood and can cause disease in people. There are many different bloodborne pathogens, including malaria, syphilis, and brucellosis, and most notably Hepatitis B (HBV), Hepatitis C (HCV) and the Human Immunodeficiency Virus (HIV).

123. Select (c)

Bloodborne pathogens can be transmitted through: Accidental punctures and cuts with contaminated sharp materials (e.g. Needle stick). Contact between mucous membranes or broken skin and infected body fluids (e.g. Splash).

124. Select (b)

The goal of the Bloodborne Pathogen Standard is to establish guidelines for organizations to develop a program providing information, training and equipment to protect individuals from occupational exposures to blood or other potentially infectious materials.

Domain II:
Management Systems

2.1 Management Aspects

Selected Management Theories:

Theory X and Y:

Douglas McGregor's Theory X and Theory Y describes two different views of the worker in the workplace. Theory X assumes that workers in general do not have any interest in their work and that the management has to force them to do the job. On the other hand, theory Y assumes that workers have a lot of interest in their work and that they are willing to take responsibility and take steps to fulfill those responsibilities.

Scientific Management Theory:

Frederick Taylor's theory of scientific management proposes different techniques to maximize the efficiency of completing a task. In his theory, it is proposed that each task in accomplishing a job should be broken down into sub-tasks. The efficiency and productivity of each sub-tasks is optimized by focusing on people and their work behavior.

Administrative Theory:

Henri Fayol's developed this management theory. This theory describes the different ways that personnel and management can interact with each other with the goal of optimizing productivity.

bureaucratic management theory:

This theory of management and its principles was developed by Max Weber. This theory like Taylor's Scientific Management Theory focuses on optimization of efficiency, but at the same time, also takes into account the downsides merely concentrating on technology alone without taking the emotional aspects into account.

human relations theory:

The human relations management theory believes that people want to be part of a team that is supportive and encourages growth and development. This means that if workers are given special attention by the management to participate in the development process, they consider that their work has a lot of significance resulting in more productivity.

OSHA Incidence Rates:

OSHA incident rates are indications of the past performance of the company and that is why they are called "lagging indicators". Leading indicators are indication of what would happen in the future.

OSHA RECORDABLE INCIDENT RATE – Describes the number of employees per 100 full-time employees that have been involved in a recordable injury or illness.

$$\text{IR} = \frac{\text{Number of OSHA Recordable Cases} \times 200{,}000}{\text{Number of Employee labor hours worked}}$$

For example, the OSHA Incidence Rate for a company which has 60 full-time employees with 10 recordable injuries in a calendar year is:

$$\text{IR} = \frac{10 \times 200{,}000}{60 \times 50 \times 40} \text{ or IR} = 16.6$$

Pearson product moment correlation coefficient:

The quantity r, called the *linear correlation coefficient*, measures the strength and the direction of a linear relationship between two variables.

The mathematical formula for computing $\boldsymbol{r}$ is:

$$\text{r} = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{n(\sum x^2) - (\sum x)^2}\sqrt{n(\sum y^2) - (\sum y)^2}}$$

where n is the number of pairs of data and x and y are the variables. The value of r is a number between -1 < r < +1. The positive and negative signs indicate a positive and negative linear relationship between the two variables. A value of r close to +1 indicates a strong positive linear relationship between the two variables and a value of r close to -1 indicates a negative linear relationships between the two variables.

Coefficient of Determination, r^2

The *coefficient of determination* is the ratio of the explained variation to the total variation. *coefficient of determination* assumes a value between zero and +1and indicates how strong a linear relationship exists between the two variables. It also indicates the percentage of data that is closest to the line of best fit. For example, a coefficient of correlation equal to 0.90 indicates a strong positive linear relationship between the two variables. In this case, the coefficient of determination is equal to 0.81 (using two significant figures). This means that 81% of the total variation in y can be explained by a linear relationship between x and y and the other 19% of variation in y is unexplained.

Example:

Company XYZ has obtained the following data relating the total number of unsafe conditions and unsafe acts to the number of incidents in its four plants in a given year:

number of unsafe conditions and acts number of incidents

Plant 1 30 5

Plant 2 48 8

Plant 3 10 1

Plant 4 42 7

Let's represent the number of unsafe conditions and unsafe acts as our independent variable x and the number of incidents in each plant as our dependent variable y. in this case sample size n = 4. By substituting for x, y, and n in the formula for calculation of the coefficient of correlation (above), we calculate a value of r = 0.9931

$\sum \times y = 30 \times 5 + 48 \times 8 + 10 \times 1 + 42 \times 7 = 838$

$\sum \times \sum y = (30 + 48 + 10 + 42)\ (5 + 8 + 1 + 7) = 2730$

$\sum x^2 = 5{,}068$

$(\sum x)^2 = 16{,}900$

$\sum y^2 = 25 + 64 + 1 + 49 = 139$

$(\sum y)^2 = (21)^2 = 441$

$r = 0.998$

The value of coefficient of correlation is very close to +1. This indicates an almost perfect positive linear relationship between the number of unsafe conditions and the number of incidents in a given plant. In other words, reducing the number of unsafe conditions by 50% would reduce the number of incidents by almost 50%

Engineering Economy

Present and Future worth of Investment:

The future value F of an initial investment P after n years at an interest rate of i percent compounded yearly can be obtained from the following relationship:

$F = P\ (1 + i)^n$

where:

F is future worth of money

P is present worth of money

i is interest rate expressed in decimals

n is number of years.

Expressing P in terms of F results in the expression:

$P = F\ (1+i)^{-n}$

Example:

What is the future worth of $100,000 five years from now at an interest rate of 6% compounded annually?

P = $100,00

n = 5 years

I = 0.06

F = ?

$F = 100{,}000\ (1 + 0.06)^5$

F = 133,822.56

Uniform Series Present and Future- worth Factor:

The formula for uniform-series present worth is:

$P = A\left[\frac{(1+i)^n-1}{i(1+i)^n}\right]$

where P is present worth and A is each value to pay the future worth F in n years and i is interest rate.

The formula for future worth of a uniform series is:

$F = A\left[\frac{(1+i)^n-1}{i}\right]$

Where F is the future worth, A is the amount of uniform series, i is the interest rate, and n is the number of years. The above formula can be rearranged as follows to allow for calculation of A

$A = F\left[\frac{i}{(1+i)^n-1}\right]$

where:

A is the uniform deposit

F is future worth

i is interest rate

n is number of years.

Example:

You make an equal yearly payment of $20,000 towards the purchase of new safety devices for your department for 5 years at an interest rate of 5% compounded annually. What is the present worth of your payments?

A = \$20,000

i = 0.05

n = 5 years

P = ?

$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$

P = 20,000 (0.2763/0.064)

P = \$86,343.75

This means that you are paying \$100,000 over 5 years. The difference between the present worth and what you actually paid goes to interest.

2.2 System Safety Techniques

Review of Basic Principles and Terminology

The system safety concept suggests accidents are the result of a number of interacting causes within a system. System safety techniques, when properly applied, can identify the hidden system failure modes and can recommend procedures or system modification for their rectification. System safety techniques can be qualitative such as Preliminary Hazard Analysis (PHA) or quantitative such as Fault Tree Analysis (FTA). This section is primarily concerned with questions dealing with the design of systems and products to eliminate or control the hazards.

System Safety Definition

The system safety approach begins by defining a system and focusing on how accidents can occur within that system as a result of equipment failure, external events such as power failure, human error, environmental conditions, or a combination of these. The preventive measures to mitigate the hazards include design of control apparatus, equipment, or development of procedural safeguards.

System Safety Techniques

System safety techniques include but are not limited to the: Preliminary Hazard Analysis (PHA), What If analysis, Hazard and Operability Analysis (HAZOP), Fault Tree Analysis (FTA), Event Tree Analysis (ETA), Failure Modes Effect and Criticality Analysis (FMECA), and Job Safety Analysis (JSA).

Understanding system safety techniques requires an in-depth study of this subject. Although a very brief description of some of the system safety techniques is presented in the following, a detailed description of these techniques is outside the scope of this workbook. For more detailed description of each technique, the reader should consult the references.

Preliminary Hazard Analysis (PHA)

A PHA is a general, qualitative study that yields a rough assessment of the potential hazards and means of their rectification within a system. The results of a PHA study can be summarized in the form of a table or a logic diagram. In either format, potential hazards along with their causes and major effects are identified. In addition, for each hazard identified, preliminary means of control are also prescribed.

"What If" Analysis

The main purpose of the "What If" method is to identify the hazards associated with a process by asking questions that start with "What If..." The results are presented in

the form of a table, which includes the questions, their consequences, and recommendations.

Failure Modes Effects and Criticality Analysis (FMECA)

FMECA, also known as **failure modes and effect analysis (FMEA)**, is a systematic method by which equipment and system failures and the resulting effects of these failures are determined. FMECA is an inductive analysis; that is, possible events are studied, but not the reasons for their occurrences. Generally, this analysis is first performed on a qualitative basis; quantitative data can later be applied to establish a criticality ranking that is often expressed as probabilities of system failures.

Hazard and Operability Study (HAZOP)

HAZOP is extensively used in Process Safety Management (PSM). This analysis applies certain guide words to process parameters to identify deviations from the design intent along with their causes and consequences. For example, application of the guide word "NO" to process parameter "FLOW" creates the deviation "NO FLOW." The causes and consequences of "NO FLOW" are then studied. The points within the process where deviations are studied are called **NODES**.

Fault Tree Analysis (FTA)

This method of hazard evaluation visually demonstrates the interrelationship between equipment failure, human error, and external and environmental factors that can result in an accident. FTA is a "backward" analysis: a system hazard, or **TOP event** is the starting point, and the study traces backwards to find the possible causes of the hazard. A **cut set** is any group of contributing elements which, if all occur, will cause the TOP event to occur. A **minimum cut set** is a minimum group of contributing elements which, if all occur, will cause the TOP event to occur.

The symbols used in FTA are displayed in Figure 3. The fault tree will begin with the TOP event and will address any possible equipment failure, human error, or environmental factors that could result in the TOP event.

- **AND** gates are used when the existence of all conditions or events indicated must occur for the TOP event to occur.
- **OR** gates indicate that any one of the conditions or events indicated leads to the TOP event.
- **Undeveloped events** are occurrences that are not further addressed, either because of lack of necessary information or for other reasons such as the particular event goes beyond the scope of the study.
- **Basic faults** are the primary cause of the TOP event. Basic faults represent a malfunction of equipment that occurs in the environment in which the equipment was intended to operate. Each branch of the fault tree should eventually end up in either a basic fault or perhaps an undeveloped event.

The triangles are used for transfer of the fault tree to another location or another page.

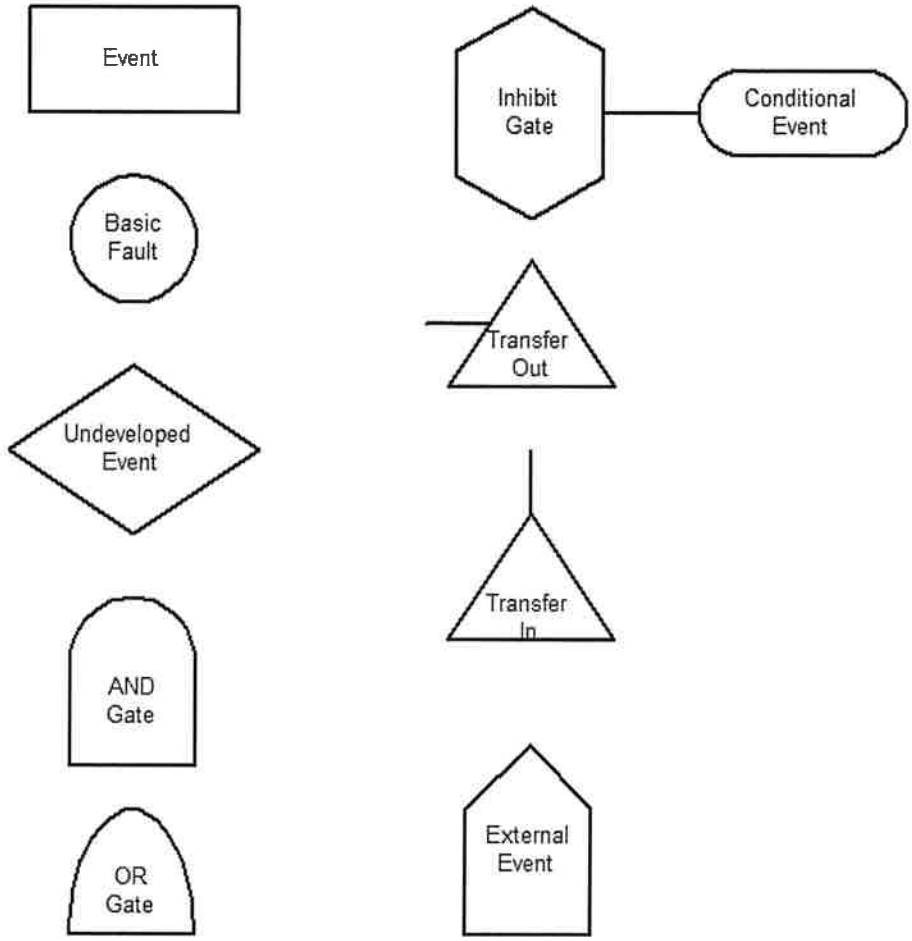


Figure 3. Fault Tree Analysis Symbols

Event Tree Analysis (ETA)

ETA is a forward analysis beginning with an initiating event and proceeding forward to find possible consequences resulting from that event. The course of events is determined by the success or failure of various safety functions as the accident progresses.

Technique for Human Error Rate Prediction (THERP)

This method deals with continuous personnel operations and probability of procedural errors. THERP breaks down the procedure for an operation into individual tasks. Each task is then assigned a probability of success (or failure). The probabilities are then multiplied to obtain the probability of success or failure of the operation (mutually exclusive events).

Job Safety Analysis

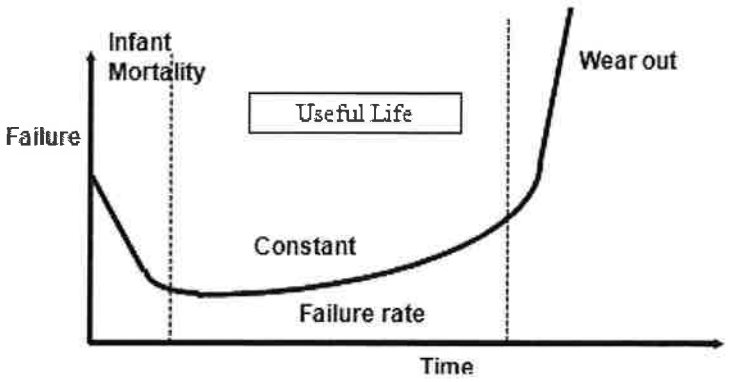
This method breaks down a task into steps and then analyzes each step.

2.3 Reliability Engineering

- **Reliability** is the *probability* that a system, component, or device will perform without failure for a *specified period of time under specified operating conditions.* Reliability is a study of the *causes, distribution*, and *prediction* of failure.
- **Hazard rate** is the number of failures in a unit of time per the number of items exposed for the same time. The hazard rate is given in terms like 1 per cent per 1,000 hours or 10-5 per hour. It should be pointed out that these tests are performed under conditions which a product is intended to be used.

Failure curve

$$R(t) = e^{-\lambda t}$$



Where:

R(t) = reliability

t = time in which reliability is measured

$$\lambda = \frac{\text{number of failures}}{\text{number of time units during which all items were exposed to failure}}$$

Example

If a device has a failure rate of 2×10^{-6} failures/hour, what is its reliability in an operating period of 500 hours?

Solution

$R(500) = \exp(-2 \times 10^{-6} \times 500)$

$= e^{-0.001}$ - 0.999

Or the probability of failure 0.001.

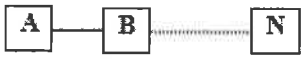
System reliability

Most mechanical and electronic systems are comprised of a collection of components. The overall reliability of the system depends on how the individual components with their individual failure rates are arranged.

Series reliability

If the components are so arranged that the failure of any component causes the system failure, it is said to be arranged in series.

$$R_{system} = R_A \times R_B \times ... \times R_N$$



If there are many components exhibiting series reliability the system reliability becomes low rather quickly.

Example

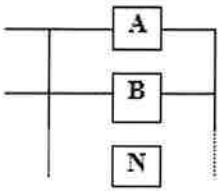
20 components each having a reliability of = 0.99 and arranged in series

$R_{system} = 0.99^{20} = 0.818$

Parallel reliability

It is necessary for all components of the system to fail in order for the system to fail.

$$R_{system} = 1 - (1 - R_A)\ (1 - R_B)\ ...\ (1 - R_n)$$



Assuming a constant failure rate for two components A and B arranged in parallel:

$$Rsystem = 1 - (1 - e^{-\lambda At})(1 - e^{-\lambda Bt})$$

Some of the more common causes of unreliability

1. Design mistakes
2. Manufacturing defects
3. Maintenance
4. Exceeding design limits
5. Environmental factors

Frequency of failures (hazard rate)

The number of failures for every hour of operation per total number of hours of operation is called the frequency of failures or the hazard rate. The reciprocal of the hazard rate is called Mean Time Between Failures (MTBF).

2.4 Globally Harmonized System (GHS)

Introduction

GHS defines and classifies the hazards of chemical products, and communicates health and safety information on labels and safety data sheets. The goal is that the same set of rules for classifying hazards, and the same format and content for labels and safety data sheets (SDS) will be adopted and used around the world. An international team of hazard communication experts developed GHS.

The Need for Global Harmonization

Currently many different countries have different systems for classification and labelling of chemical products. In addition, several different systems can exist even within the same country. This situation has been expensive for governments to regulate and enforce, costly for companies who have to comply with many different systems, and confusing for workers who need to understand the hazards of a chemical in order to work safely.

The Two Major Elements in GHS

The two major elements of GHS are:

1. Classification of the hazards of chemicals according to the GHS rules: GHS provides guidance on classifying pure chemicals and mixtures according to its criteria or rules.
2. Communication of the hazards and precautionary information using Safety Data Sheets and labels:

Hazard Groups

There are three major hazard groups:

- Physical hazards.
- Health hazards.
- Environmental hazards.

Within each of these hazard groups there are classes and categories. Each of these parts is called a building block. Each country can determine which building blocks of the GHS it will use in their different sectors (workplace, transportation, consumers). Once the building blocks are chosen, the corresponding GHS rules for classification and labels must be used.

Classes Within the Health Hazard Group

Criteria for classifying chemicals have been developed for the following health hazard classes:

- Acute toxicity.
- Skin corrosion/irritation.
- Serious eye damage/eye irritation.
- Respiratory or skin sensitization.
- Germ cell mutagenicity.
- Carcinogenicity.
- Reproductive toxicity.
- Specific target organ toxicity - single exposure.
- Specific target organ toxicity - repeated exposure.
- Aspiration hazard.

Classes Within the Physical Hazard Group

Criteria for classifying chemicals have been developed for the following physical hazard classes:

- Explosives.
- Flammable gases.
- Aerosols.
- Oxidizing gases.
- Gases under pressure.
- Flammable liquids.
- Flammable solids.
- Self-reactive substances and mixtures.
- Pyrophoric liquids.
- Pyrophoric solids.
- Self-heating substances and mixtures.
- Substances and mixtures which, in contact with water, emit flammable gases.
- Oxidizing liquids.
- Oxidizing solids.

- Organic peroxides.
- Corrosive to metals.

Classes Within the Environmental Hazard Group

Criteria for classifying chemicals have been developed for the following environmental hazard classes:

- Hazardous to the aquatic environment (acute and chronic).
- Hazardous to the ozone layer.

Selected Pictograms Used in GHS



Explosive material



Flammable material



Oxidizing agent



Compressed gases



Corrosive substance



Acute toxicity



Environmental hazard

2.5 Example Questions

1. Preliminary Hazard Analysis is a system safety technique that:
   a. Allows the results to be presented in the form of a table or logic diagram
   b. Allows the results to be presented in the form of "and" gates
   c. Starts with an undesired event within the system
   d. Employs Boolean logic
2. The main objective of a Hazard and Operability Study (HAZOP) is to:
   a. Identify deviations from the design intent with their causes and consequences.
   b. Develop "guide words" that would best describe system hazard analysis.
   c. Satisfy OSHA requirement of process safety management standard (29 CFR 1910.119).
   d. Apply guide words to safety instruments.
3. Fault Tree Analysis (FTA):
   a. Is a forward analysis
   b. Is a backward analysis
   c. Employs Boolean logic
   d. Only (b) and (c) above
4. In FTA, the event "source of ignition" as one of the necessary components of combustion must be connected to events "open flame," "static sparks," and "electrical sparks" through which of the following gates?
   a. AND
   b. SOMETIMES
   c. OR
   d. Only (a) and (c) above
5. In Fault Tree Analysis of a fire situation, air, fuel, source of ignition, and chemical chain reaction are required in order to have a fire. These events must be connected to the TOP event "fire" through an:
   a. OR gate
   b. EXTERNAL gate
   c. UNDESIRED EVENT gate
   d. AND gate

6. 10,000 light bulbs were tested for 1,000 hours and 5 bulbs failed. What is the probability that a bulb from this batch would not fail in 1,000 hours of operation?

   a. 90%

   b. 99.95%

   c. 99.99%

   d. 99.55%

7. A device has three components in series with reliabilities of 99, 95, and 98 per cent. What is the reliability of this device?

   a. 99.9%

   b. 97.9%

   c. 92%

   d. 80%

8. A system has two components in parallel with reliabilities of 99.9% and 99.8%. What is the system reliability?

   a. 99.99%

   b. 98.95%

   c. 99.70%

   d. 95.99%

9. Which of the following statements IS NOT true in regard to a Hazard and Operability study (HAZOP)?

   a. HAZOP identifies the deviation of process parameters from their design intent.

   b. A multi-disciplinary team usually conducts a HAZOP study.

   c. In a HAZOP study, guidewords are applied to process parameters such as temperature and pressure.

   d. HAZOP uses Boolean logic to quantify the probability of occurrence of the TOP event.

10. Which of the following statements IS NOT true in regard to Failure Modes Effect and Criticality Analysis (FMECA)?

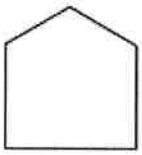
    a. FMECA identifies the deviation in process parameters by using guidewords.

    b. In FMECA criticality rankings are generally expressed in probabilities.

    c. In FMECA each failure is considered individually as an independent occurrence.

    d. Generally, FMECA is first accomplished on a qualitative basis. However, quantitative data may be applied to determine a criticality ranking.

11. In Fault Tree Analysis, the following symbol represents a(n):



    a. Basic fault

    b. Undeveloped event

    c. Initiating event

    d. External event

12. If a device has a failure rate of 2×10^{-6} failures/hour, its reliability in an operating period of 500 hours is:

    a. 0.999

    b. 0.989

    c. 0.977

    d. 0.960

13. The system safety technique which is a forward analysis and begins with an initiating event and proceeds forward to find possible consequences is called:

    a. Event Tree Analysis

    b. Fault Tree Analysis

    c. HAZOP

    d. Cause-Consequence Analysis

14. The system safety technique that is primarily devoted to the analysis of human errors in the workplace is called:

    a. HEA

    b. THERP

    c. PERT

    d. HFE

15. The system safety technique that evaluates the success or failure of safety functions is called:

    a. System Safety Analysis

    b. Failure Mode Effect Analysis

    c. Event Tree Analysis

d. Fault Tree Analysis

16. A backward system safety analysis technique that visually demonstrates the interrelationships among equipment failure, human error, and environmental factors that can result in occurrence of an accident is called:

    a. Event Tree Analysis

    b. Fault Tree Analysis

    c. THERP

    d. EHE analysis

17. The system safety technique that combines the forward thinking features of Event Tree Analysis with the reverse thinking features of Fault Tree Analysis is called:

    a. Cause-consquence Analysis

    b. HAZOP

    c. PHA

    d. Job Safety Analysis

18. FMECA is best described by which of the following statements?

    a. A technique to identify problems associated with potential hazards and deviation of plant operation from the design specifications.

    b. A systematic method by which equipment and system failures and the resulting effects of these failures are determined.

    c. A technique that visually demonstrates the interrelationship among equipment failure, human error, and environmental factors that can result in an accident.

    d. A forward analysis beginning with an initiating event and proceeding forward to find possible consequences resulting from that event.

19. A system has three components. Each component works independently of the others. If the failure probability of each component is F, what is the probability that all three components fail at the same time?

    a. 3F

    b. 6F

    c. 5F

    d. F^3

20. In Fault Tree Analysis, the probability of a top event directly connected to two events with probabilities of P and Q through an OR gate is equal to:

    a. P – Q + (PQ)

    b. P + Q + (PQ)

c. P + Q – (PQ)

d. P + PQ – (p)

21. Which of the following is an accepted probabilistic risk assessment technique that analyzes a system in the context of its environment and operation to find all possible ways that the system can fail?

a. Fault tree analysis

b. Event tree analysis

c. Safety and environmental analysis

d. Hazard and operability analysis

22. Which of the following is the correct statement of the Distributive Law?

a. $A \bullet (B \bullet C) = (A \bullet B) + (A \bullet C)$

b. $A \bullet (B + C) = (A \bullet B) + (A \bullet C)$

c. $(A \bullet B) + C = (A \bullet C) + (A \bullet B)$

d. $(A + C) - B = (A \bullet B) - (B \bullet C)$

23. A pump in a processing facility has a failure rate equal to 10^{-5} failures per hour. An identical spare pump is installed that will automatically start upon failure of the main pump. The probability that this system will fail in 50,000 hours of operation is:

a. 42.3 percent

b. 15.5 percent

c. 10.4 percent

d. 8.5 percent

24. A device with a failure rate of 10^{-6} failures per hour has a Mean Time Between Failures (MTBF) equal to:

a. 10^4 hours

b. 10^2 hours

c. 10^6 hours

d. 10^{12} hours

25. A pump feeds cooling water to the jacket around a reactor in which an exothermic chemical reaction takes place. The pump manufacturer's test results indicate a failure rate of 1×10^{-5} failures per hour. The probability that this pump will fail in 50,000 hours of operation is:

a. 39.4 percent

b. 21.4 percent

c. 12.5 percent

d. 18.7 percent

26. The following initiating event probabilities were identified as a result of an FTA analysis on a system:

Event	Probability
A	10^{-8}
B	10^{-9}
C	10^{-8}
D	10^{-8}

The minimal cut sets are:

A, B

C, D

The probability of the top event is:

a. 1×10^{-24}

b. 11×10^{-17}

c. 1×10^{-17}

d. 11×10^{-24}

27. A light bulb manufacturer claims a mean time between failures (MTBF) for one of their brands of bulbs to be 10,000 hours. What is the reliability of this type of bulb for 6,000 hours of operation?

a. 34%

b. 67%

c. 45%

d. 55%

28. The probabilities of two events connected to the top event through an AND gate are P and Q respectively. What is the probability of the top event?

a. $P + Q - PQ$

b. PQ

c. PQ^2

d. $P - Q$

29. Which of the following is a correct Boolean expression?

a. $A + A = A$

b. $A + 0 = A$

c. $A \bullet A = A$

d. All of the above

30. Which of the following is the commutative law of Boolean algebra?

a. $A + B = B + A$

b. $A \bullet B = B \bullet A$

c. $A + (B \bullet C) = A \bullet B + A \bullet C$

d. Only (a) and (b)

31. A system has two components in series, which means the failure of either component will cause the system to fail. The probability of failure for the first component is 10^{-3} and the probability of failure for the second component is 10^{-4}. What is the reliability of this system?

a. 0.9272

b. 0.9486

c. 0.9989

d. 0.9167

32. The failure curve in reliability engineering is called:

a. Hazard rate curve

b. Mean time between failures (MTBF)

c. Bathtub curve

d. Hazard curve

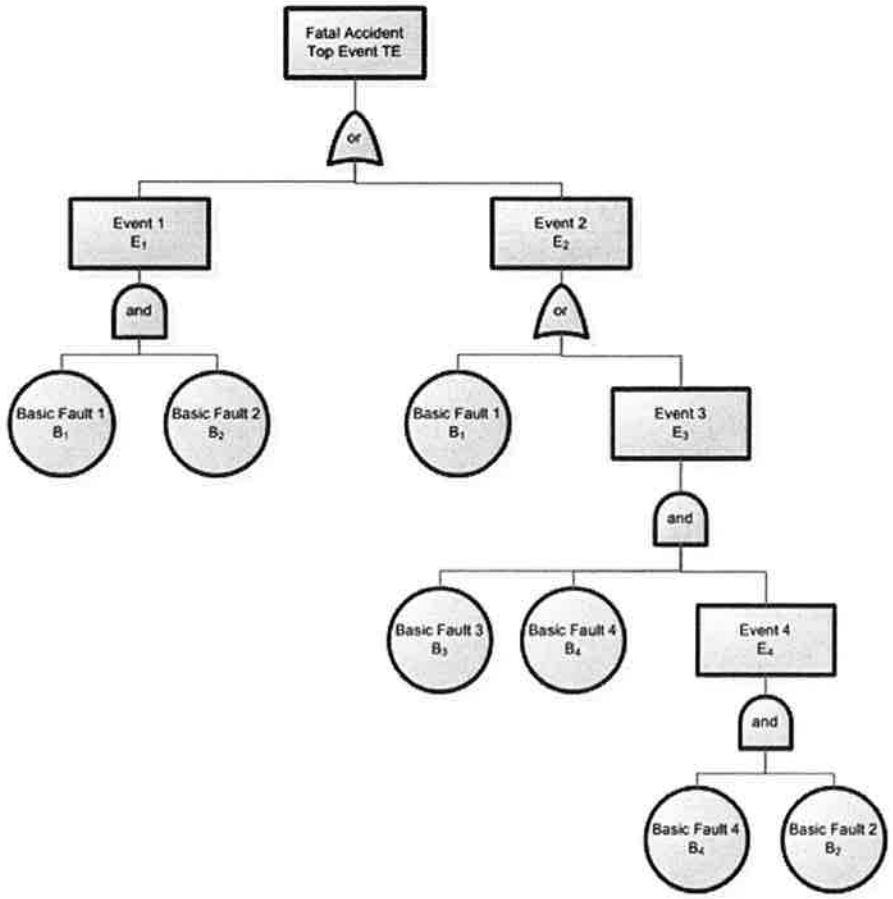
33. The minimum cut sets for the fault tree below are:

a. B_4 and $B_3 \bullet B_1$

b. B_4 and $B_3 + B_1$

c. E_1 and $E_2 \bullet B_4$

d. B_1 and $B_3 \bullet B_4 \bullet B_2$



34. The first step in management of safety within an organization is to:

    a. Appoint a safety and health officer.

    b. Develop a policy statement.

    c. Provide training to workers who may be exposed to hazards on their jobs.

    d. Develop a safety manual.

35. Different styles of management have a direct influence on the flow of information within an organization. In participative management style, the flow of information within an organization is:

    a. From top to bottom

    b. From bottom to top

    c. In all directions

    d. Horizontal

36. One of the major advantages of an external safety audit is its:

    a. Relatively low cost

    b. Objectivity

c. Lack of familiarity with the facility

d. Lack of familiarity with facility personnel

37. An employee working for a manufacturing facility is responsible for cleaning and maintenance of a storage tank which cannot support life due to its oxygen deficiency. In order to perform these tasks, the employee must enter the tank. Which of the following is a requirement which must be set forth by the management of this organization?

a. Obtain a permit prior to entry.

b. Restrict access by unauthorized personnel.

c. Use proper PPE.

d. All of the above.

38. Organizations that pay workers' compensation premiums recognize such expense as:

a. Indirect cost of accidents

b. Uninsured cost of accidents

c. Hidden cost of accidents

d. Insured cost of accidents

39. The **fundamental** way any organization's management must function is to:

a. Ensure that the safety and health of all employees are protected.

b. Ensure compliance with all federal, state, and local occupational safety and environmental health laws, regulations, and standards.

c. Make decisions and have those decisions implemented.

d. Ensure that employees have an opportunity to take part in the decision making process.

40. McGregor has proposed two theories, X and Y, describing an employee's attitude toward his/her work. Theory Y states that:

a. People are not generally interested in their work, and external motivation is required.

b. Workers should be motivated by raises and benefit plans.

c. People are generally interested in their work and are self-motivated.

d. It is the management's responsibility to motivate employees.

41. One of the responsibilities of management in safety as well as other aspects of an organization's business is to follow the 3E's principle. The 3E's are:

a. Engineering, Education, Enforcement

b. Effectiveness, Essentials, Efforts

c. Effectiveness, Education, Enforcement

d. Establishment, Effectiveness, Education

42. Eighteen injuries and illnesses were recorded on OSHA form 300 in one calendar year. Assuming that the company has 100 employees who have worked 50 weeks, 40 hours per week, the OSHA Incidence Rate is:

a. 18

b. 12

c. 24

d. 6

43. LWDI is an acronym for which of the following?

a. Lost Wages Due to Injury

b. Lost Workday and Disability Injury Rate

c. Labor Work Discipline Incidence

d. Lost Workday Incidences

44. Based on principles of Total Quality Management (TQM):

a. Top management is responsible for product quality.

b. Line supervisors are responsible for product quality.

c. Every employee is responsible for product quality.

d. Only (a) and (b) above.

45. In management terminology a flat organization refers to one:

a. With many levels of management.

b. With few levels of management.

c. With ineffective management.

d. Making only a few products.

46. Argyris, one of the most recognized behavioral scientists, proposes leveling within an organization as a solution to his conflict theory. Which of the following statements best describes the concept of organizational "leveling" as proposed by Argyris?

a. Line supervisors alone should make all decisions related to safety performance.

b. The boss does not make all decisions alone.

c. Top management alone should make all decisions related to safety performance.

d. One person, usually the safety officer, must make all decisions related to safety and communicate his/her decisions to everyone within the company.

47. Herzberg's "Motivation-Hygiene" behavioral theory breaks down the variables affecting performance into hygiene factors and motivation factors. Which of the following is an example of a hygiene factor?

    a. Sense of achievement

    b. Promotion

    c. Recognition

    d. Company policies

48. Which of the following statements is an example of a motivation factor according to Herzberg's "Motivation-Hygiene" theory?

    a. Relationships with the boss

    b. Money

    c. Responsibility

    d. Working conditions

49. The machines in a shop are to be replaced 5 years from now. It is estimated that at that time the cost of new machines will be $3,000,000. At an interest rate of 6 percent compounded annually, what lump sum of money must the machine shop owner deposit now to be able to pay for the cost of new equipment at the end of 5 years?

    a. $1,672,622

    b. $2,241,774

    c. $2,841,675

    d. $1,852,239

50. The present worth of $2 x 10^6 five years from now with an interest rate of 8 per cent compounded annually is:

    a. $1,976,323

    b. $1,361,166

    c. $1,723,872

    d. $2,672,523

51. Your department has decided to make major modifications to improve safety. The cost is estimated to be 4 million dollars that the company can borrow from a bank. If the bank charges an interest rate of 12 percent compounded annually and your company would like to pay the principal and interest in 10 years with the first payment after one year, how much the company's annual payments would be:

    a. $707,936

    b. $565,236

c. $432,175

d. $653,129

52. If you deposit $2,000 dollars per year in a bank account which pays 7 percent interest compounded annually, how much money do you have after 20 years?

a. $56,722

b. $49,723

c. $81,990

d. $63,752

53. Which of the following statements BEST describes the doctrine of "Fellow Servant Rule"?

a. In hazardous waste operations and emergency response, an employee entering a site must always be accompanied by another fellow employee.

b. The employer is not responsible for injuries suffered by an employee resulting from negligence of another employee.

c. One of the principles of Total Quality Management which encourage each employee to consider himself/herself personally responsible for providing service to customers.

d. One of the principles of Total Quality Management which encourages each employee to provide assistance to a fellow employee when possible.

54. Which of the following statements BEST describes the role of a safety professional within an organization?

a. He/she is responsible for the safety conduct of the organization.

b. He/she is responsible for both occupational and environmental safety conduct of the organization.

c. He/she develops the information needed for the line to exercise its authority for safety.

d. He/she is responsible for identifying and eliminating unsafe acts and unsafe conditions within the organization.

55. Which of the following best describes a tall organization?

a. An organization with ineffective management

b. An organization with many levels of management

c. An organization with authoritative management

d. An organization with few levels of management

56. The actual responsibility for safety within an organization lies with:

a. Line management

b. Safety director

c. Company president/CEO

d. All employees

57. A linear coefficient of correlation of (−1) between a dependent and an independent variable indicates:

a. A strong linear correlation

b. No linear correlation

c. Data is inaccurate

d. Variation is all unexplained

58. In linear correlation analysis, the coefficient of determination is:

a. Total variation divided by explained variation

b. Unexplained variation divided by total variation

c. Explained variation divided by total variation

d. Total variation divided by unexplained variation

59. In a safety program study trying to relate lost time injuries to the number of unsafe conditions identified in a given calendar year, the following data has been obtained:

Total variation = 42.95

Explained variation = 21.80

The linear coefficient of correlation is:

a. ±0.712

b. - 0.507

c. + 0.023

d. - 0.045

60. In a normal probability distribution, large values of standard deviation:

a. Increase the height of the normal curve and reduce its spread

b. Decrease the height of the normal curve and reduce its spread

c. Increase the height of the normal curve and increase its spread

d. Decrease the height of the normal curve and increase its spread

61. The deductible part of an insurance policy is an example of which of the following costs associated with an accident?

a. Insured cost

b. Uninsured cost

c. Direct cost

d. Premium cost

62. Which of the following statements is the most correct regarding implementation of a safety and health program?

a. The cost of preventing accidents must show a return on the profit line or at least avoid expenses.

b. Accidents must be prevented at any cost.

c. Accidents must be prevented if they affect the profit more than 10 percent.

d. Cost of accidents must be absorbed like the cost of any other business function.

63. The annual accident costs in the U.S. amount approximately to which of the following?

a. 1 billion dollars

b. 100 million dollars

c. 500 million dollars

d. 100 billion dollars

64. A construction company has a margin of profit of 5 percent on all its contracts. An accident occurs and the company suffers $10,000 in losses. What should the dollar value of jobs that the company bids and is awarded be to recover for this loss?

a. $50,000

b. $100,000

c. $200,000

d. $500,000

65. A telephone manufacturer suffers an accident loss of $50,000 in its manufacturing facility. If the company sells its telephones at a unit price of $20 with a margin of profit of 10 percent, the number of telephones that must be sold to cover this loss is:

a. 10,000

b. 25,000

c. 50,000

d. 100,000

66. In cost-benefit analysis, the dollar value of all costs and benefits associated with a program must be calculated:

a. On a quantitative basis only

b. On a qualitative basis only

c. On a quantitative or qualitative basis

d. Based on cost indices for each program alternative

67. A company must sell $1,000,000 worth of its product to recover $100,000 cost of loss from a recent accident in its manufacturing facility. The company's margin of profit is:

a. 10%

b. 20%

c. 5%

d. 15%

68. A television manufacturer is trying to recover from $100,000 loss. The company sells its televisions for a unit price of $300. If the company's margin of profit is 5 percent, how many television sets must the company sell to recover from this loss?

a. 2,000

b. 1,500

c. 3,000

d. 6,666

69. Overtime work required as a result of an accident is an example of which of the following costs associated with an accident?

a. Direct

b. Uninsured

c. Insured

d. Hidden

70. The first step in responding to spill of a hazardous substance is to:

a. Contain the spilled substance

b. Clean up the spilled substance

c. Identify the spilled substance

d. Ensure that people are protected

71. The evaluation of hazards posed by a spilled substance must be conducted from a safe distance located:

a. Upwind of the spill

b. Down wind of the spill

c. Cross wind of the spill

d. Only (a) and (c) above

72. If a spill that exceeds EPA reportable quantities occurs inside a building and is not released to the environment, you must contact:

    a. The National Response Center

    b. The EPA

    c. A person within the organization who is identified in SPCC

    d. The EPA and OSHA

73. The Shewhart Cycle is a concept which is used extensively in Total Quality Management. Which of the following best describes this cycle?

    a. Concept, act, plan, manage

    b. Plan, do, study, act

    c. Manage, do, act, plan

    d. Do, act, study, manage

74. Which of the following statements best describes the concept of scientific management?

    a. The job of management is to make decisions and have those decisions implemented.

    b. Management makes its decisions based on the principle of assumption of risk.

    c. Human performance can be defined and controlled through work standards and rules.

    d. Only (a) and (b) above.

75. Which of the following best describes Heinrich's theory of accident causation?

    a. Unsafe act, unsafe condition, ineffective management, injury

    b. Injury, technocracy, ineffective management, unsafe act, unsafe condition

    c. Social environment, ineffective management, accident, injury

    d. Social environment, ancestry, unsafe act/condition, accident, injury

76. Which of the following best describes the chronological order of steps involved in devising a Safety By Objective (SBO) program?

    a. Set objective, provide training, monitor the program

    b. Analyze climate, evaluate appraisal system, determine allowable objectives, train, set objectives

    c. Set objectives, provide feedback, provide training, execute, enforce

d. Determine allowable objective, set objectives, provide training, execute, monitor, enforce

77. How much money would you have in your account after 8 years if you deposit $1,000 per year starting one year from now at an interest rate of 10% compounded annually?

a. $9,762

b. $10,675

c. $11,435

d. $14,372

78. Your company plans to purchase new equipment for a manufacturing plant 5 years from now. The cost of new equipment is $2,000,000. How much should the company deposit in a bank account one year from now to be able to pay cash for the cost of the new equipment? Assume a fixed interest rate of 8 percent.

a. $500,168

b. $405,100

c. $392,155

d. $340,912

79. How much money should you be willing to pay now for a note that will yield $1,000 per year for 10 years starting next year at an interest rate of 10 percent?

a. $6,144

b. $5,293

c. $7,895

d. $4,238

80. If you deposit $5,000 dollars in an IRA account now paying an interest of 10 percent per year, how much money would you have after 15 years?

a. $11,732

b. $8,963

c. $20,886

d. $9,687

81. You are trying to purchase a new computer system. The salesclerk makes you an offer to either pay $7,000 now or $10,000 five years from now. If the interest rate is 10 percent compounded annually would you pay the $7,000 now?

a. Yes

b. No

82. In safety management theory, accidents in the work place are considered to be:

    a. Caused by failure of man or machine to perform as designed in a given environment.

    b. Symptoms of a management failure.

    c. Caused as a result of physical, chemical, biological, or ergonomics hazards.

    d. All of the above.

83. The **primary** objective of a workplace safety inspection is to:

    a. Discover situations that are in violation of federal, state, or local laws.

    b. Discover areas that should be included in the employee safety training program.

    c. Identify the probability and severity of hazards.

    d. Identify and correct unsafe conditions and unsafe acts.

84. The OSHA Incidence Rate (IR) for a company with 300 employees and 9 recordable work related injuries and illnesses and 600,000 work hours is:

    a. 5

    b. 3

    c. 4

    d. 2

85. According to Heinrich's estimates, 88 per cent of all occupational accidents are caused as a result of:

    a. Unsafe conditions

    b. Natural disasters

    c. Unsafe acts

    d. Only (a) and (c) above

86. A standard which indicates the end result to be achieved regardless of the procedures used in called:

    a. Voluntary standard

    b. Specification standard

    c. Performance standard

    d. Mandatory standard

87. Organizational safety must begin with development and implementation of a policy. Which of the following is NOT part of an organization's safety policy statement?

    a. Authority

b. Hazard analysis

c. Responsibility

d. Accountability

88. Most organizations have two major components; line and staff. Which of the following is an example of the staff component?

a. Manufacturing shift foreman

b. Security personnel

c. Sales personnel

d. Manufacturing workers

89. Staff and line members within an organization perform different functions. Line managers are involved with producing a product or delivering a service to clients while staff members assist in special matters such as finance, legal, and security. Safety must be part of:

a. Line element of an organization only

b. Line supervisors only

c. Both line and staff functions

d. Staff element only

90. Which of the following statements best describes the concept of *functional authority*?

a. Line supervisors are responsible for safety matters in their department.

b. The ultimate responsible party for safety related matters within a company are the President and Chief Executive Officer (CEO) of the company.

c. The Vice-President for manufacturing writes a letter to the safety director. The letter states that the safety director can stop any operation that he feels poses an imminent danger to the safety and health of employees.

d. The company safety policy statement must clearly assign accountability, responsibility, and authority in regard to the functional safety performance of the organization.

91. The PRIMARY objective of any accident investigation must be to:

a. Prevent future similar accidents

b. Identify the causes of accident

c. Collect evidence for legal purposes

d. Determine the equipment malfunction(s) and or human error(s) that caused the accident

92. The two major types of accident investigation are:
    a. Fault Tree and HAZOP analysis
    b. Primary and secondary
    c. Pre-accident and post-accident events
    d. General and special
93. An organization that the management closely follows the chain of command is an example of a/an:
    a. Authoritative structure
    b. Participative structure
    c. Inefficient structure
    d. Formal structure
94. Which of the following is NOT an element of 3-E's Principle?
    a. Education
    b. Efficiency
    c. Engineering
    d. Enforcement
95. "Just-in-time" inventory is used for which of the following purposes?
    a. Deliver products to customers in a timely manner.
    b. Ensure that raw materials are available for production.
    c. Reduce quantities of stored hazardous materials.
    d. Prepare a list of hazardous chemicals for compliance with OSHA's Hazard Communication Standard.
96. It is the legal responsibility of management to ensure that employee exposure to airborne hazardous substances is kept below:
    a. Threshold Limit Values (TLV)
    b. Permissible Exposure Limits (PEL)
    c. Short Term Exposure Limits (STEL)
    d. Threshold Limit Value Ceiling (TLVC)
97. The MAJOR objective of a safety inspection is to:
    a. Identify and correct unsafe conditions and unsafe acts
    b. Ensure compliance with federal, state, and local regulations
    c. Measure the effectiveness of the safety program

d. Identify any PPE which is needed in each work area

98. The cost of an injury or illness is divided into insured costs and uninsured costs. The total cost of an injury or illness is determined by:

a. Only considering the uninsured costs.

b. Subtracting the insured costs from the uninsured costs.

c. Adding the insured costs to the uninsured costs.

d. Subtracting the insured cost from the uninsured costs and dividing the result by the insured costs.

99. In workers' compensation terminology, the *no fault* system means:

a. Regardless of who is at fault the worker will be paid for workplace injuries and illnesses.

b. The employer is protected against lawsuits.

c. The worker can only be paid upon proof of negligence on the part of the employer.

d. Only a and b above.

100. An employee has been modifying the safety and health data after they have been approved by the company safety professional holding a CSP. Which approach is the most appropriate to take?

a. Verbally fire the employee on the spot.

b. Write a letter to company headquarters requesting permission to investigate the case.

c. Call OSHA.

d. Set up a meeting with the employee and the management in order to investigate the case.

101. Which of the following statements BEST describes an OSHA Performance Standard?

a. Employers with incidence rates of 2.5 or greater must upgrade their safety performance or are in violation of this standard.

b. Specific objectives must be obtained regardless of a specific method.

c. Specific objectives must be obtained using OSHA approved methods.

d. Only (a) and (c) above.

102. A Type I error in the testing of a hypothesis indicates:

a. A valid hypothesis was rejected.

b. An invalid hypothesis was accepted.

c. A valid hypothesis was accepted.

d. An invalid hypothesis was rejected.

103. Which of the following organizations sets codes for hydrostatic pressure testing of vessels?

a. ASME

b. AICHE

c. ASSE

d. ASHE

104. The total area under a normal probability distribution curve represents probability of 100%. The tests of hypothesis fall into two broad categories; two-tailed and one-tailed tests. One-tailed tests of hypothesis are conducted when one is interested in deviation of what has been observed versus what has been hypothesized in the ___-_____ direction(s).

a. Both positive and negative

b. Either positive or negative

c. Vertical

d. Horizontal

105. The management technique that graphically demonstrates management styles by assigning values to the manager's concern for people and production is known as:

a. MORT

b. Theory Y

c. The Blake Moulton Management Grid

d. The Likert Scale

106. Which of the following is the mental ability test that is used to measure an individual's IQ?

a. Student T-Test

b. Herzberg Test

c. Barlo Test

d. Otis Test

107. A team or group's cohesiveness is a critical factor in the success of the team or group in accomplishing its objectives. Which of the following statements BEST describe the concept of cohesiveness within a team or group?

a. Cohesiveness is the goal setting process by the members of a team or group.

b. Cohesiveness is the degree that members of a team or a group desire to remain in the team or group.

c. Cohesiveness is the establishment of all sets of rules and policies necessary for the group to accomplish its objectives.

d. Cohesiveness is the ability of the team or group leader to direct the team or group in the right direction.

108. Which of the following statements BEST describes the Likert Scale?

a. It is used in quality control to distinguish between patent defect and latent defect in a product batch.

b. It is a graph of budgeting vs. scheduling that measures a manager's effectiveness.

c. It is used to measure attitudes, preferences, and subjective reactions.

d. It is a site map about accessibility, groupware, and usability.

109. In the Hawthorne Studies, investigators found no strong relationship between workplace conditions and worker productivity. However, the investigators reached several conclusions. Which of the following is NOT a conclusion of the Hawthorne Studies?

a. Sentiments and participation can reduce resistance to change.

b. The workplace is an interlocking social system, not simply a production system.

c. Employees should not be considered appendages of machinery.

d. Motivation factors such as salary and vacation time play a very important role in the implementation of a behavioral-based safety culture.

110. A company with 5 lost workdays (LWD) in a calendar year and 200 employees working 50 weeks in a calendar year for 40 hours a week has an LWDI of:

a. 6.3

b. 2.5

c. 4.0

d. 7.5

111. A manufacturing company had an LWDI equal to 4 in a given calendar year. The company has 200 employees who, on the average, worked 40 hours per week for 50 weeks. What is the actual number of lost workdays for this company?

a. 3

b. 4

c. 5

d. 8

112. The LWDI for a company in a given calendar year was equal to 5. Each employee worked for 50 weeks for an average of 40 hours per week. Assuming that the actual number of lost day cases was 10, the number of employees working for this company is:

    a. 200

    b. 250

    c. 300

    d. 400

113. Application of water-based foam to a flammable liquid fire has the potential for creating which of the following?

    a. Boiling liquid expanding vapor explosion (BLEVE)

    b. High-volume mixture of steam, air, and burning fuel

    c. Phosgene gas due to breakdown of halon 1301 in water-based foam

    d. Large amount of toxic carbon dioxide gas

114. A cab company conducted a study of their accident frequency for 200 days. At the conclusion of the study, it was found that the probability of NOT having an accident is 0.99. This means that, on the average, the cab company experiences an accident every_____ days.

    a. 20

    b. 100

    c. 200

    d. 50

115. Management commitment, site analysis, hazard prevention and control, and safety and health training are the four major components of which of the following programs?

    a. OSHA Voluntary Protection Program

    b. OSHA Hazard Communication Program

    c. EPA Toxic Substances Control Program

    d. OSHA Emergency Response Program

116. When setting safety and environmental goals, the goals must have all of the following qualities EXCEPT:

    a. Be measurable

    b. Be reportable

    c. Be achievable

d. Have a time frame

117. A coefficient of correlation of 0.95 between two variables indicates that:

a. The variables are almost directly proportional to each other.

b. The variables are almost inversely proportional to each other.

c. There is no correlation between the two variables.

d. No statistical inferences can be made about the variables under study.

118. A company has five plants at different geographical locations. At the conclusion of the same comprehensive safety training program given at each plant, the same test was given to trainees to measure their level of understanding of the materials covered in the training program. Subsequently, the same outside consulting firm to measure the safety performance at each facility conducted a two-month audit at each facility. The audit results were ranked on a scale of 1 to 10, with 1 being the worst and 10 being the best safety performance. The results are tabulated below.

Plant	Average Test Score	Safety Performance
1	72	7
2	67	7
3	81	9
4	82	8
5	72	5

Based on the data presented, the coefficient of correlation is:

a. 0.275

b. - 0.275

c. 0.658

d. 0.346

119. The coefficient of correlation for two variables is 0.95 at 0.01 significance level. This means that:

a. The two variables have a strong direct relationship but there is a 1% chance that the conclusion is wrong.

b. The two variables have a strong inverse relationship but there is a 99% chance that the conclusion is wrong.

c. The two variables have a strong inverse relationship but there is a 1% chance that the conclusion is wrong.

d. The two variables have a strong direct relationship but there is a 99% chance that the conclusion is wrong.

120. Which of the following statements is true?

a. OHSAS 18000 is an international occupational health and safety management system specification.

b. OHSAS 18000 was created via a concerted effort from a number of the world's leading national standards bodies, certification bodies, and specialist consultancies.

c. OHSAS 18000 actually forms part of the acclaimed Health and Safety Electronic Kit.

d. All of the above.

121. Which of the following is considered to be the best approach in an audit process?

a. When possible, auditors should verify in person that management processes are implemented.

b. Verify compliance by interviewing the management team.

c. Verify compliance by interviewing employees.

d. Verify compliance by interviewing both management and employees.

122. Which of the following can best achieve impartiality during an audit process?

a. Not having any line or operational responsibility for the task

b. Understanding the code of ethics for the organization

c. Setting the goals and objectives for the audit process

d. Having complete management support

123. The following data was compiled after a one-year study at ABC plant. What is the expected cost of all incidents in a given year?

Probability	Incident Cost
0.15	$1,000
0.20	$5,000
0.35	$7,000
0.30	$2,000

a. $4,200

b. $7,500

c. $3,700

d. $6,800

124. Which of the following is required to be independent of line management?

a. Safety training personnel

b. Safety audit teams

c. Contractors

d. All of the above

125. All of the following statements are true in regards to Pareto charts and the Pareto principle EXCEPT:

a. The probability of risk can be calculated from the area under the curve.

b. 20% of the problems cause 80% of the risk.

c. A Pareto chart can be constructed by segmenting the range of data into groups.

d. A Pareto chart is used to graphically summarize and display the relative importance of the differences between groups of data.

126. Which of the following describes management leadership and effective employee participation as crucial factors contributing to the success of safety and health programs within organizations?

a. ANSI Z10

b. EPA Form R

c. Institute of Safety and Systems Management

d. Center for Occupational Safety and Health

127. Which of the following ISO standards deals with managing and conducting quality environmental audits?

a. ISO 2001

b. ISO 17008

c. ISO 19011

d. ISO18007

128. When selecting jobs for Job Safety Analysis, all of the following are important factors to consider EXCEPT:

a. Jobs that have high probability of leading to an incident

b. Jobs that have potential for causing a high severity incident

c. New jobs

d. Jobs that are stressful to some employees

129. The root cause of any workplace incident/accident is considered to be:

a. A number of interacting factors

b. Lack of sufficient employee training

c. Lack of proper communication

d. Poor management

130. A project is to be carried out in three phases. The error rate for Phase One is 0.34%, for Phase Two is 0.54%, and for Phase Three is 0.24%. The mean error rate for this project is:

    a. 0.0037

    b. 0.0560

    c. 0.0024

    d. 0.0067

131. Which of the following is the most important consideration in developing a data collection system?

    a. Ensure that the data is compatible for statistical use.

    b. Ensure that statistical inferences can be drawn from the data.

    c. Define how the data is going to be used.

    d. Ensure that the data represent the population under study.

132. All of the following are elements of an effective loss control system EXCEPT:

    a. Hazard identification

    b. Assessment of risks associated with the hazards

    c. Establishment of chain of custody procedures

    d. Development of means to control the risks

133. Which of the following best describes the most important step in an incident investigation program?

    a. Collect meaningful data for subsequent analysis.

    b. Preserve evidence and interview witnesses.

    c. Ensure that appropriate regulatory agencies are notified.

    d. Determine the casual factors and root causes that led to the incident.

134. Which of the following IS NOT an element of an effective system safety program plan?

    a. Define the elements and their needs for the mission.

    b. Identify means to improve the safety performance of an existing system.

    c. Identify safety deficiencies.

    d. Determine the Mean Time Between Failures (MTBF) for the system.

135. Which of the following is used to demonstrate the difference between actual expenditure at a given time and the projected budget for a project?

    a. Gantt chart

b. Budget variance report

c. Budget slack report

d. Budget bar chart

136. In a manufacturing facility, the management has established a goal to have no lost time injury for 500 days. This is an example of:

a. Benchmarking

b. Safety coaching

c. Mission statement

d. All of the above

137. Which of the following statements in regard to incidence rates is INCORRECT?

a. Incidence rates are excellent indicators of an organization's safety performance.

b. Incidence rates are lagging indicators of safety performance.

c. Overall, incidence rates alone cannot measure safety performance.

d. The standard for calculating incidence rates is an organization with 100 employees who work 40 hours per week for 50 weeks a year.

138. Which of the following statements BEST describes the purpose of ISO 9000?

a. The ISO 9000 family is primarily concerned with quality management.

b. The ISO 9000 family is primarily concerned with environmental management.

c. The ISO 9000 family is primarily concerned with proper management of occupational safety within organizations.

d. The ISO 9000 family is primarily concerned with the customer's quality requirements.

139. Which of the following statements BEST describes the overall purpose of ISO 14000?

a. The ISO 14000 family is primarily concerned with quality management.

b. The ISO 14000 family is primarily concerned with environmental management.

c. The ISO 14000 family is primarily concerned with proper management of occupational safety within organizations.

d. The ISO 14000 family is primarily concerned with the customer's quality requirements.

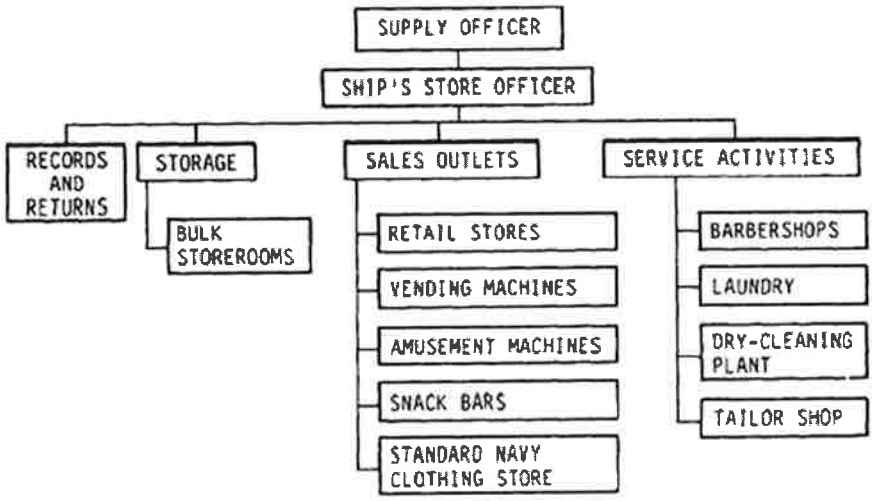
140. The organizational chart shown below is an example of a:

a. Matrix chart

b. Functional chart

c. Box chart

d. Flow chart



141. All of the following statements are true in regard to Pareto charts EXCEPT:

a. A Pareto chart is used to graphically summarize and display the relative importance of the differences between groups of data.

b. The probability can be calculated from the area under the curve.

c. A Pareto chart can be constructed by segmenting the range of the data into groups.

d. The left-side vertical axis of the Pareto chart is labeled Frequency (the number of counts for each category), the right-side vertical axis is the cumulative percentage, and the horizontal axis is labeled with the group names of your response variables.

142. Based on the information presented in Table 1, the number of recordable injuries for Plant B in 2004 is:

a. 15

b. 120

c. 50

d. 12

Table 1: Injury Information for Company X in 2004

Plant	# Injuries Treated with First Aid	# Injuries Treated Beyond First Aid	# Lost Work Days Due to Injuries	# Employees
A	25	10	80	400
B	35	15	120	600
C	40	30	200	900

143. Based on the information presented in Table 1, and assuming that each employee works 8 hours per day, 5 days a week, 50 weeks in a calendar year, the LWDI for Plant C in 2004 is:

a. 6.66

b. 22.22

c. 4.50

d. 18.32

Table 1: Injury Information for Company X in 2004				
Plant	**# Injuries Treated with First Aid**	**# Injuries Treated Beyond First Aid**	**# Lost Work Days Due to Injuries**	**# Employees**
A	25	10	80	400
B	35	15	120	600
C	40	30	200	900

144. Based on the information presented in Table 1, and assuming that each employee works 8 hours per day, 5 days a week, 50 weeks in a calendar year, the OSHA Incident Rate (IR) for recordable injuries in 2004 in Plant A is:

a. 8.50

b. 2.50

c. 5.00

d. 8.00

Table 1: Injury Information for Company X in 2004				
Plant	**# Injuries Treated with First Aid**	**# Injuries Treated Beyond First Aid**	**# Lost Work Days Due to Injuries**	**# Employees**
A	25	10	80	400
B	35	15	120	600
C	40	30	200	900

145. Based on the information presented in Table 1, the total number of recordable injuries for all plants in 2004 is:

a. 155

b. 85

c. 55

d. 400

Table 1: Injury Information for Company X in 2004				
Plant	**# Injuries Treated with First Aid**	**# Injuries Treated Beyond First Aid**	**# Lost Work Days Due to Injuries**	**# Employees**
A	25	10	80	400
B	35	15	120	600
C	40	30	200	900

146. Which of the following statements best describes the process of adsorption?

a. Removal of a component of a liquid mixture by another liquid

b. Removal of a component of a gas mixture by a liquid

c. Removal of a component of a liquid mixture by a gas

d. Removal of one or more components of a gas mixture on a solid bed

147. Factors that affect safety effectiveness include behavioral influence as well as motivational factors. Which of the following is an example of behavioral influence?

a. Achievement

b. Advancement

c. Church

d. Responsibility

148. An employee is recognized by his boss for excellent safety performance. This is an example of an:

a. Intrinsic reward

b. Extrinsic reward

c. Internal reward

d. Only (a) and (c) above

149. Which of the following statements is an example of a motivation factor according to Herzberg's "Motivation-Hygiene" theory?

a. Raise in salary

b. Responsibility

c. Company policy

d. More vacation time

150. Being independent of line management is a requirement for which of the following?

a. Safety training personnel

b. Safety audit teams

c. Contractors

d. All of the above

151. All of the following statements are true in regard to Pareto charts and the Pareto principle EXCEPT:

a. The probability of risk can be calculated from the area under the curve

b. 20% of the problems cause 80% of the risk

c. A Pareto chart can be constructed by segmenting the range of data into groups

d. A Pareto chart is used to graphically summarize and display the relative importance of the differences between groups of data

152. Which of the following statements is correct in regard to OHSAS 18001?

a. Calls for continuous improvement in safety and health management systems

b. Sets standards to predict the financial health of an organization

c. Sets standards for proper environmental management and in particular proper disposal of hazardous wastes

d. Sets standards for pollution prevention

153. The safety office of Company XYZ reports an average of four lost time injuries in the past three months. What is the probability that there will be three or less lost time injuries in the next three months?

a. 0.2754

b. 0.3265

c. 0.4332

d. 0.14618

154. According to the *Harvard Business Review*, one of the reasons people resist change is excess uncertainty. Which of the following statements is NOT an example of excess uncertainty?

a. A change that feels like walking off a cliff blindfolded

b. A change that feels like heading toward an unknown

c. A change that interferes with autonomy and can make people feel that they have lost control over their territory

d. A change that can be described by the saying "Better the devil you know than the devil you don't know."

155. The balanced scorecard developed by Robert Kaplan and David Norton of Harvard Business School suggests that we view organizations from four perspectives. It also suggests that we develop metrics, collect data, and analyze organizations relative to each of these perspectives. Which of the following is NOT one of the four perspectives used in scorecards?

a. Learning and growth

b. Management philosophy

c. The business process

d. The customer

156. All of the following statements in regard to annual performance reviews are true EXCEPT:

a. The manager and employee should review any agreed-upon next steps from the most recent performance review.

b. The manager and employee should focus on job performance and not obstacles encountered.

c. The manager should focus on observable review.

d. The review must be documented.

157. There are three basic sign categories used in the workplace. Which of the following is NOT one of these three basic categories?

a. Regulatory

b. Warning

c. Information

d. Danger

158. Total quality management (TQM) processes are divided into four sequential phases. Which of the following is NOT one of these four phases?

a. Planning

b. Doing

c. Checking

d. Improving

159. It is estimated that each year over 1.5 million patients in US hospitals become victims of medication errors. Which of the following techniques is most effective in preventing medication errors in hospitals?

a. Spectrometry

b. Barcoding

c. Pharmacometry

d. Have the nurse consult with the pharmacist prior to administering any medication

160. The Consumer Product Safety Commission (CPSC) administers product recalls. Which of the following is NOT part of initiating a product recall?

a. Stop production

b. Isolate inventory

c. Test replacement or repair

d. Keep posters up in retail locations for 120 days or longer

161. Maslow's hierarchy of needs states that we must satisfy each of our needs in turn, starting with the most obvious need for survival itself. Maslow's hierarchy of needs has five levels. Which of the following is NOT one of these five levels?

a. Esteem

b. Money

c. Belonging and love

d. Safety

162. Which of the following statements is NOT true in regard to job safety analysis (JSA)?

a. Describes job tasks in step-by-step fashion

b. Identifies associated hazards at each step

c. Outlines proper hazard controls to minimize the risk of injury or illness

d. JSA should not be created by the work group performing the task and should be conducted by an independent team.

163. Which of the following statements BEST describes conditional probability?

a. Probabilities are contingent on a previous result

b. Probabilities are calculated by logically examining existing information

c. A probability derived from an individual's personal judgment about whether a specific outcome is likely to occur.

d. A statistical function that describes all the possible values and likelihoods that a random variable can take within a given range

164. Which of the following is NOT an indirect cost of accidents?

a. Training replacement workers

b. Accident investigation

c. Repairing damaged property

d. Workers' compensation claims

165. There are several theories of accident causation. Which of the following is NOT one of these theories?

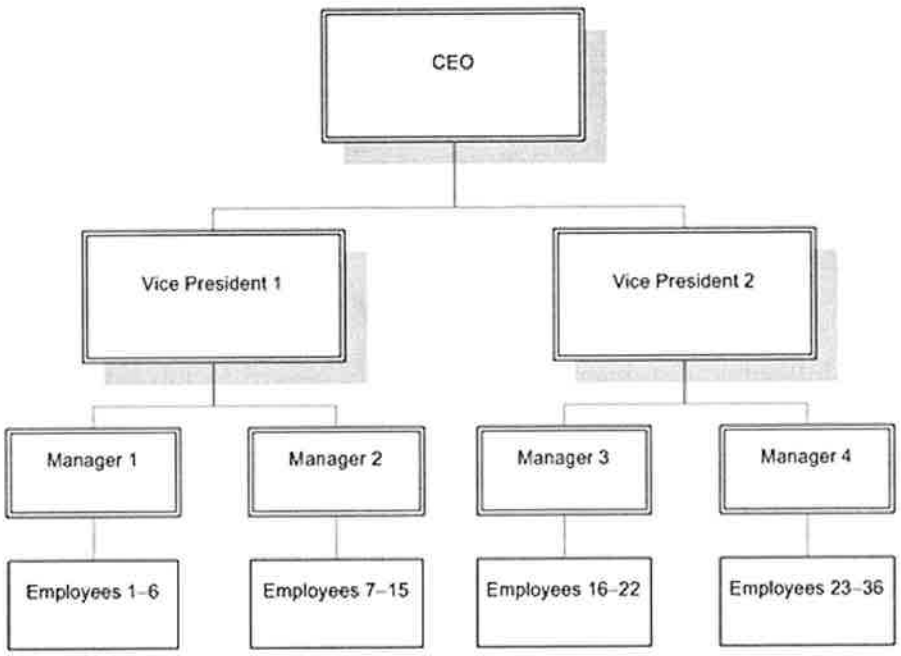
a. The domino theory

b. Epidemiological theory

c. System theory

d. Training theory

166. What type of organization chart does the diagram below represent?



a. Hierarchical

b. Matrix

c. Operational

d. Supervisional

167. The Hawthorne studies suggested that worker productivity gains occurred due to the impact of _____ effects on the workers.

a. Emotional

b. Motivational

c. Behavioral

d. All of the above

168. Which of the following is NOT part of the process of management by objective (MBO)?

a. The planning process is delegated to all members of the company

b. The organization must monitor performance measures

c. The plan can be modified when needed

d. It is a tightly controlled system of management

169. All of the following statements are true regarding program evaluation and review technique (PERT) except:

a. It is a statistical tool

b. It analyzes the tasks involved in completing a project

c. It is not suitable for planning and scheduling large and complex projects

d. It specially focuses on the time needed to complete each task in a project

170. All of the following are examples of OSHA horizontal standards EXCEPT:

a. Fire protection

b. The construction industry

c. Working

d. First aid

171. All of the following are part of safety in the design of playgrounds EXCEPT:

a. Playgrounds must be designed for one age group.

b. Equipment with moving parts must be separated from the rest of the playground.

c. For high surfaces, guard rails and protective barriers must be installed.

d. Children must be under adult supervision while in the playground.

172. According to the Consumer Products Safety Commission (CPSC), which of the following statements is true regarding a public playground safety checklist?

a. Make sure surfaces around playground equipment have at least 12 inches of wood chips, mulch, sand, or pea gravel, or are mats made of safety-tested rubber or rubber-like materials.

b. Check that protective surfacing extends at least 6 feet in all directions from play equipment. For swings, be sure surfacing extends, in back and front, twice the height of the suspending bar.

c. Make sure play structures more than 30 inches high are spread at least 9 feet apart.

d. All of the above

173. Which of the following IS NOT considered an essential function of a management team?

a. Dependency on each other

b. Open communication

c. Having a real reason for existing

d. Provide required safety training to subordinates

174. Which of the following has the direct responsibility and accountability to ensure that the company's health and safety policies are properly enforced?

a. Safety director

b. Line management

c. Top management

d. All of the above

175. Which of the following IS NOT an essential part of an effective employee performance appraisal interview?

a. Indicating that all employees may have problems and that this is not unusual.

b. Helping the employee to take a positive approach to his/her problems.

c. Ensuring that the performance review is based on factors that can be measured objectively.

d. Identifying the nature of the problems and why they happened.

176. The _____ of a project is defined as the work that, when properly completed, results in the success of the project.

a. Critical path

b. Scope

c. Sound management

d. Contingency

177. In project management, a hierarchical decomposition of work with specific objectives and deliverables at each level is called:

a. Work Breakdown Structure

b. Work Decomposition Plan

c. Formal Decomposition Plan

d. Goal Identification Plan

178. Gantt charts used in project scheduling are also called:

a. Pie charts

b. Matrix charts

c. Bar charts

d. Time charts

179. When significant operational or process changes are considered, the management should place priority on which of the following?

a. Perform a change analysis to understand the impacts of changes being considered.

b. Perform a fault tree analysis to understand the possible incident scenarios.

c. Ensure that all employees are informed about the impacts of changes on safety.

d. Provide training for employees who are affected by implementing the changes.

180. Which of the following statements is NOT true?

a. Line supervisors are interested in doing those tasks that they think are being measured.

b. Line supervisors are more interested in performing those tasks that they think they will be rewarded for doing.

c. Line supervision should be provided with written organization policies for enforcement and accountability.

d. Line supervisors are equally interested in performing all of their duties whether they are measured or not.

181. Which of the following statements BEST describes the role or function of a safety committee?

a. The committee must have meetings at least once a week.

b. The committee must have at least one representative from each department within the organization.

c. The committee must set goals and objectives and measure its performance against achieving those goals and objectives.

d. The committee must have at least one member who is familiar with safety features of all processes used in the organization.

182. Benchmarking can be a very effective tool in safety training. Which of the following statements best describes the process of benchmarking?

a. Using information about other companies' training practices.

b. Identifying potential training needs.

c. Identifying what the trainees should do after the training process.

d. Determining how the company's business strategy influences safety training.

183. All of the following are elements of a successful communication process EXCEPT:

a. Sender

b. Message

c. Interpretation

d. Receiver

184. ISO 14001 deals with which of the following?
    a. Sets out the criteria for an environmental management system
    b. Sets out a framework for safety management in the workplace
    c. Sets out standards for minimizing of global warming
    d. All of the above
185. *Safety and Health* is the official journal of which of the following organizations?
    a. American Society of Safety Engineers (ASSE)
    b. American Industrial Hygiene Association (AIHA)
    c. National Safety Council (NSC)
    d. Board of Certified Safety Professionals (BCSP)
186. NEISS is an acronym for:
    a. National Electronic Injury Surveillance System
    b. National Emergency Information Support System
    c. Navigational Emergency Information Support System
    d. National Employee Information Support System
187. The major objective(s) of injury data collection within an organization is:
    a. To make comparisons of the progress of the safety program
    b. To analyze methods of approach to safety
    c. To assist in settlement of Workers' Compensation cases
    d. All of the above.
188. The run chart is one of the most powerful and simple statistical tools for data analysis. The run chart is a:
    a. Plot of data over a period of time
    b. Plot of the mean as a function of the standard deviation
    c. Plot of experimental runs as a function of experimental results
    d. Plot of equipment failures as a function of operating conditions
189. Which of the following techniques is more commonly used to analyze accident investigation data?
    a. HAZOP
    b. Preliminary Hazard Analysis
    c. What If Analysis

d. MORT

190. Use of OSHA incident rate in evaluation of the effectiveness of a safety and health program is an example of:

a. Qualitative measurement

b. Legal measurement

c. Cause-consequence measurement

d. Quantitative measurement

191. Which of the following is NOT a necessary element of a valid contract?

a. Amount of investment by each party.

b. Legal matters associated with the contract.

c. Definition of mutuality of obligations.

d. Subject matter of the contract.

192. The employer must record information, on OSHA Form 300, about every work-related injury or illness that involves ANY of the following EXCEPT:

a. Loss of consciousness

b. Job transfer

c. Restricted work activity

d. Treatment by first aid only

193. In order to create a Total Safety Culture within an organization, the management must pay attention to three major areas. Which of the following is NOT one of these three major areas?

a. Behavioral factors

b. Engineering factors

c. Environmental factors

d. Personal factors

194. There are many unique characteristics about a real team which lead to success. Which of the following IS NOT true regarding a real team?

a. Members share common purpose and goals

b. Members are often evaluated as individuals

c. Members hold themselves mutually accountable

d. Members process complimentary skills

195. Which of the following is NOT considered to be a component of team performance?

a. Attitude

b. Behavior

c. Reinforcement

d. Knowledge

196. The coefficient of correlation is often used to determine the nature of relationship between two variables such as the relationship between safety inspections and the number of unsafe conditions or unsafe acts. The coefficient of correlation is a range of variance between:

a. Zero (0) and plus one (+1)

b. Negative one (–1) and zero (0)

c. Negative one (–1) and plus one (+1)

d. Plus one (+1) and plus two (+2)

197. The number of safety inspections and the number of on the job injuries have a coefficient of correlation of –0.95 in company XYZ. Which of the following statements is true?

a. Safety inspections can help to reduce the number of injuries.

b. Safety inspections actually cause the number of injuries to increase.

c. Safety inspections have no significant effect on the number of injuries.

d. The coefficient of correlation can not be negative. It is a number between 0 and +1.

198. *The Synergist* is a monthly periodical that provides information on occupational and environmental health. Which of the following organizations publishes this periodical?

a. The American Industrial Hygiene Association

b. The American Conference of Governmental Industrial Hygienists

c. The Environmental Protection Agency

d. The National Safety Council

199. *Professional Safety* is the official publication of the:

a. System Safety Society

b. American Society of Safety Engineers

c. American Society of Professional Safety Engineers

d. National Safety Council

200. Nowadays, many employers support telecommuting. This can offer cost benefits to the company and time and lifestyle benefits to the employee. By far, the most common location for telecommuting is:

a. Hotels

b. Satellite offices of the company

c. Employee's car

d. Employee's home

201. All of the following are examples of spreadsheet software EXCEPT:

a. Excel

b. VisiCalc

c. PowerPoint

d. Lotus

202. All of the following are BCSP professional membership organizations EXCEPT:

a. Society of Fire Protection Engineers

b. Institute of Industrial Engineers

c. American Board of Industrial Hygiene

d. System Safety Society

203. Which of the following provides the most efficient way to make Material Safety Data Sheets available to employees within an organization?

a. Internet

b. Microsoft Internet Explorer

c. HTTP

d. LAN

204. Which of the following organizations is responsible for certifying industrial hygiene laboratories?

a. ASSE

b. ABIH

c. AIHA

d. ABHL

205. Which of the following statements is true in regard to the Poisson distribution?

a. 65 percent of the population falls within four standard deviations.

b. It is used to model the number of events occurring within a given time interval.

c. It is used to optimally distribute resources among competing events.

d. It is used to calculate the distribution of events that are outside a sample space.

206. Which of the following statements is NOT true in regard to cleaning up a small mercury spill?

a. Sprinkle zinc or sulfur powder on the spill site after the visible particles of mercury have been removed.

b. Use an industrial vacuum cleaner and dispose the bags as hazardous waste.

c. Never use a broom on a mercury spill.

d. Never pour mercury down the drain.

207. The coefficient of correlation for two variables is 0.95 and is significant at the 2% level. This indicates that:

a. There is almost a positive linear relationship between the two variables and there is a 2% probability that the coefficient of correlation resulted from chance.

b. There is almost a positive linear relationship between the two variables but there is a 98% probability that the coefficient of correlation resulted from chance.

c. There is almost an inverse linear relationship between the two variables but there is a 2% chance that the coefficient of correlation resulted from chance.

d. There is almost an inverse linear relationship between the two variables but there is a 98% probability that the coefficient of correlation resulted from chance.

208. Which of the following is the most important reason for investigating a workplace accident?

a. Comply with legal requirements

b. Determine the cost of an accident

c. Process workers' compensation claims

d. Prevent similar accidents in the future

209. A RACI chart is a matrix for all decision making authorities and activities in an organization set against all the people or roles. RACI is an acronym for:

a. Responsible, accountable, consulted, and informed

b. Responsible, accountable, conveyable, and informed

c. Reproducible, accountable, conveyable, and informed

d. Responsible, accountable, conveyable, and institutionalized

210. In managing many projects, a chart is often used that identifies the responsible role, accountable role, consulted role, and informed role for each task of the project. This chart is called:

    a. RACI chart

    b. Project matrix chart

    c. ICRA chart

    d. ARCI chart

211. In project management, comparison of actual performance with potential or desired performance is called:

    a. Goal analysis

    b. Performance evaluation

    c. Gap analysis

    d. Slack analysis

212. A simple accident causation model groups the causes of any accident into five categories. Which of the following are elements of these categories?

    a. Material

    b. Management

    c. Personnel

    d. All of the above

213. Which of the following is NOT an example of types of group health plans in the workplace?

    a. Fully-insured group health insurance plans

    b. Self-insured health insurance plans

    c. Self-insured medical reimbursement plans

    d. Partially-insured group health plans

214. Management theories are implemented to optimize productivity and service quality of an organization. All of the following statements in regards to management theories are correct EXCEPT:

    a. In "Contingency theory" managers make decisions based on the situation at hand

    b. In "Systems theory" managers recognize how different systems affect a worker and how a worker affects the systems around them

    c. In "Chaos theory" change is considered to be inevitable and is rarely controlled.

d. Theory "y" assumes that workers are not naturally driven and do not want to take responsibility

215. Accident models have evolved over time and can be characterized by three models. All of the following are considered to be accident models EXCEPT:

a. Sequence of events model

b. MORT

c. Epidemiological or latent failure model

d. Systemic model

216. Which of the following statements is/are true in regards to ANSI Z10 standard?

a. The Z10 standard defines minimum requirements for an occupational safety and health management system.

b. The Z10 standard sets forth standards for proper selection and use of hard hats.

c. The Z10 standard covers new steps for lockout/tagout procedures.

d. The Z10 standard sets forth requirements for a sound environmental management system.

217. Which of the following statements is/are true in regards to OHSAS 18000?

a. It sets forth an environmental management system to optimize management efficiency.

b. It is a family of international standards relating to occupational health and safety management.

c. It sets forth new standards for sound management techniques in construction industry.

d. All of the above.

218. Which of the following statements is/are true in regards to ISO 19011?

a. It is an international standard for proper management of accident investigations.

b. It is an international standard that sets forth guidelines for management systems auditing.

c. It is an environmental management system for proper management of hazardous wastes operations.

d. All of the above.

219. Under the "management of change" element of the Process Safety Management standard, the employer is responsible for implementing written procedures to manage changes. These procedures must ensure that all of the following issues are addressed EXCEPT:

a. The technical basis for the proposed change.

b. Modifications to operating procedures.

c. Necessary time period.

d. The effect of change on the compliance audits program.

220. Which of the following has "plan, do, check, and act" as four of its basic elements?

a. OHSAS 20001

b. OHSAS 18001

c. OHSAS 19001

d. OHSAS 17001

221. Which of the following statements is true about confined spaces?

a. Always have toxic chemicals in their atmosphere

b. Have limited means for entry or exit

c. They must not be entered without an air purifying respirator.

d. All the above

222. OSHA standards require safe means of access and egress to all excavations. Ladders, steps, ramps, or other safe means of exit must be provided for workers working in trench excavations 4 feet (1.22 meters) or deeper. These devices must be located within _____ feet of all workers.

a. 10

b. 25

c. 50

d. 5

223. Which of the following is NOT one of the four protective measures to ensure excavation safety?

a. Soil stabilization

b. Benching

c. Sloping

d. Shoring

224. OSHA requires the use of fall protection when construction workers are working at heights of _____ feet or greater above a lower level.

a. 4

b. 10

c. 6

d. 8

225. Which of the following statements is correct regarding safe use of ladders?

a. Always maintain a 2-point (one hand and a foot) contact on the ladder when climbing.

b. An extension or straight ladder used to access an elevated surface must extend at least 3 feet above the point of support.

c. The proper angle for setting up a ladder is to place its base a third of the working length of the ladder.

d. All the above.

226. A ladder that is 20 feet from the base to the top support must be placed in such a way that the base distance from the vertical plane of the top support is:

a. 10 ft.

b. 5 ft.

c. 2 ft.

d. 1 ft.

227. Fall protection systems can be categorized as "passive" or "active". There are two types of active fall protection systems, fall arrest and _____ systems:

a. Stationary

b. Netting

c. Point fall protection

d. Fall restraint

228. An employee working for a manufacturing facility is responsible for cleaning and maintenance of a storage tank which cannot support life due to its oxygen deficiency. To perform these tasks, the employee must enter the tank. Which of the following is a requirement which must be set forth by the management of this organization?

a. Obtain a permit prior to entry.

b. Restrict access by unauthorized personnel.

c. Use proper PPE.

d. All the above.

229. Which of the following must be the first step to be taken prior to entry into a confined space?

a. Ensure that the appropriate type of Personal Protective Equipment is available.

b. Conduct a lockout/tagout.

c. Test the atmosphere.

d. Notify the emergency personnel.

230. A "Lock-out/Tag-out" system is used to:

a. Keep people from stealing your tools

b. Prevent accidental contact with electrical current

c. Keep you from completing your work

d. Add another step to your work

231. OSHA requires [1910.212(a)(1)] that the employer to provide one or more methods of machine guarding to protect the operator and other employees from hazardous mechanical motion or action. Which of the following IS NOT an example of hazardous mechanical motion or action requiring machine guarding?

a. Point of operation

b. Ingoing nip points

c. Rotating parts

d. Vibrating parts

232. _____ machine guards shut off or disengage power and prevent the machine from starting when the guard is opened.

a. Fixed

b. Adjustable

c. Interlocked

d. Self-adjusting

233. OSHA regulations require that the Confined Space Entry Plan for Permit-Required Situations be reviewed, and if necessary, updated:

a. Every 2 years.

b. Annually.

c. After an emergency.

d. Annually and after an emergency.

234. OSHA requires that the minimum distance between a crane and any overhead obstruction be:

a. 1 foot

b. 5 feet

c. 12 inches

d. 3 inches

235. Which of the following is the main purpose of lockout/tagout procedures?

    a. To prevent unauthorized entry into secured areas.

    b. To ensure that electrical equipment perform as their design intent.

    c. To prevent voltage surcharges which might damage the equipment.

    d. To isolate equipment or machinery that use electricity from their power sources before maintenance or servicing work.

236. All the following are components of a personal fall arrest system EXCEPT:

    a. Anchor

    b. Sling

    c. Body harness

    d. Connecting device

237. There are four different types of machine guards. Which of the following does not belong to the four categories of machine guards?

    a. Fixed

    b. Adjustable

    c. Self-adjusting

    d. Automatic

238. Cranes must meet the design specifications of which of the following organizations?

    a. American Society of Civil Engineers (ASCE)

    b. American National Standard Institute (ANSI)

    c. Consumer Products Safety Commission (CPSC)

    d. National Safety Council (NSC)

239. The best material for a step ladder used by an electrician who may be working near energized conductors is:

    a. Wood

    b. Fiberglass

    c. Aluminum

    d. Steel

240. Appendix A in 29 CFR 1926 Subpart P dealing with trenching applies when a sloping or benching system is designed as a method of protection for employees from cave-ins. OSHA requires that each soil and rock deposit be classified by a competent person as:

    a. Stable Rock, Type A, Type B, or Type C.

b. Porous, Solid, Gravel, Sand

c. Clay, Moist, Solid

d. Type G, clay, Sand

241. Which of the following statements is true about the Delphi Technique?

a. It is a structured communication technique.

b. It is a system safety Technique.

c. It is a statistical technique for prediction of human error.

d. It was used by ancient Greeks for design of structural systems.

242. Which of the following statements is true about OSHA's Voluntary Protection Programs (VPP)?

a. The Voluntary Protection Programs (VPP) promote effective worksite-based safety and health.

b. In the VPP, management, labor, and OSHA establish cooperative relationships at workplaces that have implemented a comprehensive safety and health management system.

c. Approval into VPP is OSHA's official recognition of the outstanding efforts of employers and employees who have achieved exemplary occupational safety and health.

d. All the above

243. Which of the following statements is true regarding a type II error?

a. Incorrect rejection of a true null hypothesis.

b. Correct rejection of a null hypothesis.

c. Failure to reject a false null hypothesis.

d. All the above.

244. In Globally Harmonized System (GHS), the pictogram shown below represents:

a. Toxicity

b. Explosivity

c. Flammability

d. Environmental hazard



245. In Globally Harmonized System (GHS), the pictogram shown below represents:

a. An oxidizing agent

b. Flammability

c. Corrosivity

d. Explosivity



246. OSHA requires inspection of trenches on a _____ basis and as conditions change to ensure elimination of excavation hazards.

a. Weekly

b. Daily

c. Biweekly

d. Hourly

247. 24. Ropes used for material handling must be inspected at least once every _____ days.

a. 7

b. 10

c. 30

d. 14

248. Ropes, chains, and slings should never be used to lift a load if they have which of the following?

a. Kink

b. Twist

c. Knot

d. Any of the above

249. ISO 45001 deals with which of the following?

a. Occupational health and safety management systems

b. Environmental management

c. Toxic substances control management

d. Process safety management

250. A set of data has a Pearson correlation coefficient of 0.5 between the dependent and independent variables. This indicates that:

a. As the independent variable increases, the value of the dependent variable decreases.

b. There is no relationship between the dependent and independent variables.

c. As the value of the independent variable increases, the value of the dependent variable increases.

d. As the value of the dependent variable increases, the value of the independent variable decreases.

251. Which of the following is the best description of "safety case approach?"

a. Uses system safety techniques to identify the hidden system failure modes.

b. Is a structured argument, supported by a body of evidence, that provides a compelling, comprehensible and valid case that a system is safe for a given application in an operating environment.

c. Is a methodology that investigates the failure modes of the system by assigning probabilities to each case that can contribute to an accident.

d. All the above.

252. The main elements of a "safety case approach" are "claim," "evidence," "argument" and:

a. Decision

b. Support

c. Inference

d. Documentation

253. Which of the following statements best describe the Risk Factor Summation (RFS) method?

a. The RFS-method uses a base-value of a comparable startup for the valuation of your company. This means you compare your startup to other startups and assess whether you have higher or lower risk.

b. This method uses an inductive method to identify and quantify risk factors.

c. Assigns probability and severity to all identified system hazards to minimize risk.

d. All the above.

254. Which of the following statements best describes the concept behind modern approaches to **business continuity planning**?

a. Organizations cannot operate in isolation.

b. Organizations depend on an extended network of external suppliers and stakeholders.

c. A failure in any part of the network of suppliers and stakeholders can compromise the ability of the business to achieve its aims.

d. All the above.

255. Preparing a successful ***business continuity plan*** involves six major steps. Which of the following is not among these major steps?

a. Identify the scope of the plan.

b. Identify the structure of engineering and administrative controls.

c. Identify key business areas.

d. Identify critical functions.

256. Which of the following best describes the concept of **Gap Analysis**?

a. Gap analysis focuses on the deficiencies in communication between the management and the workforce.

b. Gap analysis involves the comparison of actual performance with potential or desired performance.

c. Gap Analysis is the comparison of actual performance with previous performance.

d. All the above.

257. There five major steps involved in conducting a thorough gap analysis. Which of the following is not among these major steps?

a. Identify the area to be analyzed and identify the goals to be accomplished.

b. Establish the ideal future state.

c. Analyze the current state.

d. Compare the current state with the past performance.

2.6 Example Answers

1. Select (a)

   PHA is a qualitative system safety technique that allows its results to be presented in the form of a table or logic diagram. See the description in the text.

   In either format, potential hazards that pose a high risk are identified, along with their cause and major effects. In addition, for each hazard identified, a preliminary means of control is prescribed in the analysis.

2. Select (a)

   The main purpose of HAZOP is to determine how a process can deviate from its design intent and what the causes and consequences of these deviations would be. It must be pointed out that the main objective in a HAZOP study is problem identification not problem solution. However, if the solution to a problem becomes obvious during the course of study, the solution is recorded.

3. Select (d)

   FTA is a backward analysis. This means that the accident or system hazard is traced backward to all its possible causes.

   Three steps are required to conduct a fault tree analysis thoroughly and accurately. First, the undesired event, or top event, is defined. In the second step, investigators develop a thorough understanding of the system to be analyzed. This can be accomplished by studying design drawings, equipment specifications, literature, and operation procedures, as well as any other source information that may be available. The third step is constructing the fault tree.

4. Select (c)

   AND gates are used when the existence of two or more simultaneous conditions is required. OR gates are used when any of the events leads to an upper event in the tree. In this case, any of the three events mentioned lead to the event "source of ignition."

5. Select (d)

   "AND" gates are used when the existence of two or more simultaneous conditions is required. In this case all four events are required simultaneously to lead to the event "fire."

6. Select (b)

   $$\text{Reliability} = 1 - \frac{\text{number of failures}}{\text{total number of items exposed}}$$

   $$R = 1 - \frac{5}{10{,}000}$$

   $$R = 99.95\%$$

7. Select (c)

$R_{(system)} = R_1 \times R_2 \times R_3$

$R_{(system)} = 0.99 \times 0.95 \times 0.98$

$R_{(system)} = 92\%$

8. Select (a)

$R_{system} = 1 - (1 - R_1)(1 - R_2)$

$R_{system} = 1 - (1 - 0.999)(1 - 0.998)$

$R_{system} = 99.99\%$

9. Select (d)

Statements in (a), (b), and (c) are all true about a HAZOP study. Fault Tree Analysis uses Boolean logic.

10. Select (a)

Statements in (b), (c), and (d) are true about FMECA. HAZOP uses guidewords to identify deviation of process parameters from their design intent.

11. Select (d)

External events in Fault Tree Analysis are those events that one has little control over. Examples are the existence of air, difference in water temperature between summer and winter time, etc.

Basic faults are the primary cause of the top event. Basic faults represent a malfunction of equipment that occurs in the environment in which the equipment was intended to operate. Undeveloped events are occurrences that are not further addressed, either for lack of necessary information or for other reasons. Each branch of the fault tree should eventually end up in either a basic fault or in an undeveloped event.

12. Select (a)

$R_{500} = \exp(-2 \times 10^{-6} \times 500)$

$= e^{-0.001} = 0.999$

or the probability of failure 0.001.

13. Select (a)

Event tree analysis (ETA) is an analysis beginning with an initiating event and proceeding forward to find possible consequences resulting from that event. The course of events is determined by the success or failure of various safety functions (controls) as the accident progresses.

14. Select (b)

The Technique for Human Error Rate Prediction (THERP), is a system safety technique which can identify and analyze human errors in conducting a given task.

THERP provides the means to reduce the probability of errors occurring and therefore can greatly improve the overall safety within a system.

15. Select (c)

    ETA begins with an initiating event and analyzes both the success and failure of safety functions that are designed to control the initiating event.

16. Select (b)

    This is a good description of Fault Tree Analysis.

17. Select (a)

    CCA results in a diagram that displays the relationships between accident sequences and their basic causes.

18. Select (b)

    FMECA is best described by statement (b). Also, FMECA is an inductive analysis: that is, possible events are studied, but not the reasons for their occurrences.

19. Select (d)

    Since each component can fail independently, the probabilities are multiplied.

    $F \times F \times F = F^3$

20. Select (c)

    For example, if a top event is connected to two events with probabilities of 0.2 and 0.3 through an OR gate, the probability of top event is:

    $0.2 + 0.3 - (0.2 \times 0.3) = 0.44$ or 44%

21. Select (a)

    Fault tree analysis is a deductive method that starts with a top event and determines all possible causes of the top event. Furthermore, fault tree analysis allows the calculation of the probability of the top event.

22. Select (b)

    The Boolean expression states that the union of one subset with two others is equal to the union of their intersections.

23. Select (b)

    In this case we are dealing with a parallel system. In other words, both pumps must fail for the system to fail. Parallel reliability can be calculated from:

    $R_{(t)\text{system}} = 1 - \left(1 - R_{1(t)}\right)\left(1 - R_{2(t)}\right)(\cdots)$

    In this case :

    $R_{1(t)} = R_{2(t)} = e^{-10^{-5}(50{,}000)} = 0.606$

    R_{system} = 1 - (1-0.606)(1-0.606) = 0.845

P_f = 1 - 0.845 - 0.155 or 15.5 percent

24. Select (c)

MTBF = $\frac{1}{\lambda}$

MTBF = $\frac{1}{10^{-6}} = 10^6$hours

25. Select (a)

The reliability in t hours of operation is:

$R_{(t)} = e^{-\lambda t}$ where λ is the failure rate

$R_{(50,000)} = e^{-10^{-5}(50,000)} = 0.606$

Probability of failure is 1 – reliability

P_f = 1 - $R_{(t)}$

P_f = 1 - 0.606 = 0.394 or 39.4 percent

26. Select (b)

First we multiply the probabilities within each set.

Set A,B: $10^{-8} \times 10^{-9} = 10^{-17}$

Set C,D: $10^{-8} \times 10^{-8} = 10^{-16} = 10 \times 10^{-17}$

Then we add the probability of all sets to get the probability of top event:

$10^{-17} + 10 \times 10^{-17} = 11 \times 10^{-17}$

27. Select (d)

$R_t = e^{-\lambda t}$

Where:

R_t is the reliability in time t

λ is the hazard rate

t is time

$MTBF = \frac{1}{\lambda}$

For the problem at hand:

$R_t = e\frac{-t}{MTBF}$

$R_t = e\frac{-6000}{10000}$

R_t = 0.55 or 55%

This means that the probability of the bulb operating for 6,000 hours without failure is 55%. The probability that the bulb fails is:

P_f = 1 - R_t = 1 - 0.55 = 0.45 or 45%

28. Select (b)

    The AND gate indicates that both events must happen in order for the top event to happen. Therefore, the probabilities are multiplied.

29. Select (d)

    In Boolean logic, a plus sign (+) is interpreted as OR and a dot (•) is interpreted as AND.

    - Expression (a) reads: set A or set A is set A. Expression (b) reads: set A and the empty set (0) is also set A. Expression (c) reads: set A and set A is set A.

30. Select (d)

    The distributive law is:

    $A \bullet (B + C) = A \bullet B + A \bullet C$

31. Select (c)

    Let's solve this problem using two approaches. Since we have series components, we can write:

    $R_{system} = R_1 \times R_2$

    Reliability = 1 - probability of failure

    $R_{system} = (1 - 1 \times 10^{-3}) \bullet (1 - 1 \times 10^{-4}) = 0.9989$

    Now let's use the probability approach. Since the components are in series, the probabilities are added:

    $P_f(\text{system}) = (1 \times 10^{-3}) + (1 \times 10^{-4}) = 0.0011$

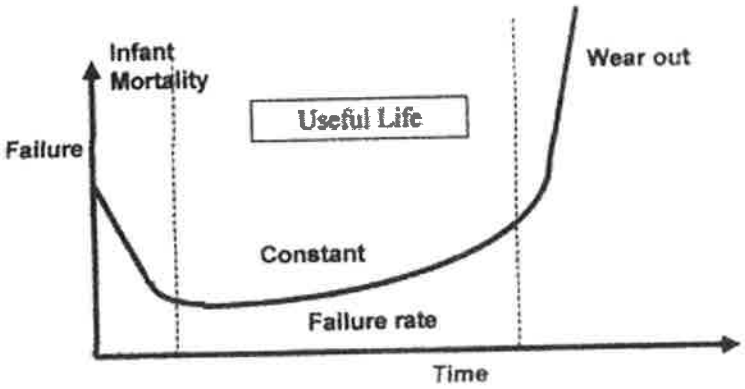
    $R_{system} = 1 - 0.0011 = 0.9989$

    Both approaches result in the same answer.

32. Select (c)

    The failure or bathtub curve is shown in the diagram below. It is a plot of the number of failures versus time. The curve is made of three distinct regions.

    - In the Infant Mortality region, the number of failures is very high initially but drops as the product is debugged.
    - In the Useful Life region, the number of failures is almost constant, although it increases very slowly with time.
    - In the Wear Out region, the number of failures increases very rapidly with time.



33. Select (d)

In order to determine the minimum cut sets, we represent the fault tree by a Boolean equation.

Step 1: E_2 and E_1 are connected to the top event (TE) through an OR gate. Therefore, we can write:

$TE = E_1 + E_2$

Step 2: Substitute for E_1 and E_2:

$TE = (B_1 \bullet B_2) + (B_1 + E_3)$

Remember that OR gates cause addition and AND gates cause multiplication.

Step 3: $TE = (B_1 \bullet B_2) + B_1 + (B_3 \bullet B_4 \bullet E_4)$

Once again, E_3 is connected to E_4, B_4, and B_3 through an AND gate.

Step 4: Substitute for E_4, which is connected to B_2 and B_4 through an AND gate:

$TE = (B_1 \bullet B_2) + B_1 + (B_3 \bullet B_4 \bullet B_4 \bullet B_2)$

Step 5: Using the idempotent law, which states that $A + A = A$ and $A \bullet A = A$, we reduce:

$B_3 \bullet B_4 \bullet B_4 \bullet B_2 = B_3 \bullet B_4 \bullet B_2$

Therefore:

$TE = (B_1 \bullet B_2) + B_1 + (B_3 \bullet B_4 \bullet B_2)$

Step 6: Using the law of absorption, which states that $A \bullet (A + B) = A$ and $A + A \bullet B = A$, we reduce:

$B_1 \bullet B_2 + B_1 = B_1$, and therefore:

$TE = B_1 + B_3 \bullet B_4 \bullet B_2$

The two terms B_1 and $B_3 \bullet B_4 \bullet B_2$ are the minimal cut sets. The occurrence of either one of these two sets causes the top event to happen. B_1 is a single point failure. However, occurrence of all three faults B_2, B_3, and B_4 is required for the occurrence of the top event.

34. Select (b)

Development of a policy statement by an organization must be the first step in successful management of safety within that organization. This policy statement must clearly define who is responsible, who has the authority, and who will be held accountable.

35. Select (c)

One of the advantages of participative management is that the flow of information within the organization is in all directions. In this style of management, the managers have access to better information as a basis for their decisions.

36. Select (b)

External audits have the clear advantage of objectivity, that is , it provides an opportunity for an independent evaluation. High cost and minimum or no follow-up are among the disadvantages of this type of safety audit.

37. Select (d)

The management must set forth an in-house permitting program for employees to obtain a permit prior to entry into any confined spaces. These areas must be inaccessible to unauthorized personnel and use of proper PPE is required.

38. Select (d)

These costs are definite and known to the organization, and therefore, they comprise the insured cost of the total cost associated with an accident.

39. Select (c)

Management fulfills its responsibilities of managing by making decisions and implementing those decisions. In order to make sound management decisions, the management must have access to facts and information. Management styles greatly affect whether or not a manager has all the right information to make a decision.

40. Select (c)

Theory Y states that people are generally interested in their work and are self-motivated. Theory X, on the other hand, states the opposite, i.e., people are not generally interested in their work and are not self-motivated.

41. Select (a)

The 3E's in management stands for Engineering, Education, and Enforcement.

42. Select (a)

The OSHA Incidence Rate (IR) can be calculated from:

$$IR = \frac{(number\ of\ incidences)(200{,}000)}{actual\ number\ of\ hours\ worked}$$

$$IR = \frac{(18)(200{,}000)}{(50)(40)(100)} = 18$$

43. Select (d)

LWDI is an acronym for statement (d).

44. Select (c)

Based on the principles of TQM, every employee is responsible for product quality and its continual improvement.

45. Select (b)

A flat organization has few levels of management; for example the management structure in most religious or charity organizations is flat. Tall management structure, on the other hand, has many levels of management. The U. S. government management structure is an example of a tall management organization.

46. Select (b)

Leveling, according to Argyris, means that everyone should participate either directly or indirectly in the decision making process. In other words, leveling encourage a participative style of management.

47. Select (d)

Statements a, b, and c are all motivation factors. Company policies, however, is an example of a hygiene factor.

48. Select (c)

Statements a, b, and d are examples of hygiene factors. Responsibility is a good example of a motivation factor.

49. Select (b)

The formula for future worth of money is:

$F = P\ (1 + i)^n$

where:

F is future worth of money

P is present worth of money

i is interest rate

n is number of years.

For the problem at hand:

$3{,}000{,}000 = P\ (1 + 0.06)^5$

$P = \frac{3 \times 10^6}{(1.06)^5}$

P = $2,241,774

50. Select (b)

$P = F\left[\frac{1}{(1+i)^n}\right]$

$P = 2 \times 10^6 \left[\frac{1}{(1+0.08)^5}\right]$

P = $1,361,166

51. Select (a)

The formula for uniform-series present worth is:

$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$

where P is present worth and A is each value to pay the future worth F in n years.

$4 \times 10^6 = A\left[\frac{(1+0.12)^{10} - 1}{0.12(1+0.12)^{10}}\right]$

$707,936

52. Select (c)

$F = A\left[\frac{(1+i)^n - 1}{i}\right]$

$F = 2000\left[\frac{(1+0.07)^{20} - 1}{0.07}\right]$

F = $81,990

53. Select (b)

Before promulgation of workers' compensation laws, this concept was embodied in the law that strongly favored the employer. This means that the employer was not responsible for injury suffered by an employee if the injury resulted from negligence of another employee:

54. Select (c)

The safety professional is merely management's representative. The chief operating executive is responsible for the conduct of the organization's safety. The safety professional acting as a staff member is responsible for providing adequate information to management so it can exercise its authority in regard to the safety conduct of the organization.

55. Select (b)

A flat organization is referred to one with few levels of management. For example most religious or charity organizations are flat. A tall organization, on the other hand, is one with many levels of management. The U.S. government is an example of a tall organization.

56. Select (a)

The actual responsibility for safety within an organization lies with the line supervisors (first level of management).

57. Select (a)

The coefficient of linear correlation between two variables lies within ±1. A coefficient of correlation close to 1 or -1 indicates that the two variables are strongly related. A coefficient of correlation of zero is an indication of no linear relationship between the two variables.

58. Select (c)

Coefficient of determination is:

$r^2 = \frac{explained\ variation}{total\ variation}$

$\sqrt{r^2} = \pm r\ is\ called\ "coefficient\ of\ correlation"$

The coefficient of determination r^2 is a measure of how well the linear relationship equation is performed by two variables.

59. Select (a)

Coefficient of determination $r^2 = \frac{21.80}{42.95} = 0.507$

Coefficient of correlation $r = \sqrt{0.507} = \pm 0.712$

Note: It should be pointed out that a value of r close to ±1 indicates a strong linear relationship, and a value of r close to zero indicates a very weak linear relationship.

60. Select (d)

Large values of standard deviation in normal probability distribution indicate a large spread of the data around the population mean. Therefore, the height of the normal curve is reduced and its spread is increased.

61. Select (b)

This is an example of the uninsured cost associated with an accident.

The insured (direct) costs of accidents are those that are generally covered by workers' compensation insurance.

The uninsured (indirect) costs of accidents are much higher than the direct costs of accidents (by about 2–10 times). Examples of uninsured costs of accidents include, but are not limited to, loss of production, OSHA penalties, property damage, and reduced morale among employees.

62. Select (a)

In cost-benefit analysis, accident prevention can only be justified if the cost shows a return on profit or at least avoids expenses.

63. Select (d)

The annual accidents cost in the U.S. is approximately 100 billion dollars.

64. Select (c)

(Cost of loss) = (margin of profit) (dollar volume of business)

10,000= (0.05) (dollar volume)

dollar volume $= \frac{10{,}000}{0.05} = \$200,000$

65. Select (b)

Cost of loss = (margin of profit) (number of products sold) (unit price)

number of telephones to be sold $= \frac{50{,}000}{(0.1)(20)} = 25,000$

66. Select (c)

Although it is desirable to calculate all costs associated with program alternatives on a quantitative basis, some costs such as reduced worker productivity can not be quantified and must be estimated on a qualitative basis.

67. Select (a)

$$\text{margin of profit} = \frac{\text{cost of loss}}{\text{dollar volume to recover the loss}}$$

margin of profit $= \frac{100{,}000}{1{,}000{,}000} = 0.1$ or 10%

68. Select (d)

Cost of loss = (margin of profit) (number of products) (unit price)

Number of TV sets $= \frac{100{,}000}{(0.05)(300)} = 6,666$

69. Select (b)

This is an example of uninsured costs associated with an accident.

70. Select (d)

Although identification of the spilled substance and its characteristics is a critical factor in determining the most effective clean up procedures, the first step is to ensure that people (both responders and others) are protected.

In developing a spill containment program, the organization may need certain tools, such as drain protectors, neutralizers, and sorbents, and have the capability to use them in case of an emergency spill.

71. Select (a)

Evaluation of physical, health, and environmental hazards of a spilled substance must be conducted from a safe distance upwind of the spill.

72. Select (c)

If a spill occurs inside a building and is not released into the environment, the person within the organization who is identified in Spill Prevention Control Countermeasure (SPCC) program must be notified.

73. Select (b)

The Shewhart cycle is "Plan, Do, Study, Act." This cycle is one of the most widely used tools in TQM and is also known as the PDSA cycle.

In the Plan phase, objectives and processes are defined for the delivery of expected outputs. In the Do phase, the plan is executed and necessary data is collected for subsequent use in the Study phase. In the Study phase, the actual results are compared to the expected results outlined in the Plan phase. In the Act phase, actions are taken to correct the differences between the expected and actual results.

74. Select (c)

Fredrick Taylor and Drs. Frank and Gilbreath were the foremost leaders in the development of the new theory of scientific management.

Scientific management is a theory of management that analyzes workflows. The main objective of this type of management is to improve economic efficiency with the primary focus on labor productivity.

The application of scientific management was based on a high level of management control over employee work practices. This resulted in a high ratio of management personnel to workers, which resulted in high levels of friction between management and workers.

75. Select (d)

Heinrich's theory of accident causation is best represented by statement (d).

76. Select (b)

SBO is best described by statement (b). See *Analyzing Safety Performance* by Dan Petersen.

77. Select (c)

We have to calculate the future worth (F) of a uniform series (A) at an interest rate (i) for (n) years. We use the formula:

$F = A\left[\frac{(1+i)^n-1}{i}\right]$

$F = 1000\left[\frac{(1.1)^8-1}{0.1}\right]$

F = \$11,435

78. Select (d)

The formula we use is:

$A = F\left[\frac{i}{(1+i)^n-1}\right]$

where:

A is the uniform deposit

F is future worth

i is interest rate

n is number of years.

For the problem at hand:

$A = 2,000,000 \left[\frac{0.08}{(1+0.08)^5-1}\right]$

A = $340,912

79. Select (a)

We use the formula:

$P = A \left[\frac{(1+i)^n-1}{i(1+i)^n}\right]$

where:

P is present worth

A is uniform series amount

i is interest rate

n is number of years

For the problem at hand:

$P = 1000 \left[\frac{(1+0.1)^{10}-1}{0.1(1+0.1)^{10}}\right]$

P = $6,144

80. Select (c)

The formula we use is:

$F = P(1 + i)^n$

where: F, P, i, and n are as defined earlier.

For the problem at hand:

F = 5,000 $(1 + 0.1)^{15}$

F = $20,886

81. Select (b)

$P = F \left[\frac{1}{(1+i)^n}\right]$

$P = 10,000 \left[\frac{1}{(1+0.1)^5}\right]$

P = $6,209

82. Select (b)

In safety management, the accidents have both direct and indirect causes. Although it is true that the direct cause of a given accident may be a combination of factors ranging from not controlling hazards to human failure, the basic cause of all accidents goes back to management failure.

83. Select (d)

According to National Safety Council, 98 percent of all workplace accidents are caused by either unsafe acts or unsafe conditions; the remaining 2 percent are attributed to natural causes such as earthquakes or flooding. The primary goal of any safety inspection program must be to identify and eliminate unsafe acts and unsafe conditions.

84. Select (b)

The incidence Rate is calculated by multiplying the recordable injuries and illnesses by 200,000 and dividing by actual number of hours worked.

$$IR = \left[\frac{\text{(injuries or illnesses) } 200{,}000}{\text{actual number of hours worked}}\right]$$

$$IR = \left[\frac{9 \times 200{,}000}{600{,}000}\right] = 3$$

85. Select (c)

Heinrich reviewed more than 75,000 accident cases and concluded that about 88 percent of accident cases reviewed were caused by unsafe acts of people.

86. Select (c)

Performance standards only specify the end result that needs to be achieved. Many employers prefer this type of standard because of the freedom that they have in meeting the standard. Specification standards, on the other hand, specify the detailed requirements such as dimensions.

87. Select (b)

Safety policy statement must clearly define the organization's position in regard to safety issues. It must assign responsibility, authority, and accountability for safety related matters.

88. Select (b)

Line elements of an organization are those who are involved in producing a product or delivering a service while the staff elements take care of other business matters such as legal, security, finance, etc.

89. Select (c)

The organization safety policy statement must clearly express that safety is part of everyone's job.

90. Select (c)

The Vice-President for manufacturing is responsible for all functions (including safety) within his/her department. In this case, the safety director is given a functional authority. It is important to keep in mind that the Vice-President for manufacturing remains responsible for all matters within his/her department.

91. Select (a)

The primary objective is to prevent occurrence of similar accidents in future. Determining the cause(s) of the accident is a first step towards accomplishing this objective.

92. Select (d)

General investigations use generic procedures and usually do not require special techniques or instruments. Special investigations, on the other hand, require special knowledge such as fire investigation or aviation accident investigations.

93. Select (d)

This is an example of a formal management structure. A formal structure can be defined as an organization that is hierarchical in nature. The formal structure of a company can usually be found on its organizational chart. This chart normally identifies each staff member with his or her job title.

94. Select (b)

The elements of 3-E's Principals are engineering, education, and enforcement.

95. Select (c)

"Just-in-time" inventory manages delivery of hazardous substances when they are needed on site, and therefore, minimizes unnecessary storage of hazardous substances.

96. Select (b)

PELs are set by OSHA, and compliance with established PELs for different chemicals is mandatory. OSHA sets these enforceable PELs to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. They may also contain a skin designation.

OSHA PELs are based on an eight-hour time-weighted average (TWA). PELs are addressed in specific standards for general industry, shipyard employment, and the construction industry.

97. Select (a)

A safety inspection must focus on identifying and correcting unsafe conditions and unsafe acts. According to a National Safety Council statistics, 98% of industrial accidents are caused by either unsafe conditions or unsafe acts. 2% of industrial accidents are caused as a result of natural disasters such as an earthquake.

98. Select (c)

The total cost of an injury or illness is obtained by adding the insured cost associated with the injury or illness to its uninsured costs.

Direct costs of accidents are those covered by insurance. Indirect costs of accidents are those that are not covered by insurance, and the company has to pay those costs. The uninsured costs of accidents are much greater than the insured costs. Examples of uninsured costs are loss of production, property damage, the cleanup and startup of operations, and the time to hire and train replacement workers.

99. Select (d)

"No Fault" system ensures that the worker is paid and protects employer against law suits.

100. Select (d)

The best way to handle this situation is described in statement (d). Generally, the safety professionals do not have the authority to fire an employee.

101. Select (b)

An OSHA Performance Standard requires specific objectives be obtained regardless of the method the employer chooses to use.

102. Select (a)

In tests of hypotheses, a Type I or α error refers to a valid hypothesis that was rejected as a result of the test. A Type II error is not rejecting the null hypothesis when in fact the alternate hypothesis is true.

103. Select (a)

The American Society of Mechanical Engineers (ASME) has codes for hydrostatic pressure testing of vessels. The test must be conducted at 1.5 times the maximum operating pressure.

104. Select (b)

One-tailed tests are conducted to study the deviation between the observed value and the hypothesized value in either the positive or negative direction. Two-tailed tests are conducted to study the same in both positive and negative directions.

105. Select (c)

The Blake Moulton Management Grid assigns values based on the respondent's answers to questions about how he or she regards his or her employees versus the value of production. Each concern (people and production) is assigned a value between 1 and 9 on the management grid. The assigned values are plotted on 2-axis grid.

- Respondents who score a 9,1 are said to be Authoritarian, with a high concern for production and little concern for people.

- Respondents who score a 1, 9 are said to have a Country Club style of management. This means that people always get what they want and the manager avoids conflict.
- Respondents who score a 1,1 are considered Impoverished management. Conflict is avoided and the minimum amount of work is done to get by.
- Respondents who score a 9,9 are said to have a Team Management style where managers motivate people to work at the highest level of productivity.
- Respondents who score a 5,5 are considered Middle of the Road managers, or the Dampened Pendulum.

106. Select (d)

The Otis Test is used to measure an individual's IQ. This is a test that evaluates abstract thinking and a person's ability to reason. It is a multiple choice test that focuses on measuring quantitative, spatial, and verbal reasoning ability.

107. Select (b)

Cohesiveness is defined as the degree that members of a team or group desire to remain in the team or group.

108. Select (c)

A Likert Scale is used to measure attitudes, preferences, and subjective reactions. For example, in software design, it can often subjectively measure efficiency and effectiveness with performance metrics such as time taken or errors made. The Likert Scale and other attitudinal scales help get at the emotional and preferential responses that people have to the design. For example:

I find this software easy to use.

Strongly disagree, 1, 2, 3, 4, 5, 6, 7, strongly agree

109. Select (d)

The Hawthorne Studies opened the door to the study of client-centered therapy, small group behavior, organizational theory, and research methodology.

110. Select (b)

LWDI is calculated by multiplying Lost Work Days (LWD) by 200,000 and dividing by the actual number of hours worked by all employees.

$$\text{LWDI} = \frac{(200{,}000)(\text{Lost Work Days})}{\text{total hours worked by all employees}}$$

111. Select (d)

$$\text{LWDI} = \frac{(200{,}000)(\text{Lost Work Days})}{\text{total hours worked by all employees}}$$

$$4 = (200{,}000)(\text{Lost Work Days})/(50)(40)(200)$$

$$\text{Lost Work Days} = 8$$

112. Select (a)

$$\text{LWDI} = \frac{(200{,}000)(\text{Lost Work Days})}{\text{total hours worked by all employees}}$$

$5 = (200{,}000)(10)/(50)(40)(\text{number of employees})$

Number of employees $= 200$

113. Select (b)

Assuming that the surface temperature of the burning liquid is above the boiling point of water, this application has the potential for creating a very high volume of an air, fuel, and steam mixture above the surface of the burning liquid.

114. Select (b)

The probability of having an accident is 0.01 or 1/100 or one accident every 100 days.

115. Select (a)

This program is an optional program and has the four components named in the question.

The VPP recognize employers and workers in the private industry and federal agencies who have implemented effective safety and health management systems and maintain injury and illness rates below national Bureau of Labor Statistics averages for their respective industries. In VPP, management, labor, and OSHA work cooperatively and proactively to prevent fatalities, injuries, and illnesses through a system focused on: hazard prevention and control; worksite analysis; training; and management commitment and worker involvement.

To participate, employers must submit an application to OSHA and undergo a rigorous onsite evaluation by a team of safety and health professionals. Union support is required for applicants represented by a bargaining unit. VPP participants are re-evaluated every three to five years to remain in the programs. VPP participants are exempt from OSHA programmed inspections while they maintain their VPP status.

116. Select (b)

The goals and objectives must also be realistic and specific for the program at hand.

117. Select (a)

The coefficient of correlation varies between -1 and $+1$. A coefficient of correlation of -1 indicates a perfect inverse relationship between the variables. A coefficient of correlation of $+1$ indicates a perfect direct relationship between the two variables. In this case, with a coefficient of correlation of 0.95, we can conclude that the two variables have an almost perfect direct relationship between them.

118. Select (c)

Plant	x	y	xy	x^2	y^2
1	72	7	504	5,184	49
2	67	7	469	4,489	49
3	81	9	729	6,561	81
4	82	8	656	6,724	64
5	72	5	360	5,184	25

$n = 5$

$\sum x = 374$

$\sum y = 36$

$\sum xy = 2,718$

$\sum x^2 = 28,142$

$\sum y^2 = 268$

$r = \left(\frac{Sxy}{S_{xx} \times S_{yy}}\right)^{\frac{1}{2}}$

Where:r is the coefficient of correlation$x$ and y are the individual values of data in each set$n$ is the sample size

$s_{xy} = \sum x^2 - \frac{(\sum x)(\sum y)}{n} = 2,718 = \frac{(374)(36)}{5} = 25.2$

$s_{xx} = \sum x^2 - \frac{(\sum x)^2}{n} = 166.8$

$s_{yy} = \sum y^2 - \frac{(\sum y)^2}{n} = 8.8$

Therefore,

$r = \frac{25.2}{(166.8 \times 818)^{\frac{1}{2}}} = 0.658$

Discussion. The coefficient of correlation varies between -1.0 and +1.0. A coefficient of correlation equal to -1.0 indicates perfect inverse relationship between variables under study and +1.0 indicates a perfect direct relationship. In this case, we can conclude that the safety training had a positive impact on safety performance but that there is room for improvement.

119. Select (a)

The coefficient of correlation varies between -1.0 and +1.0. A coefficient of correlation equal to -1.0 indicates a perfect inverse relationship between the variables under study and +1.0 indicates a perfect direct relationship. The significance level is usually calculated at a level of 0.01 or 0.05. A significance level of 0.01 indicates a 1% probability that a hypothesis that should have been accepted is rejected.

120. Select (d)

All statements are true in regard to OHSAS 18000. Also, companies that use such management systems are subject to audits. It is important that a member of the

management team certifies in writing that the reviews required by the particular management system were conducted.

OHSAS 18000 has two parts, 18001 and 18002.

OHSAS 18001 has been developed to be compatible with the ISO 9001 (Quality) and ISO 14001 (Environmental) management systems standards, in order to facilitate the integration of quality, environmental, and occupational health and safety management systems by organizations, should they wish to do so.

OHSAS 18002 helps companies to better implement OHSAS 18001.

121. Select (a)

During an audit, it is best for the auditors to verify the management processes that are implemented within the organization in person. Otherwise, the auditors must rely on management certification.

122. Select (a)

The readers of the final audit report can only perceive the report as being free of bias if the auditor has no line or operational responsibility for the audited task.

123. Select (a)

$0.15\ (1{,}000) + 0.2\ (5{,}000) + 0.35\ (7{,}000) + 0.3\ (2{,}000) = 4{,}200$

124. Select (b)

Safety audit teams must be independent of the line management and be familiar with the systems or processes that they audit.

125. Select (a)

Statements (b), (c), and (d) are true in regards to Pareto charts and the Pareto principle. The Pareto principle also states that mitigating 20% of the problems associated with a system can reduce the risk by 80%.

The Pareto principle was developed by the Italian economist Vilfredo Pareto after he observed that 20% of the Italian people owned 80% of their nation's wealth. Putting this principle in management context indicates that 80% of the results generated takes only 20% of a manager's efforts.

126. Select (a)

American National Standard Institute (ANSI) Z10 and the American Industrial Hygiene Association (AIHA) describe both management leadership and employee participation to be crucial factors in the success of safety and health programs.

127. Select (c)

The ISO 19011 standard has provisions on how to manage and conduct effective environmental audits.

128. Select (d)

Jobs should not be selected randomly for Job Safety Analysis. Both frequency (probability) and severity of potential incidents must be considered in selecting jobs for analysis. New jobs must also be considered for Job Safety Analysis.

129. Select (d)

Workplace accidents are considered to be symptoms of poor management.

130. Select (a)

The mean error rate is obtained by adding individual error rates and dividing the sum by the total number of observations.

$\frac{(0.34+0.54+0.24)}{300} = 0.0037$

131. Select (c)

Defining the subsequent use of data is the most important consideration in design of a data collection system.

In the design of a data collection system, the consultation with data users and providers as well as the choice of how to meet data requirements must be considered. In order to define how the data is going to be used, the following considerations are important:

- What data items are needed and how they will be used
- The precision level required for estimates
- The format, level of detail, and types of tabulations and outputs
- When and how frequently users need the data

132. Select (c)

Loss control systems that do not address items (a), (b), and (d) are incomplete and cannot be very effective.

133. Select (d)

One of the major goals of an effective incident investigation program must be to prevent the occurrence of similar incidents. This can be accomplished by determining the casual factors and their subsequent root causes that led to the incident.

134. Select (d)

Items listed in (a), (b), and (c) are elements of an effective system safety program plan.

The System Safety Program Plan (SSPP) is a very important document in any system safety program. The SSPP is a critical document for subsequent system safety analyses. It must address management's tasks and activities and those of the system safety engineering staff in order to identify, analyze, and mitigate the hazards within the system.

135. Select (b)

The budget variance report is usually presented in the form of a table. The table lists the actual year-to-date expenditure, the actual year-to-date budget, and the difference between them.

Gantt charts are bar charts commonly used in project scheduling. A Gantt chart demonstrates the start and finish times for different tasks in a project.

136. Select (a)

Benchmarking is setting a goal for the organization. This is usually accomplished by comparing the safety performance of the organization with other similar organizations and using the results for safety performance goal settings.

137. Select (a)

Incidence rates are calculated by multiplying the number of incidences in a given year by 200,000 and dividing the result by the actual number of hours worked. The number 200,000 is calculated based on an organization with 100 employees who worked 40 hours per week for 50 weeks a year ($100 \times 40 \times 50 = 200{,}000$). For example, the incidence rate for a company where employees worked for 400,000 hours in a year with 20 incidences is:

$\frac{20 \times 200{,}000}{400{,}000} = 10$

138. Select (a)

The ISO 9000 family is primarily concerned with quality management. This means what the organization does to fulfill the customer's quality requirements, comply with applicable regulatory requirements, and achieve continual improvement of its performance.

139. Select (b)

The ISO 14000 family is primarily concerned with environmental management. This means minimizing harmful effects on the environment caused by the organization's activities and achieving continual improvement of its environmental performance.

ISO is the short name for the International Organization for Standardization, located in Geneva, Switzerland. ISO promotes the development and implementation of voluntary international standards, both for particular products and for environmental management issues.

ISO 14000 refers to a series of voluntary standards in the environmental field. Included in the series are the ISO 14001 EMS standard and other standards in fields such as environmental auditing, environmental performance evaluation, environmental labeling, and life-cycle assessment.

140. Select (b)

This is an example of a functional organization chart. A drawback of a functional design is the difficulty growing into new types of work and market segments. A

functional organization design makes it essential that the managers of each department be highly effective.

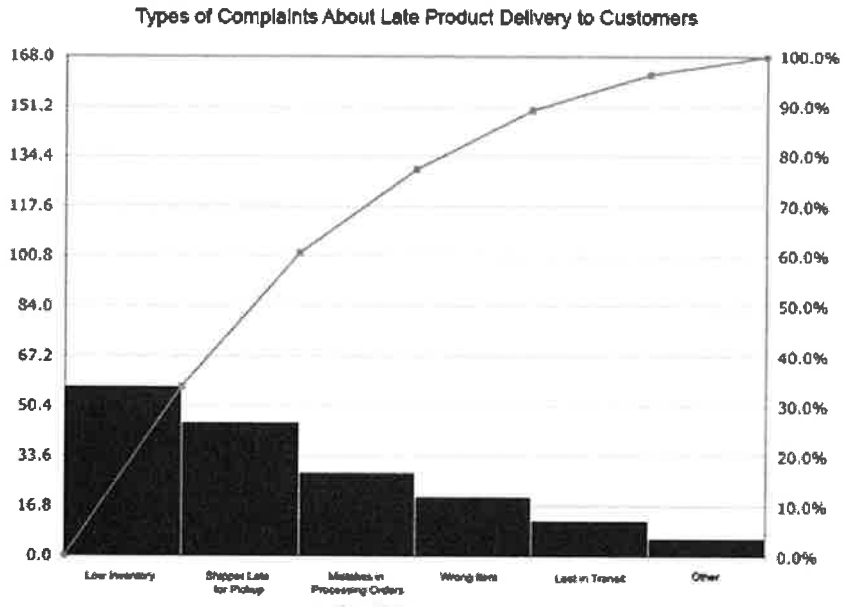
A matrix organization design allows communication among different departments when needed. In general, matrix organizations provide better opportunities to serve customers, but can be very confusing to members of the organization.

141. Select (b)

Statements (a), (c), and (d) are all true in regard to Pareto charts.

A Pareto chart is a type of chart that contains both bars and a line graph, where individual values are represented in descending order by bars, and the cumulative total is represented by the line.

The left vertical axis is the frequency of occurrence, but it can alternatively represent cost or another important unit of measure. The right vertical axis is the cumulative percentage of the total number of occurrences, total cost, or total of the particular unit of measure. Because the reasons are in decreasing order, the cumulative function is a concave function. To take the example below, in order to lower the amount of late arriving by 78%, it is sufficient to solve the first three issues.



142. Select (a)

According to OSHA, only the injuries that require attention beyond first aid are recordable.

143. Select (b)

LWDI = number of lost work day cases $\times$ 200,000 $\div$ total number of hours worked by all employees

In this case:

Total number of hours worked $= 900 \times 50 \times 5 \times 8 = 1{,}800{,}000$

$\text{LWDI} = \frac{200 \times 200{,}000}{1{,}800{,}000} = 22.22$

144. Select (b)

$IR = \frac{10 \times 200{,}000}{400 \times 50 \times 5 \times 8} = 2.5$

145. Select (c)

$10 + 15 + 30 = 55$

146. Select (d)

"Adsorption" refers to the removal of one or more components of a gas mixture on a solid bed. For example, air purifying respirators remove the contaminants from air by this process.

147. Select (c)

Achievement, advancement, and responsibility are job motivational factors while church is an example of past behavioral influence.

148. Select (b)

Recognition by the boss is an example of an extrinsic or external reward. Feeling good about one's own performance is an example of an intrinsic or internal reward.

149. Select (b)

Statements (a), (c), and (d) are examples of hygiene factors. Responsibility is a good example of a motivation factor.

150. Select (b)

Safety audit teams must be independent of line management and be familiar with the systems or processes that they audit.

151. Select (a)

Statements (b), (c), and (d) are true in regard to Pareto charts and the Pareto principle. The Pareto principle also states that mitigating 20% of the problems associated with a system can reduce the risk by 80%.

152. Select (a)

OHSAS calls for continuous improvement in safety and health performance in an organization.

153. Select (c)

We use the Poisson distribution. The formula for this distribution is:

$P_r = \frac{(\lambda t)^r e^{-\lambda t}}{r!}$

Since we are looking at probability in a time interval, the value of t is equal to 1.0 and λ is equal to 4. In order to calculate the probability of three lost time injuries, we have to calculate the probabilities of 0, 1, 2, and 3 incidents and add them up:

$P_0 + P_1 + P_2 + P_3$

Thus:

$P_0 = \frac{(4)^0 e^{-4}}{0!} = 1.83 \times 10^{-2}$

$P_1 = \frac{(4)^1 e^{-4}}{1!} = 7.33 \times 10^{-2}$

$P_2 = \frac{(4)^2 e^{-4}}{2!} = 0.1464$

$P_3 = \frac{(4)^3 e^{-4}}{3!} = 0.1952$

Therefore, the probability of having 3 lost time injuries in the next 3 months is:

$(1.83 \times 10^{-2}) + (7.33 \times 10^{-2}) + 0.1464 + 0.1952 = 0.4332$

154. Select (c)

This statement is an example of loss of control. Other reasons for resisting change include loss of face, concerns about competence, and the sense of having to do more work.

155. Select (b)

The fourth perspective used in conjunction with scorecards is the financial perspective.

156. Select (b)

The manager and employee must review any obstacles encountered since the last conversation. Why did they arise? What are some possible ways to deal with them?

157. Select (d)

Regulatory, Warning, and Information are the three basic categories of signs used in the workplace. The following table describes these sign categories, their subcategories, and how they are used.

Category	Subcategory	Use
Regulatory	Prohibition	Forbids an action
Regulatory	Mandatory	Requires an action
Warning	Caution	Potential hazard
Warning	Danger	Definite hazard
Information	Emergency	First aid, health, fire protection, fire-fighting, and emergency equipment
Information	General Information	Permission and public information

158. Select (d)

The fourth phase is Acting.

- In the Planning phase, the problem is defined and relevant data is collected.
- In the Doing phase, a solution to the problem is developed and implemented.
- In the Checking phase, the results are confirmed through before-and-after data comparison.
- In the Acting phase, the results are documented, others are informed about process changes, and recommendations are made.

159. Select (b)

In this system, the patient wears a wrist band that has been barcoded with all the information about his or her medications. The nurse uses a mobile computer to scan the patient's medication barcode. Using the wrong medication or wrong dosage will trigger an alarm.

160. Select (d)

This statement is one of the actions that must be taken after publicly announcing the recall and is not part of initiating a recall.

161. Select (b)

The five levels of Maslow's hierarchy of needs are as follows:

- The first level is biological/physiological needs (air, food, and water).
- The second level is safety needs (protection and security)
- The third level is belonging/love needs (family, affection, and relationships)
- The fourth level is esteem needs (achievement and status)
- The fifth level is self-actualization needs (personal growth and fulfillment)

162. Select (d)

The JSA is usually completed on a form. The most common form is a table with three columns with the headings Job Step, Hazard, and Controls.

163. Select (a)

For example, if there are three balls in a bag—one black, one white, and one green—we can talk about the conditional probability of drawing the black ball after having already drawn the green ball.

Statement (b) is the definition of a *priori probability.* For example, consider how the price of gasoline can change. It can increase, decrease, or remain the same. Therefore, according to a priori probability, we can assume that there is a 1 in 3 (33%) chance of one of these outcomes occurring.

Statement (c) is the definition of *subjective probability.* For example, if you ask the fans of a given team if their team would win, the answer constitutes a subjective

probability.

Statement (d) is the definition of a probability distribution.

164. Select (d)

Workers' compensation claims are considered a direct cost of accidents.

According to OSHA, the ratio of indirect to direct costs of accidents varies from a high of 20:1 to a low of 1:1.

165. Select (d)

Heinrich's domino theory states that an accident is one factor in a sequence that may lead to injury. Each of the factors is dependent on the preceding factor. These factors are:



The factor preceding the accident (unsafe act or condition) should receive the most attention.

There are two key components in epidemiological theory:

1. Predisposition characteristics—tendencies may predispose workers to certain actions

2. Situational characteristics—peer pressure, poor attitude, and risk taking

Together these characteristics can cause or prevent accidents.

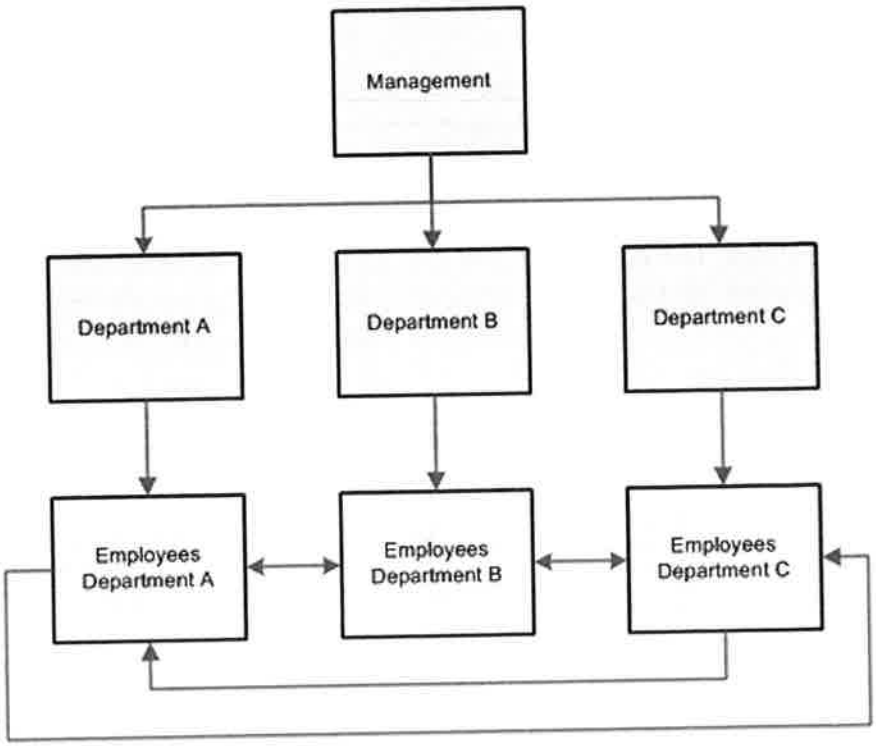
In the system theory model, the assumption is made that accidents arise from interactions among humans, machines, and the environment.

166. Select (a)

In this type of organization, each employee has one clear supervisor.

Another type of common organizational structure is matrix management. In this type of structure, people with similar skills are pooled for work assignments, resulting in an individual reporting to more than one manager. For example, all engineers may be in one engineering department reporting to an engineering manager. However, the same engineers may be assigned to different projects in other departments and report to a different manager while working on that project.

The following diagram is a sample matrix organization chart.



167. Select (b)

The productivity gain occurred due to motivational effects on workers as a result of the interest being shown in them.

168. Select (d)

MBO, also known as management by results (MBR), was first proposed by Peter Drucker in his 1954 book, *The Practice of Management.* In this system of management, objectives within an organization are defined in such a way that both employees and management agree to the objectives and understand what needs to be done to achieve them.

169. Select (c)

PERT was developed primarily to simplify planning and scheduling large projects. PERT focuses on time as the factor that affects resource applications as well as performance applications.

170. Select (b)

Horizontal standards apply to any employer in any industry. Vertical standards apply only to a particular industry. Examples of vertical standards are the longshoring industry, the construction industry, and special industries.

171. Select (a)

In general, playgrounds are designed for different age groups. However, it is important that the areas for older children be separated from those for younger children and proper signs be installed for each area.

172. Select (d)

Here are some other points to consider for playground safety:

- Check for dangerous hardware, like open S hooks or protruding bolt ends.
- Make sure spaces that could trap children, such as openings in guardrails or between ladder rungs, measure less than 3.5 inches or more than 9 inches.
- Check for sharp points or edges in equipment.
- Look out for tripping hazards, like exposed concrete footings, tree stumps, and rocks.
- Make sure elevated surfaces, like platforms and ramps, have guardrails to prevent falls.
- Check playgrounds regularly to see that equipment and surfacing are in good condition.
- Carefully supervise children on playgrounds to make sure they're safe.

173. Select (d)

Another function of an effective management is ensuring that each subordinate supervisor understands his/her responsibilities and those of other subordinate supervisors.

174. Select (b)

Line supervisors are responsible and accountable for ensuring that the company's safety and health policies are properly implemented in their departments.

175. Select (c)

The interview must also address the importance of the employee working on his/her problems, the rating must be discussed with the employee, and guidance on improvement be provided.

It is also important to start the session with an icebreaker, then explain the purpose of the interview, agree on actual performance ratings for this and the next interview, and close the interview on a positive note.

176. Select (b)

The scope of a project refers only to the work that is essential in the successful completion of a project.

The project scope determines the project goals such as deliverables, deadlines, specific tasks, and their associated costs.

The project scope document specifies each team member's responsibilities and establishes guidelines on how each completed task will be verified and approved.

177. Select (a)

This process is called the Work Breakdown Structure (WBS). WBS decomposes a project into smaller elements. It defines and groups the project's elements in such a way as to organize and define the scope of the project.

For example, a WBS element can be a service, a product, or data. WBS also establishes a framework for project cost estimation.

178. Select (c)

Gantt charts are used to break down a project into different tasks and graphically show the time assigned for the completion of each task.

179. Select (a)

It is critical that change in processes or operational activities be managed. A comprehensive change analysis is needed before a decision to implement changes is made.

Management of change must be used to ensure that safety, health, and environmental risks are controlled when a company makes changes in their facilities, documentation, personnel, or operations.

When decisions and changes are made rapidly, safety and health risks can increase and result in accidents.

180. Select (d)

The first three statements are true in regards to line supervisors.

181. Select (c)

An effective safety committee must set goals and objectives that are realistic and measurable. Safety committees that represent several departments allow the company to evaluate overall safety and health requirements.

182. Select (a)

Benchmarking in general can be a very effective tool for improvement in any business. The idea is to identify and apply best demonstrated practices to all aspects of a business such as operations, processes, and sales.

183. Select (c)

Successful communication involves the sender, the message, and the receiver. Also, the channel through which the communication is made, as well as feedback, are important elements of a successful communication.

184. Select (a)

The ISO 14000 family of standards addresses various aspects of environmental management.

185. Select (c)

ASSE's journal is *Professional Safety* and the AIHA's journal is *Synergist.*

186. Select (a)

For more than 30 years, the U.S. Consumer Product Safety Commission (CPSC) has operated a statistically valid injury surveillance and roll-back system known as NEISS. The primary purpose of NEISS is to collect data on consumer product-related injuries occurring in the United States.

187. Select (d)

Statements in a, b, and c are all considered to be objectives of an injury data collection system within an organization.

188. Select (a)

A run chart is a plot of data over a period of time, for example, plot of unsafe acts or conditions during a period when safety programs are being implemented can be used as a measure of the effectiveness of such programs.

The benefits of run charts include the following:

- They help an organization formulate goals by showing a process's good or bad performance.
- They help in determining when changes have resulted in improvements by showing data that can be observed as changes are made.

189. Select (d)

The Management Oversight and Risk Tree (MORT) is one of the techniques that can be useful in analyzing accident investigation data.

190. Select (d)

OSHA incident rate can provide quantitative comparison of effectiveness of safety measurement within an organization.

191. Select (a)

Monetary considerations is not a necessary element of a contract.

192. Select (d)

OSHA does not require reporting of injuries or illnesses that are treated by first aid.

193. Select (b)

Engineering factors is not considered to be one of the three domains for creating a Total Safety Culture within an organization.

194. Select (b)

This is a characteristic of a work group. There are several differences between a team and a work group. Wok groups, in general, may not share common purposes or goals and they are evaluated as individuals.

195. Select (c)

The major objective of team training is to coordinate the efforts of team members to achieve a common goal. Knowledge, attitude and behavior are all considered being components of team performance. Reinforcement is not considered to be a component of team performance.

196. Select (c)

The coefficient of correlation, which is used to measure how two variables are related to each other, varies between –1 and +1.

A value close to +1 indicates a direct linear relationship. A value close to –1 indicates an inverse linear relationship.

197. Select (a)

The coefficient of correlation is a number between –1 and +1. It is used to determine how two variables are related. A coefficient of correlation close to +1 indicates a positive relationship while a coefficient of correlation close to –1 indicates an inverse relationship. In this case, the number of safety inspections and on the job injuries have a coefficient of correlation which is very close to –1. This indicates that on the job injuries and the number of safety inspections are inversely related. In other words, as the number of safety inspections increases, the number of on the job injuries decreases.

198. Select (a)

AIHA publishes this monthly periodical.

199. Select (b)

Professional Safety is the official journal of the American Society of Safety Engineers.

200. Select (d)

It is estimated that more 80% of telecommuting is conducted from employee's home.

Another advantage of telecommuting is increased productivity by separating employees from the distraction of the office environment.

One disadvantage of telecommuting is poor staff relationships between those employees who telecommute and those who don't. Another disadvantage is career stagnation. It is difficult for management to monitor the performance of teleworkers.

201. Select (c)

Microsoft PowerPoint is not a spreadsheet program. An electronic spreadsheet organizes information into user-defined rows and columns. The data can then be manipulated by a formula to give a result. This type of software can be very useful in occupational safety management. For example, it can be used to manage accidents, unsafe conditions or acts, and lost work days data.

Lotus is a spreadsheet application developed by Lotus Development Corporation. IBM purchased the company in 1995 for $3.5 billion.

VisiCalc was the first spreadsheet application released in 1979 for Apple II computers.

202. Select (c)

The American Board of Industrial Hygiene offers examinations and issues certification as a Certified Industrial Hygienist (CIH). Other BCSP professional membership organizations are the American Industrial Hygiene Association, the American Society of Safety Engineers, and the National Safety Council. BCSP is accredited by the National Commission for Certifying Agencies and by the Council of Engineering and Scientific Specialty Boards.

203. Select (d)

Local Area Network (LAN) is an excellent way for making MSDS available to employees within an organization. A LAN is a network of computers for a relatively small area, usually a single building or a group of buildings.

204. Select (c)

The American Industrial Hygiene Association (AIHA) is in charge of issuing certification for industrial hygiene laboratories.

AIHA is one of the largest and most prestigious international organizations that serve the needs of professionals practicing industrial hygiene. AIHA works with the American Board of Industrial Hygiene (ABIH) to promote the certification of industrial hygienists.

205. Select (b)

The Poisson distribution expresses the probability of a number of events occurring in a fixed time if these events occur with a known average rate, and are independent of the time since the last event.

For example, let's assume that someone receives an average of five phone calls per day. However, there will be days that the number of calls received may be six, three, four, two, one, or perhaps none at all. If we assume that the processes that produce the event are random, the Poisson distribution calculates the probability that the count will be any number (for example, four, six, or ten) during one period of observation.

206. Select (b)

Vacuum cleaners heat up and spread mercury vapors. Sulfur or zinc powder bind any remaining invisible mercury.

207. Select (a)

The coefficient of correlation varies between -1 and $+1$. A value close to $+1$ indicates a strong positive linear relationship between the two variables. A value close to -1 indicates a strong inverse linear relationship between the two variables.

The 2% significance level indicates that there is a 2% probability that the coefficient

of correlation resulted from chance or a 98% probability that it did not result from chance.

208. Select (d)

Incidents that did not cause any injury or property damage should still be investigated to determine and eliminate the hazards with the goal of preventing similar incidents in the future.

209. Select (a)

RACI is an acronym for Responsible, accountable, consulted, and informed. RACI matrix describes the participation by various roles within an organization in completing tasks for a project. For each task, the chart identifies who is responsible and /or accountable. The chart also identifies who has been consulted and/or informed about each task of the overall project.

210. Select (a)

In order to construct an RACI chart, one must identify the tasks and list them on the left-handed side of the chart in completion order. All project roles must be identified and listed along the top of the chart. Then each cell must identify who is responsible, accountable, consulted, and/or informed for each task.

211. Select (c)

If an organization does not make the optimum use of its resources, it may produce or perform below its potential. Gap analysis identifies the gap between potential or desired performance and the actual performance. This analysis can help companies to set goals to achieve the desired or potential performance.

212. Select (d)

When this model is used, possible causes in each category should be investigated. For example, if an accident was caused by human error, the investigation must focus on the causes of the human error.

213. Select (d)

A group health plan is a medical care benefit plan offered by the employer to employees and their dependents. All group health plans must follow applicable IRS, HIPAA, COBRA, ERISA, and ACA rules.

IRS:	Internal Revenue service
HIPAA:	Health Insurance Portability and Accountability Act
COBRA:	Consolidated Omnibus Budget Reconciliation Act
ERISA:	Employee Retirement Income Security Act
ACA:	Affordable Care Act

214. Select (d)

Statement (d) describes theory "x" of management. Statements (a), (b), and (c) are correct in regards to different management theories.

215. Select (b)

The sequence of events model is a linear cause and effect model. The epidemiological model allows the investigator to think in terms other than casual series. It offers the possibility of seeing some complex interaction, and focuses attention on the organizational issues. The Systemic model is a complex non-linear model where both accidents (and successes) are seen to emerge from unexpected combinations of normal variability in the system.

216. Select (a)

The Z10 standard provides an overall blueprint for widespread benefits in health and safety, as well as in productivity, financial, performance, quality and other organizational and business objectives. The standard's seven sections include Management Leadership and Employee Participation, Planning, Implementation and Operation, Evaluation and Corrective Action, Management Review. Appendices address roles and responsibilities, policy statements, assessment and prioritization, audit information and much more.

The Z10 standard also provides critical management systems requirements and guidelines for improvement of occupational health and safety. Experts from labor, government, professional organizations and industry formulated this valuable standard after extensive examination of current national and international standards, guidelines and practices.

Source: ASSE

217. Select (b)

OHSAS 18000 is an international occupational health and safety management system specification. It comprises two parts, 18001 and 18002. OHSAS 18001 contains specified requirements which consists of 5 basic sections:

- Occupational Health & Safety Policy
- Planning
- Implementation and Operation
- Checking and Corrective Action
- Management Review.

OHSAS 18002 provides guidelines for the implementation of OHSAS 18001.

218. Select (b)

ISO 19011 is an international standard that sets forth guidelines for management systems auditing. The standard offers four resources to organizations to "save time, effort and money":

- A clear explanation of the principles of management systems auditing.
- Guidance on the management of audit programs.
- Guidance on the conduct of internal or external audits.
- Advice on the competence and evaluation of auditors.

219. Select (d)

The effect of change on the compliance audits program is not addressed in the "management of change" element of the Process Safety Management standard.

220. Select (b)

The OHSAS 18000 series was published in 1999. the series consisted of two specifications: the 18001 offer the requirements for Occupational Health and Safety (OHS) management system and 18002 contains implementation guidelines.

221. Select (b)

A confined space has limited or restricted means for entry or exit and is not designed for continuous occupancy. Examples of confined spaces include tanks, vessels, silos, etc.

222. Select (b)

OSHA also requires that trenches 5 feet (1.5 meters) deep or greater be equipped with a protective system unless the excavation is made entirely in stable rock. If less than 5 feet deep, a competent person may determine that a protective system is not required. Trenches 20 feet (6.1 meters) deep or greater require that the protective system be designed by a registered professional engineer or be based on tabulated data prepared and/or approved by a registered professional engineer in accordance with 1,926.652(b) and (c)

223. Select (a)

There are different types of protective systems. Benching means a method of protecting workers from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near vertical surfaces between levels. Benching cannot be done in Type C soil. Sloping involves cutting back the trench wall at an angle inclined away from the excavation. Shoring requires installing aluminum hydraulic or other types of supports to prevent soil movement and cave-ins. Shielding protects workers by using trench boxes or other types of supports to prevent soil cave-ins.

224. Select (c)

OSHA requires use of fall protection at heights of less than 6 feet when working near dangerous equipment, for example, working over machinery with open drive belts, pulleys or gears or open vats of degreasing agents or acid.

225. Select (b)

Always maintain a 3-point (e.g. two hands and a foot) contact on the ladder when climbing. Keep your body near the middle of the step and always face the ladder while climbing. The proper angle (15 degrees) for setting up a ladder is to place its base a quarter of the working length of the ladder from the wall or other vertical surface.

226. Select (b)

The safe procedure is that the distance of the ladder base from the vertical plane of the top support should be 1/4 of the distance between ladder base and top support.

$\frac{20}{4} = 5ft.$

227. Select (d)

Passive fall protection systems are, in general, stationary and do not require active participation from the worker. Examples of passive fall protection systems are guardrails, handrails, and netting systems. Active fall protection systems are dynamic in nature, and in general, require active worker participation. Active fall protection systems fall into two broad categories, fall arrest systems and fall restraint systems. Examples of active fall protection systems are immovable point fall protection systems, vertical fall protection systems, and horizontal fall protection systems.

228. Select (d)

The management must set forth an in-house permitting program for employees to obtain a permit prior to entry into permit required confined spaces. These areas must be inaccessible to unauthorized personnel and use of proper PPE is required.

229. Select (c)

Before a permit space that may have a hazardous atmosphere can be entered, the atmosphere must be tested using the steps identified on the permit (developed during evaluation testing). Verification testing is done to make sure that the chemical hazards that may be present are below the levels necessary for safe entry, and that they meet the conditions identified on the permit. The atmosphere must first be tested for oxygen, then for combustible gases, and last for toxic gases and vapors. the actual test concentrations must be recorded on the permit near the levels identified for safe entry.

230. Select (b)

Before performing any maintenance work, workers must ensure electricity is off and "locked-out". The switch must be tagged. The tag informs others why the switch is off. Locks and tags are warning signs. Workers who conduct lockout/tagout procedures must be trained.

231. Select (d)

The problem of vibrating parts usually does not require guarding and is solved using vibration dampers.

232. Select (c)

Self-adjusting guards provide barriers that move according to the size of the stock entering the danger area. Fixed guards can be constructed to suit many applications and can provide a high level of protection. Adjustable guards provide an adjustable barrier.

233. Select (b)

The plan must be reviewed and, if necessary, updated annually.

234. Select (d)

At least 3 inches or 7.6 centimeter of clearance is required.

235. Select (d)

Workers who handle lockout/tagout must be trained in the procedures that need to be followed and must be instructed to replace the safeguards once the maintenance or service work is completed. It is the responsibility of the supervisors to ensure that the company's lockout/tagout policies are enforced.

236. Select (b)

The first component of a Personal Fall Arrest System (PFAS) is the anchorage and anchorage connector. This is a tie-off point such as scaffolding, an I-beam, or other structural parts. In situations where a direct connection does not exist, an anchorage connector is used to attach the connecting device to the anchorage. Anchorages and their connectors must be easy to access, can support at least 5,000 lb (2,268 kg) of force per worker, and be located high enough for a worker to avoid contact with a lower level should a fall occur.

Body wear is the second component of a PFAS. The only acceptable form of body wear is full-body harness which allows the distribution of a fall force throughout the body reducing the possibility of excessive force in one area of the body. In case of a fall, full-body harnesses keep the worker upright and supported while waiting for rescue.

The third component of a PFAS is the connecting device. This maybe a shock-absorbing lanyard, rope grab and vertical lifeline or a similar device to connect the body wear to the anchorage. The potential fall distance is a key factor to be considered in selection of a connecting device.

237. Select (d)

The fourth type of machine guard is interlocking barrier guards.

Fixed guard's barrier allows for stock feeding but does not permit operator to reach the danger area. The advantages of this type of machine guarding include the fact that they can be constructed to suit many applications, permanently encloses the point of operation or hazard area, and allows simple, in-plant construction, with minimal maintenance.

Adjustable guards' barrier adjusts for a variety of production operations. The advantages of this type of machine guard include construction in a way to suit many

applications and can be adjusted to admit varying stock sizes.

Self-adjusting guards' barrier moves according to the size of the stock entering point of operation. Guard is in place when machine is at rest and pushes away when stock enters the point of operation.

Interlocking barrier guards shuts off or disengages power and prevents machine start-up when guard is open.

238. Select (b)

All cranes must meet the design specifications set forth by ANSI. Among other requirements, ANSI requires that all parts of cranes should be of adequate strength for its intended service.

239. Select (b)

Fiberglass is the only reliable electrical *insulator* of the materials listed. Wood conducts electricity when it's wet; and, never trust wood if the ladder is near a power line. Aluminum and steel are metals and electrical *conductors.*

240. Select (a)

The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the characteristics of the deposits and the environmental conditions of exposure.

"Stable rock" is natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

"Type A" are cohesive soils with an unconfined, compressive strength of 1.5 ton per square foot.

"Type B" means is cohesive soil with an unconfined compressive strength greater than 0.5 ton per square foot but less than 1.5 ton per square foot.

"Type C" is Cohesive soil with an unconfined compressive strength of 0.5 ton per Square foot or less.

241. Select (a)

Delphi technique or method is a structured communication technique developed as an interactive forecasting method. A panel of experts answer questionnaires in several rounds. At the conclusion of each round, a facilitator provides anonymized summary of the expert's answers from the previous round. The expert revise their earlier answers based on the answers given by other members. It is believed that during this process, the list of answers become smaller and the panel eventually reaches the correct answer.

242. Select (d)

The Voluntary Protection Programs (VPP) recognize employers and workers in the private industry and federal agencies who have implemented effective safety and health management systems and maintain injury and illness rates below national

Bureau of Labor Statistics averages for their respective industries. In VPP, management, labor, and OSHA work cooperatively and proactively to prevent fatalities, injuries, and illnesses through a system focused on: hazard prevention and control; worksite analysis; training; and management commitment and worker involvement. To participate, employers must submit an application to OSHA and undergo a rigorous onsite evaluation by a team of safety and health professionals. Union support is required for applicants represented by a bargaining unit. VPP participants are re-evaluated every three to five years to remain in the programs. VPP participants are exempt from OSHA programmed inspections while they maintain their VPP status.

243. Select (c)

A type I error (or error of the first kind) is the incorrect rejection of a true null hypothesis. A type II error (or error of the second kind) is the failure to reject a false null hypothesis.

244. Select (d)

The pictogram represents an environmental hazard. See Study Session.

245. Select (a)

The pictogram represents an oxidizing agent. See Study Session.

246. Select (b)

OSHA standards require that employers inspect trenches daily and as conditions change by a competent person before worker entry to ensure elimination of excavation hazards. A competent person is an individual who can identify existing and predictable hazards or working conditions that are hazardous, unsanitary, or dangerous to workers, soil types and protective systems required, and who is authorized to take prompt corrective measures to eliminate these hazards and conditions.

247. Select (c)

The ropes must be inspected at least once every 30 days. If the ropes are used to support scaffolding on which people work, they must be inspected every day. Fiber ropes are used extensively in the workplace for material handling and they are usually made of sisal, manila, or nylon.

248. Select (d)

Having kink, twist, or knot have the potential for straining the rope and weakening the rope by overstressing the fibers. Ropes should be stored in a dry place with good air circulation to avoid weakening of the material by humidity.

249. Select (a)

To combat the burden of occupational accidents, injuries, and diseases, ISO has developed the new standard ISO 45001. This standard was developed by a committee occupational safety and health experts and it follows other generic management system approaches.

250. Select (c)

The dependent variable is the one that changes based on the changes in the independent variable. For example, in the equation of a straight line (y = 2x), y is dependent variable and x is the independent variable.

The Pearson coefficient of correlation is a number between – 1 and +1. -1 indicates a negative linear relationship between the dependent and independent variables which means that as the value of the independent variable increase, the value of the dependent variable decreases proportionately. A coefficient of correlation of +1 indicates a positive linear relationship between the dependent and independent variables. In other words, the value of the dependent variable increases proportionately as the value of the independent variable increases. A coefficient of correlation of 0 indicates that the value of the dependent variable does not change with any increase or decrease in the value of the independent variable or that no correlation exists between the two variables.

251. Select (b)

A **Safety Case** is a structured argument, supported by evidence, intended to justify that a system is acceptably safe for a specific application in a specific operating environment. Safety cases are often required as part of a regulatory process, a certificate of safety being granted only when the regulator is satisfied by the argument presented in a safety case. Industries regulated in this way include transportation (such as aviation, the automotive industry and railways) and medical devices. As such there are strong parallels with the formal evaluation of risk used to prepare a Risk Assessment, although the result will be case specific.

252. Select (c)

The claim is about the property of a system or sub-system. Evidence is the basis of the safety argument. Argument is the process of linking the evidence to the argument. Inference is the mechanism that provides the transformational rules for the argument.

253. Select (a)

The RFS-method uses a base-value of a comparable startup for the valuation of your company. This base-value is then adjusted for 12 standard risk factors. This means you compare your startup to other startups and assess whether you have higher or lower risk.

254. Select (d)

Effective continuity management is the responsibility of every business. Modern business continuity planning approaches, such as ISO 22301, recognize that organizations cannot operate in isolation. They depend on an extended network of external suppliers and stakeholders. A failure in any part of that network can compromise the ability of the business to achieve its aims.

255. Select (b)

The six major steps in creating a successful ***Business Continuity Plan*** are:

(a) Identify the scope of the plan.

(b) Identify key business areas.

(c) Identify critical functions.

(d) Identify dependencies between various business areas and functions.

(e) Determine acceptable downtime for each critical function.

(f) Create a plan to maintain operations.

256. Select (b)

In management literature, gap analysis involves the comparison of actual performance with potential or desired performance. If an organization does not make the best use of current resources, or forgoes investment in capital or technology, it may produce or perform below an idealized potential.

257. Select (d)

The other two major steps are:

(a) Compare the current state with the ideal state.

(b) Describe the gap and quantify the difference.

Domain III:
Risk Management

3.1 Managing Risks

There are four steps involved in risk management:

1. Hazard Identification

The first step in the process of risk management is hazard identification. This is probably the most important step in this process. If certain hazards are not identified, their risk cannot be assessed and properly managed. Hazards in the workplace fall into broad categories, from exposure to hazardous chemicals, injurious physical agents, noise and vibration, heat stress, etc. however, in the process of risk management, every effort must be made to identify all hazards and potential hazards. Working closely with workers and looking at every task at the workplace will assist in finding potential hazards.

Manufacturers and suppliers can provide information about hazards and safety precautions for specific substances (safety data sheets), plant or processes instruction manuals.

2. Risk Assessment

The risk assessment process will yield more comprehensive and better results when reliable statistical and probability data are available. In the absence of such data, the results are a strong function of the engineering judgement of the assessors. The important issue is that both the severity and probability of the accident must be taken into account. Although the acceptability of risk is a management decision, one can divide the area in a risk matrix (plot of probability vs severity) into unacceptable, marginally acceptable, and acceptable regions.

3. Risk Control

Risk can be controlled or minimized by implementing engineering and/or administrative controls. For example, placing a shield between a worker and an ionizing radiation source is an example of engineering control. Rotation of workers in high noise area to reduce exposure is an example of administrative control. For hazards that cannot be controlled by engineering or administrative techniques, proper Personal Protective Equipment must be provided.

4. Review Control Measures

Once a hazard is identified and its risks have been assessed, control measures are put in place to either eliminate or minimize the risk. However, risk controls must be re-

viewed on a regular basis to ensure that they are still capable of controlling the risk. Many times, changes in the workplace may affect risk control measures.

Who should be covered?

The process of risk management must also address the safety and health of not only the workers but all others such as contractors, visitors, etc. who might be affected by the presence of hazards in the workplace.

Keeping records:

It is good practice to document and keep records of the risk assessment process. This can help with compliance activities as well as future risk assessments.

3.2 Example Questions

1. In the process of risk assessment, risk can be classified into two general categories; societal risk and individual risk. Which of the following statements is the best description of a societal risk?
   a. The risk associated with a large group of individuals
   b. Number of incidences or consequences that can occur per year
   c. The risk of release of a hazardous chemical into the community
   d. All the risks that a given society is exposed to
2. Which of the following statements best describes the concept of individual risk?
   a. The risk associated with workplace hazards to an individual
   b. Number of undesirable incidences or consequences that can occur to an individual in any given day
   c. Probability of a single consequence occurring to an individual in a given year
   d. The risk an individual assumes in a given day
3. Risk analysis in occupational and environmental safety:
   a. Is a qualitative method only
   b. Is a quantitative method only
   c. Can be qualitative or quantitative
   d. Must provide solutions to eliminate risks
4. In regard to the process of risk assessment, which of the following statements is the most correct?
   a. Risk must first be managed and then assessed.
   b. Risk can only be assessed after hazard identification.
   c. Risk must be assessed before hazard identification.
   d. Only (a) and (b) above.
5. MORT is used extensively in Total Quality Management (TQM). MORT is an acronym for:
   a. Management Oversight Risk Tree
   b. Minimum Operational Readiness Test
   c. Management Objectives and Reorganization Technique
   d. Management Organization and Restructure Technique
6. The Management Oversight Risk Tree (MORT):

a. Starts with an undesirable event and traces that event to all its possible causes

b. Is a diagram which primarily focuses on risk analysis and management failures to adequately respond to risks

c. Is similar to fault tree analysis

d. Only (a) and (c) above

7. Unit Risk Exposure is calculated by:

a. Dividing total lost dollars by the total number of units lost.

b. Calculating the reliability of each component of a system and using the appropriate relationship for series or parallel system reliability.

c. Dividing the total risk exposure by the total number of units.

d. Calculating the reliability of each component within a system and adding the results for all components.

8. Risk identification must be conducted before:

a. Risk management

b. Risk analysis

c. System safety application

d. All of the above

9. Proper risk assessment is one of the key steps in the process of hazardous waste management. Which of the following would you use as the first step in the process of risk assessment for a hazardous waste site?

a. Site assessment

b. Contact OSHA

c. Contact the LEPC and SERC

d. Contact the U.S. Coast Guard

10. In the process of risk assessment, both the probability and severity of an incident must be taken into account. From the following table, which case poses the highest risk?

Case	Probability	Severity
1	0.000005	2
2	0.000003	5
3	0.000001	6
4	0.000001	4

a. Case 1

b. Case 2

c. Case 3

d. Case 4

11. Which of the following statements is true in regards to cost-benefit analysis?

a. Cost-benefit analysis calculates the benefits and costs of competing alternatives.

b. The analysis can be performed by calculating the cost-to-benefit ratio.

c. The analysis can be performed by calculating the benefit-to-cost ratio.

d. All of the above.

12. Hazard and Operability (HAZOP) studies are conducted to identify the deviations of process parameters from their design intent. A team conducts a HAZOP study. Which of the following IS NOT true in regards to HAZOP team leaders or their functions?

a. The HAZOP team leader must be completely familiar with the process and its safety features.

b. The HAZOP team leader must be able to assist in brainstorming the process.

c. The HAZOP team leader must be able to document the findings of each brainstorming session.

d. The HAZOP team leader must be able to prepare a sound HAZOP report.

13. Which of the following is considered to be an environmental risk assessment technique?

a. Probability analysis

b. Systems analysis

c. Cost-benefit analysis

d. All of the above.

14. The risk assessment process must be conducted in the following order:

a. Hazard accounting, hazard identification or risk evaluation, risk characterization

b. Hazard identification, risk evaluation, risk characterization, hazard accounting

c. Hazard identification, hazard accounting, risk characterization, risk evaluation

d. Hazard identification, hazard accounting, risk evaluation, risk characterization

15. Residual risk is defined as equal to inherent risk less the effect of controls. Which of the following is NOT one of the three types of controls that are commonly used to reduce inherent risk?

a. Preventive

b. Probabilistic

c. Detective

d. Remedial

16. Which of the following statements is not true in regard to a management oversight risk tree (MORT)?

a. It can be used to predict the adequacy of control elements already in place to prevent accidents.

b. MORT uses similar symbols and logic to those used in fault tree analysis.

c. MORT does not look at what happened during an accident, but traces causal factors back to management systems to identify why events happened.

d. It is very effective in identifying the underlying management root causes of hazards.

17. *Pure risk* is defined as risk that can only produce negative outcomes. *Speculative risk* is defined as risk that can produce both positive and negative outcomes. Which of the following is not an example of pure risk?

a. Fire

b. Unrecoverable disability

c. Gambling

d. Accident

18. You are a CSP in charge of safety for a petrochemical plant. A reactor explodes and 4 workers are killed and 3 are severely injured. The local newspapers and TV personnel pour into the plant and want information from you. Which of the following courses of actions would be most appropriate for you to take?

a. Try to downplay the accident.

b. Try to tell them everything that you know.

c. Stay in the background and provide information to management.

d. Try to blame the accident on unavoidable causes.

19. As a safety and health professional in a midsize company, you have established a safety and health program. One of the employees in the production department has consistently been ignoring safety rules and policies. You have discussed the matter with his supervisor without getting any results. You should:

a. Contact the company vice president

b. Contact the personnel department

c. Contact OSHA

d. Contact the employee's labor union

20. All of the following must be considered in developing a safety and health program for an organization EXCEPT:

    a. Emotional aspects

    b. Individual differences

    c. Motivational issues

    d. Availability of personal protective equipment

21. Formal hazard analysis techniques can be divided into two general categories. Which of the following is the correct description of these two categories?

    a. HAZOP and Fault Tree

    b. FMEA and Event Tree

    c. FMEA and OHA

    d. Inductive and deductive

22. According to Berlo, the communication process is made up of seven steps. Which of the following is NOT one of the seven communication steps suggested by Berlo?

    a. Encoding

    b. The channel

    c. Interpretation

    d. Decoding

23. Which of the following is NOT considered to be a valid approach in safety programs that primarily focus on behavior modification?

    a. Eliminate unwanted behavior.

    b. Provide training to eliminate or reduce the number of unsafe conditions.

    c. Educate employees on desired responses.

    d. Provide reward and/or praise for working safely.

24. All of the following are examples of situations that knowledge of the risks involved may not lead to safe behaviors EXCEPT:

    a. Smoking

    b. Handling toxic chemicals

    c. Eating high-cholesterol, high fat foods

    d. Not wearing seat belts

25. All of the following are steps involved in conducting Job Hazard Analysis EXCEPT:

    a. Determine the steps involved in each job

b. Identify hazards related to each task

c. Quantify the results using minimum cut sets

d. Determine how hazards can be mitigated

26. Which of the following statements is true in regard to Root Cause Analysis?

a. It combines the forward thinking pattern of PHA with the backward thinking pattern of FTA to predict the failure of safety functions that could lead to an undesirable event.

b. It is the process by which the cause and effect relationship of an event, usually with undesirable consequences, are analyzed.

c. It is a process by which the members of a team engage in brainstorming sessions to find out the deviation of process parameters from their design intent.

d. It is best suited for predicting human errors by breaking a job into several steps and analyzing each step separately.

27. Which of the following IS NOT considered an essential step in the process of risk management?

a. Communication with supervisors

b. Development of risk scenarios

c. Means of control

d. Implementation of best control method

28. In the process of risk assessment, both the probability and severity of risk must be addressed. This can be done either graphically, with one axis showing the probability and the other axis showing the severity, or in the form of a table. This representation of risk data is called:

a. Risk chart

b. Risk matrix

c. Risk table

d. Risk domain

29. Which of the following techniques is most helpful to top management in placing priorities on corrective actions to eliminate or reduce risks?

a. Fault tree analysis

b. Risk analysis

c. Failure analysis

d. Cost/benefit analysis

30. All of the following are steps which must be undertaken in a risk assessment process EXCEPT:

    a. Hazard identification

    b. Decide on who and what may be harmed and how

    c. Evaluate the risks and decide on control measures

    d. The person in charge of the risk assessment process must attend risk assessment training

31. In proper risk assessment, a cost-benefit analysis must be performed. Both tangible and intangible costs must be considered. All of the following are examples of tangible costs associated with a project EXCEPT:

    a. Shipping

    b. Energy costs

    c. Real Estate

    d. Price of goods or equipment

32. A measure of the combined probability and severity of potential harm to one or more resources as a consequence of exposure to one or more hazards is the correct definition of:

    a. Risk

    b. Risk assessment

    c. Risk control

    d. Risk management

33. The process of determining the degree of threat that is posed by one or more hazards is called:

    a. Risk control

    b. Risk management

    c. Risk assessment

    d. Risk acceptance

34. The process of minimizing or eliminating accidental losses by anticipating and preventing the occurrence of unplanned events is called?

    a. Risk assessment

    b. Risk management

    c. Risk acceptance

    d. Risk control

35. The professional assessment of all loss potentials in an organization's structure and operations leading to the establishment and administration of a comprehensive loss control program is called:

    a. Risk control

    b. Risk assessment

    c. Risk management

    d. Risk acceptance

36. "Risk homeostasis" is a theory that:

    a. A person may operate at a given risk level regardless of the safeguards provided

    b. Deals with non-industrial risks such as smoking

    c. Deals with risk of hazards encountered off the job such as climbing a ladder at home

    d. All of the above

37. Fault Tree Analysis (FTA) is:

    a. Bottom up system safety technique

    b. Top down system safety technique

    c. Used to determine the deviation in process parameters from their design intent

    d. A qualitative system safety technique that identifies the consequences of success or failure of safety functions in a system.

38. Which of the following BEST describes the concept of safety and health "benchmarking"?

    a. Benchmarking cannot be applied to ALL aspects of a safety and health program.

    b. Benchmarking does not necessarily require management commitment but it does require employee involvement.

    c. Any information that is exchanged does not have to be comparable with partner's information.

    d. Safety and health benchmarking compares an organization's safety and health performance with similar organizations.

39. In performing a Job Safety Analysis (JSA), several factors affect prioritizing different jobs for analysis. All of the following are factors which affect the prioritization of jobs for analysis EXCEPT:

    a. Incident frequency

    b. Incident severity

c. New jobs

d. Complexity of an operation

40. All the following statements are correct about Job Safety Analysis (JSA) EXCEPT:

a. JSA breakdowns a job into several steps.

b. JSA identifies the hazards associated with each step.

c. JSA can be used to educate employees on safe practices.

d. JSA can quantify the accident probabilities.

41. In conducting a Job Safety Analysis, the priority should go to which of the following jobs?

a. Jobs with the highest injury or illness rates.

b. Jobs with the potential to cause severe or disabling injuries or illnesses.

c. Jobs in which one simple human error could lead to a severe accident or injury.

d. All the above.

42. Which of the following best describes the "**Casual Analysis**?"

a. To find the root cause of a problem instead of finding the symptoms.

b. Helps to uncover the facts that lead to a certain situation.

c. Cause refers to a reason.

d. All the above.

3.3 Example Answers

1. Select (b)

   Societal risk is defined as the number of undesirable incidences or consequences that can occur per year.

2. Select (c)

   The correct definition of individual risk is stated in (c).

3. Select (c)

   Risk analysis can be conducted on either a qualitative or quantitative basis. Both probability and severity of undesirable events must be taken into account and every effort should be made to either eliminate the risk or reduce its value to acceptable levels.

4. Select (b)

   Risk assessment is conducted after hazard evaluation. The next step is to determine the probability and severity of the events which create the risk.

5. Select (a)

   MORT which has William G. Johnson as its principle author is an acronym for Management Oversight Risk Tree.

6. Select (d)

   MORT, which is a technique similar to Fault Tree Analysis, starts with an unwanted event and traces that event to all its possible causes. MORT charts, which are similar to fault trees, are primarily used for accident investigation. MORT can also be used for inspection, audit, and appraisal purposes.

7. Select (c)

   Calculation of unit risk exposure is done as described in (c). For example, if in 10,000 units, the risk exposure is 100, then the unit risk exposure is $100 \div 10{,}000$.

8. Select (d)

   In the process of risk management, the first step is identification of situation that create risk.

   The objectives of risk identification are to identify and categorize risks that could affect the project and document these risks. The outcome of risk identification is a list of risks. What is done with the list of risks depends on the nature of the risks and the project.

   On noncomplex, low-cost projects with little uncertainty (few risks), the risks may be kept simply as a list of red flag items. The items can then be assigned to individual team members to watch throughout the project development process and used for risk allocation purposes.

On complex, high-cost projects that are by nature uncertain, the risks can feed the rigorous process of assessment, analysis, mitigation and planning, allocation, and monitoring.

9. Select (a)

   Proper site assessment provides information on the risks posed by a hazardous waste site.

   The major objective of site assessment is to identify all conditions or suspected conditions that might be immediately dangerous to life or health. A secondary site assessment is conducted to identify these hazardous conditions and recommend appropriate protective measures. Examples of such hazards include, but are not limited to, entry into confined spaces, potentially explosive or flammable situations, visible vapor clouds, or areas where a biological indicator, such as dead animals or vegetation, is located.

10. Select (b)

    One way to define risk is to multiply probability and severity. In this case:

Case	Risk
1	0.000010
2	0.000015
3	0.000006
4	0.000004

11. Select (d)

    All statements are true in regards to cost-benefit analysis.

    Cost-benefit analysis considers the equivalent dollar value of costs to benefits among competing projects. If the costs exceed the benefits the project is not considered worthwhile to pursue. Many components of costs and benefits lend themselves to simple analysis. However, there are other components for which intuition fails to offer an accurate method of measurement.

12. Select (a)

    Although a HAZOP team leader must in general be familiar with the process, complete familiarity with the process is not a requirement. One of the responsibilities of the team leader is to form a multidisciplinary team that is completely familiar with the process and its safety features.

13. Select (d)

    All are techniques used in environmental risk assessment.

14. Select (c)

    Statement (c) describes the correct order for environmental risk assessment.

15. Select (b)

    Preventive controls focus on reducing the probability of risk occurring. Detective controls attempt to identify the occurrence of risk. If detective controls are applied before the occurrence of risk, they reduce the likelihood of occurrence. If they are applied after the occurrence of risk, they reduce the consequences of the risk. Remedial controls attempt to reduce the consequences of a risk that has occurred.

16. Select (c)

    MORT has the capability to analyze what happened during an accident. It is a comprehensive, analytical, and disciplined method for determining the causes and contributing factors of an incident.

17. Select (c)

    Gambling can offer winnings as well as losses.

18. Select (c)

    In situations like this, the safety professional should stay in the background and provide adequate information to management (unless specifically directed by management to get directly involved).

19. Select (b)

    The best course of action is to inform the personnel department.

20. Select (d)

    PPE is not a consideration in developing a safety and health program. It is a consideration after the program has been developed.

21. Select (d)

    Formal hazard analysis techniques are often divided into two general categories, inductive and deductive.

    In inductive hazard analysis (bottom up), future behavior is based on experience which is hypothetical, and the conclusion is generally more than just the sum of observations. In deductive hazard analysis (top down), future behavior is concluded from a number of premises which may be true or false.

22. Select (c)

    According to Berlo, the communication process is made up of seven steps; the communication source, encoding, the message, the channel, decoding, the receiver and feedback.

23. Select (b)

    Training on eliminating unsafe conditions is not considered to be a behavioral modification approach to enhance safety programs.

24. Select (b)

Knowledge of the risks involved in handling toxic chemicals usually leads to safe behaviors.

25. Select (c)

Minimum cut sets are used in Fault Tree Analysis. A minimal cut set is the smallest combination of component failures which, if they all occur, will cause the top event to occur.

By definition, a minimal cut set is thus a combination (intersection) of primary events sufficient for the top event. The combination is a "smallest" combination, in that all the failures are needed for the top event to occur. If one of the failures in the cut set does not occur, then the top event will not occur (by this combination).

Any fault tree will consist of a finite number of minimal cut sets that are unique for that top event. The one-component minimal cut sets, if there are any, represent those single failures that will cause the top event to occur. The two-component minimal cut sets represent the double failures that together will cause the top event to occur.

26. Select (b)

Root Cause Analysis (RCA) is the process by which the cause and effect relationship of an event, usually with undesirable consequences, are analyzed. The goal of conducting an RCA is to find a solution that ensures that the undesirable event does not happen.

RCA uses a specific set of steps to find the main cause of a problem. This gives the analyst an opportunity to determine a) what happened, b) why it happened, and c) what to do in order to prevent its recurrence.

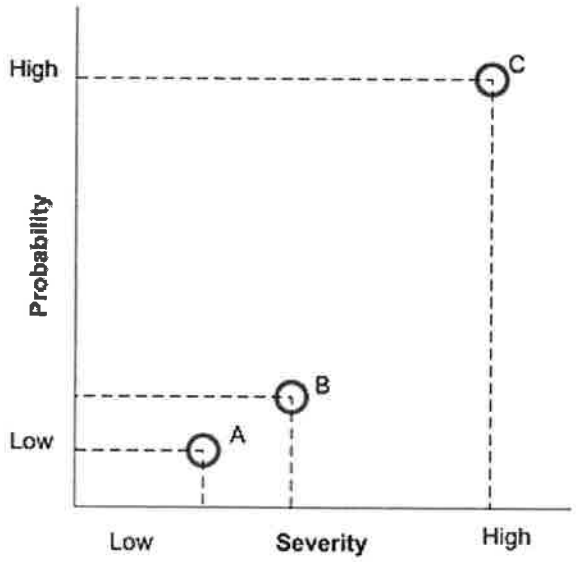
In RCA, the causes of a problem can be physical (for example, a control valve failed to open), human error (the technician failed to perform a scheduled maintenance on the control valve), and/or organizational causes (for example, no one was assigned to do maintenance and everyone thought someone else was assigned to do it).

27. Select (a)

The fourth step in the process of risk management is management and control of the risk and feedback on the effectiveness of the process.

28. Select (b)

The representation of risk data in graphical or tabular form is called a risk matrix. For example, the following graph illustrates a typical risk matrix.



Point A is a relatively low probability and low severity risk. However, Point C has a high probability and high severity. Determining the acceptability or nonacceptability of risks is a management decision.

29. Select (d)

The benefit obtained from risk reduction must be justified through benefits to the organization.

30. Select (d)

The other steps involved in the risk assessment process are to record the findings and implement them, then review the assessment and update if necessary.

31. Select (b)

Energy costs are considered an intangible cost for a project. Tangible *costs* typically include things a business can buy directly for specific *costs*, such as labor, materials and space.

32. Select (a)

Risk is the defined as the simple product of probability and severity. In order to reduce risk, the probability or severity or both must be reduced. For example, consider an exothermic (heat generating) reaction in a chemical reactor where the heat of reaction is removed by pumping a coolant through the jacket around the reactor. If the coolant pump fails, heat will accumulate in the reactor leading to a runaway reaction and explosion. Installation of a spare pump would reduce the probability of losing coolant flow to the reactor because two pumps must fail at the same time.

33. Select (c)

Risk may be assessed either subjectively (non-quantitatively) or numerically (quantitatively).

34. Select (d)

    Risk control incorporates a wide range of elements including worker safety. Once the hazards are identified and the risk assessed, risk should be managed and controlled. Engineering and administrative measures are used to control risk. For example, use of enclosures to protect workers is an example of engineering control and measures such as job rotation is an example of administrative control.

35. Select (c)

    Risk management's goal is to eliminate or to reduce losses to an acceptable minimum at the lowest possible cost.

36. Select (a)

    For example, a worker who feels he/she is protected by a back-belt may attempt to lift even more with the belt than he/she would without it.

37. Select (a)

    Fault tree starts with an undesired event and traces backward to all possible causes. Failure mode effect analysis (FMEA) is also a bottom up system safety technique. Event Tree Analysis (ETA) is a system safety technique that determines the consequences of success or failure of safety functions in a system.

38. Select (d)

    Benchmarking requires both management commitment and employee involvement. Information that is exchanged must be comparable to the other organization's information and arrangements for confidentiality issues must be made.

39. Select (d)

    Complexity of an operation is not considered to be a factor in prioritizing a job for Job Safety Analysis.

40. Select (d)

    JSA breaks down a job into many steps and identifies the hazards associated with each step and their means of control. This technique can be used to educate employees on safe work practices.It must be pointed out that the priority for JSA should be assigned to those jobs that have a relatively high probability of leading to an accident which has severe consequences.

41. Select (d)

    A job hazard analysis can be conducted on many jobs in the workplace. Priority should go to the following types of jobs:

    - Jobs with the highest injury or illness rates.
    - Jobs with the potential to cause severe or disabling injuries or illnesses, even if there is no history of previous accidents.
    - Jobs in which one simple human error could lead to a severe accident or injury.

- Jobs that are new to the facility operation or have undergone changes in processes and procedures.
- Jobs complex enough to require written instructions.

42. Select (d)

Cause refers to a reason. The purpose of causal analysis is trying to find the root cause of a problem instead of finding the symptoms. This technique helps to uncover the facts that lead to a certain situation.

Domain IV: Advanced Safety Concepts

4.1 Process Safety Management

INTRODUCTION

The advent of complex and high-energy hazardous processes has made process safety management an integral element of process design and operation. Catastrophic events such as Flixboro explosion, Seveso Dioxin release and Bhopal toxic plume release, and a host of others are examples of disasters that could have been prevented by proper application of process safety management techniques. The Flixboro event showed the importance of proper controls when administering changes in plant design such as engineering verification of changes and effects of vapor cloud explosion. The Bhopal event showed the importance of maintenance and administrative controls.

The major objective of process safety management is to prevent unwanted releases of hazardous chemicals especially into locations, which could expose employees and others to serious hazards. An effective process safety management program requires a systematic approach to evaluating the whole process. Using this approach, the process design, process technology, operational and maintenance activities and procedures, non-routine activities and procedures, emergency preparedness plans and procedures, training programs and other elements which impact the process are all considered in the evaluation. The various lines of defense that have been incorporated into the design and operation of the process to prevent or mitigate the release of hazardous chemicals need to be evaluated and strengthened to assure their effectiveness at each level. Process safety management is the proactive identification, evaluation and mitigation or prevention of chemical releases that could occur as a result of failures in process, procedures or equipment.

Elements of Process Safety Management (PSM)

1. Employee Participation

A successful Process Safety Management program must be based on the concept of teamwork between management and employees. It is imperative for management to consult with their employees regarding the management's efforts in the development and implementation of the PSM program elements and hazard assessments. A sound management approach to employee participation allows more and more employees to influence decisions and have access to process information.

2. Process Safety Information

Complete and accurate written information on process definition and design criteria, process and equipment design, documentation of risk management decisions, protective systems, normal and upset conditions, and chemical and occupational health hazards is essential to an effective PSM program. This information is a necessary resource to a

variety of users including the team that will perform the process hazard analysis. This information must be comprehensive and provide accurate assessment of the fire and explosion characteristics, reactivity hazards, the safety and health hazards to workers and the corrosion and erosion effects on the process equipment and monitoring tools.

3. Process Hazard Analysis

A process hazard analysis is one of the most important elements of the Process Safety Management program. This is an organized and systematic effort to identify and analyze the significance of potential hazards associated with the processing or handling of hazardous chemicals. The selection of a process hazard analysis methodology or technique will be influenced by many factors including the amount of existing knowledge about the process.

Is it a process that has been operated for a long period of time with little or no innovation? Or, is it a new process or one that has been changed frequently by the inclusion of innovative features? Also, the size and complexity of the process will influence the selection of the appropriate process hazard analysis methodology. For a review of Hazard Evaluation Methodologies, see domain 2 Study Session under "System Safety".

4. Risk Analysis

Before selection and application of any process hazard analysis methodology, a comprehensive risk assessment must be conducted. This assessment must provide information on the degree of risk as a result of system component failures. Although risk analysis can be conducted either on a quantitative or qualitative basis, the important issue is that both the severity and probability (frequency) of the undesirable events must be taken into account. The combination of probability and severity of undesirable events must provide the management with the information on whether the risk is acceptable or not. In the event that risk is unacceptable, the system must be modified to reduce the probability, severity or both the probability and severity of the undesirable events. For example, consider a high-pressure jacketed reactor with a highly exothermic reaction. Assume that the heat of reaction is removed by pumping a coolant through the reactor jacket. A risk assessment of this process reveals that failure of the pump can result in a runaway chemical reaction and explosion. This is, obviously, an unacceptable risk. Adding a spare pump can modify the system. This lowers the probability of an explosion as a result of pump failure because two pumps must fail for the system to fail.

Once a risk assessment has been completed, the appropriate process hazard analysis methodology can be selected and applied to the process. This analysis must identify different types of hazards within the system components and to propose possible solutions to eliminate the hazards. These procedures are extremely useful in identifying system modes and failures that can contribute to occurrence of accidents, and should be an integral part of different phases of process development from conceptual design to installation, operation and maintenance.

5. Employee Training

All employees, including maintenance and contractor employees, involved with highly hazardous chemicals need to fully understand the safety and health hazards of the chemicals and processes they work with for the protection of themselves, their fellow employees and the citizens of nearby communities. Training in subjects such as operating procedures and safe work practices, emergency evacuation and response, safety procedures, routine and non-routine work authorization activities and other areas pertinent to process safety and health will need to be covered.

In establishing the training programs, we must clearly define the employees to be trained and what subjects are to be covered in their training. In setting up the training program, we need to clearly establish the goals and objectives we wish to achieve with the training that is provided. The learning goals or objectives should be written in clear measurable terms before the training begins. These goals and objectives need to be tailored to each of the specific training modules or segments.

6. Contractors

Employers, who use contractors to perform work in and around processes that involve highly hazardous chemicals, will need to establish a screening process so that they hire and use contractors who accomplish the desired job tasks without compromising the safety and health of employees at a facility.

7. Pre-Startup Safety Review

For new processes, the employer will find a process hazard analysis helpful in improving the design and construction of the process from a reliability and quality point of view. Making use of the recommendations before final installations are completed will enhance the safe operation of the new process. The Piping & Instrumentation Diagrams (PID) are to be completed along with having the operating procedures in place and the operating staff trained to run the process before startup. The initial startup procedures and normal operating procedures need to be fully evaluated as part of the pre-startup review to assure a safe transfer into the normal operating mode for meeting the process parameters.

For existing processes that have been shut down for turnaround, or modification, etc., the management must assure that any changes other than "replacement in kind" made to the process during shutdown go through the management of change procedures.

8. Mechanical Integrity

Management will need to review their maintenance programs and schedules to see if there are areas where "breakdown" maintenance is used rather than an ongoing mechanical integrity program. Equipment used to process, store, or handle highly haz-

ardous chemicals needs to be designed, constructed, installed and maintained to minimize the risk of releases of such chemicals. This requires that a mechanical integrity program be in place to assure the continued integrity of process equipment. Elements of a mechanical integrity program include the identification and categorization of equipment and instrumentation, inspections and tests, testing and inspection frequencies, development of maintenance procedures, training of maintenance personnel, the establishment of criteria for acceptable test results, documentation of test and inspection results, and documentation of manufacturer recommendations as to meantime to failure for equipment and instrumentation.

9. Non-routine Work Authorizations

Non-routine work that is conducted in process areas needs to be controlled by the management in a consistent manner. The hazards identified involving the work that is to be accomplished must be communicated to those doing the work, but also to those operating personnel whose work could affect the safety of the process. A work authorization notice or permit must have a procedure that describes the steps the maintenance supervisor, contractor representative or other person needs to follow to obtain the necessary clearance to get the job started.

10. Management of Change

To properly manage changes to process chemicals, technology, equipment and facilities, one must define what is meant by change. Change includes all modifications to equipment, procedures, raw materials and processing conditions other than "replacement in kind". These changes need to be properly managed by identifying and reviewing them prior to implementation of the change. For example, the operating procedures contain the operating parameters (pressure limits, temperature ranges, flow rates, etc.) and the importance of operating within these limits. While the operator must have flexibility to maintain safe operation within the established parameters, any operation outside of these parameters requires review and approval by a written management of change procedure.

11. Investigation of Incidents

Incident investigation is the process of identifying the underlying causes of incidents and implementing steps to prevent similar events from occurring. The intent of an incident investigation is to learn from past experiences and thus avoid repeating past mistakes.

12. Emergency Preparedness

Management must address what actions employees are to take when there is an unwanted release of highly hazardous chemicals. Management will need to decide if they want employees to handle and stop small or minor incidental releases. Whether they wish to mobilize the available resources at the plant and have them brought to bear on a more significant release; or whether employers want their employees to evacuate the danger area and promptly escape to a pre-planned safe zone area, and allow the local community emergency response organizations to handle the release; or whether the employer want to use some combination of these actions. Employers will need to select how many different emergency preparedness procedures they plan to have and then develop the necessary plans and procedures, and appropriately train employees in their emergency duties and responsibilities and then implement these lines of defense.

13. Audits

Management needs to select a trained individual or assemble a trained team of people to audit the process safety management system and program. A small process or plant may need only one knowledgeable person to conduct an audit. The audit is to include an evaluation of the design and effectiveness of the process safety management system and a field inspection of the safety and health conditions and practices to verify that the systems are effectively implemented. The audit should be conducted or led by a person knowledgeable in audit techniques and who is impartial towards the facility or area being audited. The essential elements of an audit program include planning, staffing, and conducting the audit, evaluation and corrective action, follow-up and documentation.

CONCLUSION

Application of the Process Safety Management techniques to processes that use, produce, or store highly hazardous chemicals can greatly reduce the probability of a catastrophic accident. These techniques are designed to aid management in their efforts to prevent or mitigate chemical releases that could lead to a catastrophe in the workplace and in the surrounding community. To control these types of hazards, the management needs to develop the necessary expertise, experiences, judgement, and proactive initiative within the workplace to properly implement and maintain an effective Process Safety Management program.

4.2 Personal Protective Equipment (Respirators)

Respirators

- Under OSHA regulations (29CFR1910.134), an employer who utilizes respirators in their operation must have a written respiratory protection program prior to use of respirators in the work place. This program must address Standard Operating Procedures (SOP's) for the selection and use of respirators, training issuers and users, disinfecting respirators, and maintenance, as well as storage requirements and inspection of respirators.
- Respirators can be categorized in these major types; Air Purifying Respirators and Atmosphere Supplying Respirators.
- An atmosphere is considered to be oxygen deficient if the concentration of oxygen is less than 19.5 per cent by volume.(ACGIH considers an atmosphere with less than 18% oxygen to be oxygen deficient.)
- Air purifying respirators can only remove the contaminants for which they are designed.
- Air purifying respirators must not be used in atmospheres which are oxygen deficient.
- Air purifying respirators must not be used in atmospheres where the type and concentration of the contaminants are unknown.
- Air purifying respirators remove contaminant gases and vapors from the air by the process of "adsorption." This process refers to removal of a component of a gaseous mixture on a solid bed.
- Air purifying respirators must not be used in atmospheres that are Immediately Dangerous to Life or Health (IDLH) because in such atmospheres even smallest leaks can not be tolerated and for contaminants which do not have odor thresholds above PEL or TLV.
- Supplied air respirators have their own supply of air, and therefore, are independent of the atmosphere in which they are used. OSHA limits the length of the airline to a maximum of 300 feet.
- The advantage of the supplied air respirators is that they can provide to the user breathing air for a long period of time. The disadvantage of this type of respirator is that it limits the mobility of the user.
- Self Contained Breathing Apparatus (SCBA) can be open circuit or closed circuit.The former exhausts the used air from the user while the latter recycles the air after removal of carbon dioxide and water and addition of make up oxygen. The advantage of closed loop SCBA is that it can provide breathing air to the user for a much longer period of time compared to the open loop SCBA.

- Positive pressure demand SCBA's maintain a positive pressure in the face mask and reduce the possibility of inward leakage from surrounding contaminated air.

Example 1

The most important concept in selection of Personal Protective Equipment (PPE) is to:

a. Convince workers in its proper use.

b. Provide training in its proper use.

c. Match PPE to the hazard.

d. Ensure that it can easily be disinfected.

Select (c) Matching PPE to the hazard is the most important step in the selection process. Using the wrong kind of PPE can create a false sense of security and increase the probability of an accident.

Example 2

Which of the following organizations set forth standards for eye and face protective devices?

a. OSHA

b. CPSC and OSHA

c. NIOSH

d. ANSI

Select (d)

The American National Standard Institute ANSI sets forth standards for eye and face protection (ANSI Z87.1). These standards have been adopted by OSHA.

Example 3

Which of the following statements is true regarding Self-Contained Breathing Apparatus (SCBA)?

a. Open circuit SCBA's have a relatively long operating time as compared to closed circuit SCBA's.

b. Open circuit SCBA's remove CO2 and water from exhaled air.

c. Positive pressure SCBA's should be used in IDLH conditions.

d. Closed circuit negative pressure SCBA provide the highest level of protection in IDLH conditions.

Select (c) Positive pressure SCBA's provide a positive pressure inside the face mask at all times. This would reduce the possibility of leaks from the contaminated atmosphere into the face mask.

Example 4

According to OSHA regulations, Self-Contained Breathing Apparatus (SCBA) must be inspected at least once every _____days and after each use:

a. 15 days

b. 30 days

c. 7 days

d. 45 days

Select (b) OSHA requires that SCBA's be inspected at least once every 30 days and after each use (29CFR 1910.133).

4.3 Example Questions

1. Placing a shield between an ionizing radiation source and an employee is an example of:
   a. Engineering control
   b. Administrative or management control
   c. Management control
   d. Only (a) and (b) above
2. A stock insurance company is best defined by which of the following statements?
   a. Insurance company which is profit motivated
   b. Insurance company with at least 100,000 shares of stock
   c. Insurance company protected by FDIC
   d. Insurance company that is not allowed to sell Workers' Compensation insurance
3. The BEST method to reduce employee exposure to airborne chemicals to an acceptable level is by means of:
   a. Administrative controls
   b. Using a respirator
   c. Reducing the number of exposure hours
   d. Engineering controls
4. Point source airborne contaminants are best controlled by:
   a. Dilution ventilation
   b. Local exhaust ventilation
   c. General ventilation
   d. General ventilation with a compression ratio of 10 or more
5. Which of the following is an example of engineering noise control?
   a. Use of earmuffs
   b. Reducing the number of hours of exposure
   c. Use of sound absorbing materials
   d. Audiometric testing
6. Which of the following insurance coverage is used to provide liability coverage for a company engaged in the cleanup of a hazardous waste site?
   a. Premium and medical coverage

b. Chemical exposure coverage

c. Manufacturers' and contractors' coverage

d. Strict liability coverage

7. The preferred angle range for fixed industrial stairs is:

a. 30 to 35 degrees

b. 15 to 25 degrees

c. 10 to 25 degrees

d. 5 to 15 degrees

8. In ventilation design, the number of room air changes per unit time can be obtained by:

a. Multiplying the room volume by the volumetric flow rate of air in the ventilation system.

b. Dividing the room volume by the volumetric flow rate of air in the ventilation system.

c. Dividing volumetric flow rate of air in the ventilation system by the room volume.

d. Subtracting the volumetric flow rate of air in the ventilation system from the room volume.

9. Which of the following organizations mandates lockout/tagout programs for service or maintenance of certain types of equipment?

a. NIOSH

b. OSHA

c. FEMA

d. CPSC

10. Which of the following statements is NOT true in regard to chemical labels?

a. Labels are used on drums of hazardous chemicals.

b. Labels are used on transportation vehicles carrying hazardous materials.

c. Labels are used on gas cylinders.

d. Labels are used on bottles of hazardous chemicals.

11. In liability insurance coverage, the term "OCP" is an acronym for:

a. Operation and Chemical Protection

b. Owners and Contractors Protection

c. Operators and Contractors Protection

d. Operators and Constructors Protection

12. Insurance coverage falls into four broad categories. Which of the following is NOT one of these categories?

    a. Property insurance

    b. Liability insurance

    c. Life insurance

    d. Fire insurance

13. Business Income Coverage (BIC) insurance addresses the loss exposures relating to loss of income and/or extra expense to operate. Which of the following is NOT one of the three elements of the loss exposure covered by the basic BIC form?

    a. Property

    b. Health

    c. Perils

    d. Consequences

14. Ground Fault Circuit Interrupters (GFCI) work on the principal of sensing a difference in the amount of electric current entering and leaving a circuit. The difference is considered to be electric current that is leaking to the ground. Once a difference has been detected, a GFCI opens the circuit in:

    a. 0.02 to 0.03 seconds

    b. 0.2 to 0.3 seconds

    c. 2 to 3 seconds

    d. 0.5 to 1.5 seconds

15. Which of the following fall protection systems absorb the energy of an actual fall?

    a. Fall arrest systems

    b. Fall depression systems

    c. Fall suppression systems

    d. Fall prevention systems

16. Ozone (O_3) is a powerful oxidizing agent and is considered to be a hazardous gas. Which of the following operations is most likely to produce ozone?

    a. Paint spraying

    b. Electric arc welding

    c. Catalytic reforming

    d. Catalytic cracking

17. Hexavalent chromium, which is toxic, can most likely be produced as a result of which of the following operations?

    a. Arc welding cast iron

    b. Distilling chromium oxide

    c. Welding stainless steel

    d. Precipitating hydrochromic salts

18. The total pressure in a/an _____ ventilation system is equal to the sum of velocity pressure and static pressure.

    a. Open

    b. Atmospheric

    c. Dynamic

    d. Closed

19. Which of the following markings is used on many products manufactured in Europe, indicating that the product meets the health and safety standards?

    a. CE

    b. ES

    c. ESH

    d. EHS

20. Per DOT regulations, _____ drivers are not allowed to consume alcohol within four hours before starting their driving shift.

    a. All

    b. Commercial

    c. Hazardous materials truck

    d. Commercial hazardous materials truck

21. The type of liability insurance that helps protect individuals and companies that provide professional advice and services from bearing the full cost of defending against a negligence claim made by a client is called:

    a. Professional liability insurance

    b. Professional indemnity insurance

    c. Errors and omissions insurance

    d. All of the above

22. Which of the following statements is NOT true in regard to course of construction insurance?

a. It covers a building under construction.

b. It covers perils such as fire, wind, and theft.

c. The policy will pay for damages up to the coverage limit.

d. The coverage limit must accurately reflect the total value of the structure, including labor costs and land value.

23. Per DOT regulations, the post-accident drug and alcohol test applies to all drivers who are involved in fatal crashes. The test must also be conducted on all CDL drivers who are cited for moving violations arising in a crash that requires a vehicle being towed or an injury requiring medical attention away from the scene. The alcohol test must be conducted within _____ hours and the controlled substances test must be conducted within _____ hours of the crash.

a. 10, 25

b. 8, 32

c. 4, 8

d. 15, 45

24. All of the following are components of an insurance contract EXCEPT:

a. Exclusions

b. Conditions

c. Declarations

d. Privity

25. Incorporation of safety at the design stage of a potentially hazardous industrial process, rather than after it is operating, is important because:

a. OSHA regulations requires a place of employment free of all hazards.

b. It has an economic advantage to the company.

c. It decreases management liability before plant operation.

d. It educates design engineers in safety standards.

26. In facility design, the responsibility for identifying and controlling hazards associated with equipment lies with:

a. Mechanical engineers

b. Purchasing agents

c. Design team

d. Equipment manufacturer

27. A pump is sending cooling water to a reactor. Loss of cooling water to this reactor would cause the reactor to explode. A fail-safe design for the system is BEST portrayed by:
    a. Activation of a spare pump on failure of the cooling water pump.
    b. Automatic shut down of process on failure of the cooling water pump.
    c. Relieve pressure in the reactor.
    d. All of the above.
28. The concept of Energy Theory in safe design of processing facilities states that the severity of an accident is related to:
    a. Amount of energy release
    b. Rate of energy release
    c. Means of energy transfer
    d. All of the above
29. Floor slipperiness is measured by:
    a. Slip meter
    b. Friction meter
    c. Viscometer
    d. Hydrometer
30. One of the more commonly encountered hazards for ground supported scaffolds is:
    a. Breakage at a given leg
    b. Over-pressurizing the scaffold
    c. Breakage at the surface
    d. Tipping
31. Drums containing Polychlorinated Biphenyls (PCB) must be made of:
    a. Metal
    b. Polyethylene
    c. Ceramic
    d. PVC
32. The severity of electric shock primarily depends on:
    a. The electric current flowing through the body
    b. The body capacitance to absorb electrical energy
    c. The body transmittance for electrical conductivity

d. All of the above

33. Ventricular fibrillation caused as a result of electric shock refers to:

    a. Blockage of the heart muscles

    b. Fibers of the heart contract separately

    c. Fibers of the heart contract simultaneously

    d. Fibers of the heart expand beyond limit of elasticity

34. Interlocks used in electrical equipment must meet which of the following criteria?

    a. Lockout-tagout

    b. Fail-active

    c. Fail-passive

    d. Fail-safe

35. An electrical circuit protective device such as a fuse or circuit breaker protects the circuit from overload by:

    a. Closing the circuit

    b. Dissipating excess heat

    c. Opening the circuit

    d. Electrical bonding

36. "Arcing" refers to:

    a. Flow of electrons through air

    b. Welding of metal parts

    c. Type of protective helmet

    d. Process of bending metal sheets

37. Electrical bonding:

    a. Eliminates the electrical charges between two conductors

    b. Eliminates the potential difference between two conductors

    c. Sends electrical charges to the ground

    d. Reduces electrical power consumption

38. The electrolytic fluid in lead-acid batteries during charging can produce:

    a. Poisonous lead gas

    b. Lead oxide gas

    c. Hydrogen gas

d. Lead hydride gas

39. An electrical system is considered to be de-energized (no potential difference in any component of the system):

a. When the power to the circuit has been shut off

b. After the system has been shut off and tested

c. After the power has been shut off and proper lockout/tagout has been performed

d. When it is grounded

40. For control of electrostatic hazards which one of the following types of clothing is preferable?

a. Non-conductive

b. Semi-conductive

c. Conductive

d. Type of clothing has no effect

41. The surface conductivity of an electrostatically charged surface:

a. Will increase with an increase in humidity

b. Will decrease with an increase in humidity

c. Humidity has no effect on surface conductivity

d. Will increase with an increase in temperature

42. Which of the following is associated with equipment failure for facility design and operation?

a. Poor maintenance program

b. Lack of fail-safe instrumentation

c. Metal fatigue

d. All of the above

43. Which of the following is NOT associated with plant layout for facility design and operation?

a. Direction of wind

b. Number of people required to operate the plant

c. Cost of process control instruments

d. Cost of future revision

44. In new chemical plant layout where most processing equipment is located outdoors, which of the items listed below should be considered first?

a. To group similar equipment in one location

b. To determine the direction of the prevailing wind

c. To provide room for maintenance

d. To minimize piping and pumping costs

45. In designing outdoor plant layout, all equipment that may spill flammable materials should be located:

a. In an isolated area on the upwind side

b. On the downwind side

c. Near fire stations and on the upwind side

d. Close to the receiving area

46. The areas for containment of relatively large spills of liquefied petroleum gases must always be constructed below grade because:

a. These gases have a vapor density that is greater than one.

b. A person on the grade level or above will not be asphyxiated.

c. Spilled material can flow to these areas by gravity.

d. Only (a) and (b) above.

47. Which of the following is the leading cause of work related injuries and deaths?

a. Electrical shock

b. Falls and slips

c. Motor vehicle accidents

d. Exposure to toxic chemicals

48. When a source emits light that reaches a given surface, the surface can:

a. Absorb the light

b. Transmit the light

c. Reflect the light

d. All of the above

49. The quantity of illumination is measured by which of the following instruments?

a. Foot-candle meter

b. Illuminometer

c. Transmitter

d. Light meter

50. Which of the following organizations set forth standards for eye and face protection?
    a. CPSC
    b. FDA
    c. NIOSH
    d. ANSI
51. Most personal devices used in fall protection:
    a. Prevent a person from falling
    b. Minimize the impact of a fall
    c. Interrupt falls already in progress
    d. Shield an individual from falling objects
52. All of the following are effective measures for fall protection EXCEPT:
    a. Remove slipping and tripping hazards
    b. Barriers
    c. Hard hat
    d. Guard rails
53. Which one of the following is NOT an administrative control of hazards?
    a. Discipline an employee for unsafe work practices
    b. Provide periodic training
    c. Provide work rotation to reduce fatigue
    d. Provide personal protective equipment
54. Before an employer can assign an employee to jobs requiring the use of a respirator, the employer:
    a. Must consult with employee and obtain his/her consent to use a respirator.
    b. Must test employee's reactions and performance while using a respirator in a non-hazardous atmosphere.
    c. Must obtain written permission from a physician on employee's ability to use a respirator.
    d. Document employee's performance while using a respirator for a period of no less than 10 days.
55. The stress generated in an object as a result of application of a force is equal to the:
    a. Value of the compression stress minus the tensile stress
    b. Value of the compression stress minus the shear stress

c. Value of the compression stress divided by the shear stress

d. Value of the force divided by the area upon which it acts

56. The term "creep" is referred to as:

a. The ability of a given material to resist tensile stress

b. Slow but permanent deformation of a material under a given load

c. The ability of a material to withstand shear stresses

d. An individual with uncivilized, and at times, unusual behavior

57. Shoring is required for all the trenches more than 4 feet deep unless:

a. They are sloped to an angle of repose

b. The trench is in a stable rock

c. A ladder is provided

d. Only (a) and (b) above

58. A trench is:

a. A narrow excavation

b. Deeper than it is wide

c. Never wider than 15 feet

d. All of the above

59. The guard on a grinding wheel must:

a. Completely enclose the wheel

b. Cover the wheel as completely as the nature of the work permits

c. Be adjustable

d. Only (b) and (c) above

60. Which of the following organizations has the most number of standards for unfired pressure vessels?

a. ANSI

b. NFPA

c. ASME

d. OSHA

61. The recommended maximum allowable slope for a ramp is:

a. 45 degrees

b. 25 degrees

c. 20 degrees

d. 15 degrees

62. An indoor warehousing operations, the preferred type of powered truck is:

a. Liquefied petroleum gas trucks

b. Electric trucks

c. Diesel trucks

d. Gasoline trucks

63. The most common occupational injuries resulting from manual materials handling are injuries to the:

a. Foot

b. Hand

c. Eyes

d. Back

64. Many powered materials handling vehicles have a high center of gravity. This means that:

a. The maximum load rating of the vehicle is increased compared to an identical low center of gravity vehicle.

b. The pressure exerted on tires is less than an identical vehicle with a low center of gravity.

c. The gravitational force exerted on the center of the vehicle is less than that of an identical vehicle with a low center of gravity.

d. When the vehicle operated in a turn, it has a greater potential for rollover compared to an identical vehicle with a low center of gravity.

65. One of the problems associated with safety inspections is:

a. Regulations may not be updated

b. Control methods may not be economical

c. Hazards are allowed to accumulate between inspections

d. Lost time cases cannot be detected

66. One of the disadvantages to an external safety inspection is:

a. Its objectivity

b. High cost

c. Several follow-up inspections

d. All of the above

67. During a safety inspection of your facility, you have discovered an unsafe act being committed by an employee. Your best course of action is:

    a. To stop the unsafe act and instruct how the job can be done safely.

    b. To report an unsafe act to employee's supervisor.

    c. Provide adequate training.

    d. All of the above.

68. Accident causes can be classified into basic, indirect, and direct causes. An unsafe act by an employee which results in an accident is an example of which one of the following accident causes?

    a. Basic

    b. Indirect

    c. Direct

    d. Basic and direct

69. There are four different types of machine guarding: fixed, adjustable, interlocked, and self-adjusting. Which of the following is NOT an advantage of fixed guards?

    a. Can be constructed to suit many applications

    b. Can provide a high level of protection

    c. Low maintenance

    d. Adjustment and repair may require removal

70. _____ machine guards shut off or disengage power and prevent the machine from starting when the guard is opened.

    a. Fixed

    b. Adjustable

    c. Interlocked

    d. Self-adjusting

71. OSHA requires [1910.212(a)(1)] that the employer must provide one or more methods of machine guarding to protect the operator and other employees from hazardous mechanical motion or action. Which of the following IS NOT an example of hazardous mechanical motion or action requiring machine guarding?

    a. Point of operation

    b. Ingoing nip points

    c. Rotating parts

    d. Vibrating parts

72. Which of the following is NOT true in regard to Class A hard hats?
    a. These helmets are for general services.
    b. They provide good impact protection but limited voltage protection.
    c. They are used mainly in mining, building construction, shipbuilding, lumbering, and manufacturing.
    d. They provide limited impact protection but good voltage protection.
73. Which of the following statements IS NOT true in regard to Class B hard hats?
    a. Choose Class B helmets if your employees are engaged in electrical work.
    b. They protect against falling objects and high-voltage shock and burns.
    c. The shells are water resistant and slow burning.
    d. They do not have to meet ANSI standards.
74. Which of the following statements is true in regard to Class C hard hats?
    a. They offer limited head protection.
    b. They protect against falling objects and high-voltage shock and burns.
    c. They provide good impact protection.
    d. Both (b) and (c).
75. Which of the following colors are used on the coverings of grounded conductors?
    a. Red
    b. White or natural gray
    c. Green
    d. Yellow
76. Many combustible gas devices burn the contaminants catalytically. This causes an increase in temperature, resulting in an increase in the resistance of the filament. Which of the following BEST describes the principle used in these devices?
    a. Wheatstone bridge
    b. Catburner
    c. Combustion chamber
    d. Catcomb
77. Which of the following statements in NOT true in regard to cathodic protection?
    a. It is used to control the corrosion of a metal surface
    b. It makes the metal surface the cathode of an electrochemical cell
    c. It makes the metal surface the anode of an electrochemical cell

d. It connects protected metal to a more easily corroded sacrificial metal acting as the anode

78. Which of the following statements is NOT true regarding a ground fault circuit interrupter (GFCI)?

a. It is a fast-acting circuit breaker designed to shut off electric power in the event of a ground fault.

b. It can shut off power in as little as 1/40 of a second.

c. It works by comparing the amount of current going to and returning from the equipment along circuit conductors.

d. It protects the user from line contact hazards.

79. CAD is an acronym for:

a. Construction and design

b. Cumulative anxiety disorders

c. Computer aided design

d. Construction and development

80. The two most common software packages used in occupational health and safety departments are:

a. Industrial hygiene and occupational safety

b. Occupational safety and regulatory compliance

c. Word processing and database management

d. Industrial hygiene and regulatory compliance

81. The principle of receiving value (i.e. quality, safety, etc.) for an original purchase of a product is called:

a. Caveat emptor

b. Caveat venditor

c. Caveat privitor

d. Caveat vendor

82. If a product fails to meet a warranty, then:

a. The manufacturer must be negligent

b. The manufacturer can be held liable

c. The consumer must prove unreasonable risk to receive compensation

d. The consumer must prove negligence in design to receive compensation

83. A retailer has made an oral promise concerning a product's life expectancy. Which one of the following best describes this concept?

    a. Warranty of use

    b. Warranty of merchantability

    c. Express warranty

    d. Implied warranty

84. You are a CSP working for a midsize company. During a routine inspection, you observe a few minor infractions. Which of the following courses of action would you undertake?

    a. Talk to the employees involved and instruct them on how to do the job safely.

    b. Issue a written warning to employees involved and send a copy to the Human Resources department.

    c. Notify the supervisor in writing.

    d. Issue a written warning to the employees involved and send a copy to the supervisor.

85. In database systems design, SQL is an acronym for:

    a. Secondary Quantitative Language

    b. Secondary Qualitative Language

    c. Simulation Quantitative Language

    d. Structured Query Language

86. CAD/CAM is an acronym for which of the following?

    a. Computer Aided Drawing/Camera Accepted Method

    b. Computer Aided Design/Computer Aided Manufacturing

    c. Computer Acceptable Design/Computer Aided Management

    d. Computer Acceptable Design/Computer Aided Manufacturing

87. Which of the following statements is incorrect?

    a. The internet is a network of public and private networks.

    b. The intranet is a private network that is generally inaccessible to outsiders.

    c. The extranet is an intranet, which allows access to outsiders who are permitted.

    d. In peer-to-peer computer networks, the capability of the workstations is generally the same.

88. In order to find something in the World Wide Web, one must know its URL. URL is an acronym for:

a. Unified Reset Language

b. Uniform Resource Language

c. Unified Resource Language

d. Uniform Resource Locator

89. The address of web sites starts with HTTP. This is an acronym for:

a. High Transfer Terminal Program

b. High Transfer Terminal Protocol

c. Hyper Text Transport Protocol

d. Hyper Text Transfer Program

90. The most basic features of a web browser include the capability to display all of the following EXCEPT:

a. Hypertext links

b. Images

c. RealPlayer by RealNetworks

d. Text

91. Which of the following statements is true regarding Adobe Acrobat, which can be downloaded from the Internet?

a. Plays flash presentations, containing animations and vector graphics

b. Displays files in its native Portable Document Format (PDF)

c. Plays macromedia graphics and multimedia audio

d. Plays audio and video content in RealMedia format

92. Which of the following software can be used as a tool for reading and composing E-mail?

a. SeaMonkey Composer

b. Microsoft Outlook Express

c. Mozilla Firefox

d. Microsoft Meeting Space

93. Most E-mail programs give the option of creating mail in either plain text or HTML formats. The advantage of creating mail in HTML format is that one can add:

a. Images

b. Color

c. Text formatting

d. All of the above

94. UNIX workstations are generally used for which of the following applications?

a. Low CPU applications

b. Browser applications

c. Hub applications

d. CPU-intensive applications

95. Computer networks fall into two general categories: peer-to-peer networks and client/server networks. All of the following are considered to be advantages of a peer-to-peer network EXCEPT:

a. Inexpensive.

b. Simplicity.

c. All workstations can share the same printer.

d. The control is not centralized.

96. All of the following statements are correct in regard to a spectrophotometer EXCEPT:

a. It can measure the transmission of liquids or solids as a function of wavelength.

b. It can measure absorption of liquids or solids as a function of wavelength.

c. The beam can be split in two: one beam that goes through a reference cell, and another beam that goes through a sample cell.

d. It measures the amount of ionizing radiation as a function of the intensity of radiation.

97. Many web servers and file servers run on UNIX operating systems. Which of the following statements best describes this operating system?

a. UNIX is a Windows-based program developed by the Microsoft Corporation.

b. UNIX is an operating system by which your network is physically laid out and developed by Procom Technology.

c. UNIX is a multi-user, multi-tasking computer operating system. This operating system was developed by AT&T Corporation.

d. UNIX is a protocol that allows workstations to access Internet electronic centralized servers. This operating system was developed by the XP Corporation.

98. The frequency of eye injuries in a machine shop with new machines added has been on the rise. Which of the following course of actions is the MOST appropriate?

a. Provide employees with safety glasses with side shields.

b. Provide employees with face shields.

c. Provide employees with face shields to be worn on top of safety glasses with side shields.

d. Apply engineering controls and ensure that the needed personal protective equipment is used.

99. Use of Ground-Fault Circuit Interrupters (GFCI) is an example of which of the following?

a. Loss reduction

b. Loss prevention

c. Risk reduction

d. All of the above

100. According to OSHA regulations contained in 29 CFR 1910.145, all of the following are examples of safety signs EXCEPT:

a. Danger signs

b. Signs for pedestrian crossing on a public road

c. Caution signs

d. Safety instruction signs

101. Workers in many different occupations are exposed to hexavalent chromium. Calcium chromate, chromium trioxide, lead chromate, strontium chromate, and zinc chromate are known human carcinogens. Which of the following types of cancer is associated with overexposure to hexavalent chromium?

a. Lung cancer

b. Skin cancer

c. Stomach cancer

d. Colon cancer

102. Which of the following organizations issues health effects certification for tiles and installation materials?

a. Consumer Products Safety Commission (CPSC)

b. Underwriter's Laboratories (UL)

c. National Institute for Occupational Safety and Health (NIOSH)

d. National Fire Protection Association (NFPA)

103. Which of the following is NOT a characteristic of nanoparticles that are related to adverse health effects:

a. Size

b. Chemical composition and surface character

c. Shape

d. Color

104. Which of the following can become combustible dust under specific situations?

a. Rubber

b. Plastics

c. Aluminum

d. All of the above

105. All of the following are examples of workplaces and industries that have potential for dust explosions EXCEPT:

a. Grain elevators

b. Metal processing

c. Food production

d. Crude oil distillation

106. As compared to a normal fire, dust explosion needs two additional elements known as the dust pentagon. Which of the following is one of these two additional elements?

a. Fuel to burn

b. Ignition Source

c. Suspension of Particles in air

d. Oxygen

107. The most important concept in selection of Personal Protective Equipment (PPE) is to:

a. Train workers in its proper use

b. Decide on procedures for disinfection

c. Match PPE to the hazard

d. Ensure that it is properly stored

108. OSHA requires (29CFR1910.138) that whenever an employee uses his/her own PPE:

a. The employer is responsible to ensure that it is of the approved type.

b. The employee assumes full responsibility.

c. The employee assumes responsibility for PPE being of the approved type but employer is responsible for its maintenance and disinfection.

d. OSHA requires that no employee owned PPE be used in the workplace.

109. Workers who are assigned to jobs requiring eye protection and wear prescription glasses must be provided with which of the following?

    a. Prescription safety glasses

    b. Prescription safety goggles

    c. Safety goggles that would fit over prescription glasses

    d. Any of the above.

110. Which of the following organizations provide recommended levels of illumination for different work areas?

    a. ANSI

    b. Illuminating Engineering Society (IES)

    c. American Society of Lighting Engineers (ASLE)

    d. NFPA

111. Goggles with indirect ventilation ports are most appropriate for which of the following situations?

    a. Welding operations

    b. Corrosive chemicals

    c. Flying objects

    d. Cutting operations

112. Hard hats must meet the requirements and specification established by which of the following organizations?

    a. NIOSH

    b. CPSC

    c. ANSI

    d. OSHRC

113. Which of the following statements is correct regarding a respirator wearer in an atmosphere which is considered to be Immediately Dangerous to Life or Health (IDLH)?

    a. The buddy system must be used.

    b. The worker must be supplied with an air purifying respirator.

    c. A closed loop SCBA with constant flow regulator is required.

    d. An open loop SCBA with variable flow regulator is required.

114. Air purifying respirators remove the contaminants from air primarily by which of the following mechanisms?

a. Absorption

b. Gas-Liquid extraction

c. Adsorption

d. Only (a) and (c) above.

115. Air purifying respirators must not be used in which of the following situations?

a. Atmospheres containing less than 19.5% oxygen by volume

b. In IDLH atmospheres

c. In atmospheres where contaminants cannot be detected by odor or taste at levels below PEL or TLV

d. All of the above.

116. Which of the following statements is true regarding a Self-Contained Breathing Apparatus (SCBA)?

a. Open circuit SCBA's have a relatively long operating time as compared to closed circuit SCBA's.

b. Open circuit SCBA's remove CO_2 and water from exhaled air.

c. Positive pressure SCBA's should be used in IDLH conditions.

d. Closed circuit negative pressure SCBA provide the highest level of protection in IDLH conditions.

117. Which of the following test methods can be used to check the fit of a respirator?

a. Qualitative or quantitative

b. Closed loop, open loop

c. Positive pressure, negative pressure

d. Only (a) and (c) above.

118. According to OSHA regulations, a Self-Contained Breathing Apparatus (SCBA) must be inspected at least once every _____ days and after each use:

a. 15 days

b. 30 days

c. 7 days

d. 45 days

119. Butyl rubber has a solubility parameter of 16. Gloves made of butyl rubber are most effective against which of the following chemicals.

a. A chemical with a solubility parameter of 18

b. A chemical with a solubility parameter of 28

c. A chemical with a solubility parameter of 16

d. A chemical with a solubility parameter of 47

120. OSHA's Process Safety Management standard applies to all of the following EXCEPT:

a. A process which involves a chemical at or above specified threshold quantities.

b. A process which involves a flammable liquid on site in one location, in a quantity of 10,000 lb or more.

c. Hydrocarbon fuels used solely for workplace consumption for fuel.

d. A process which involves a flammable gas on site in one location, in a quantity of 10,000 lb or more.

121. The Process Safety Management of highly hazardous chemicals is contained in:

a. 40 CFR part 263

b. 29 CFR 1910.1200

c. 29 CFR 1910.120

d. 29 CFR 1910.119

122. All of the following are exempt from Process Safety Management standard EXCEPT:

a. Normally unoccupied remote facilities.

b. Retail facilities.

c. Oil or gas well-drilling

d. A process, which involves a flammable gas in one location in quantities of 10,000 lb or more.

123. Under PSM standard an "atmospheric tank" means:

a. A tank, which is designed to operate from atmospheric pressure to 0.5 psig.

b. A tank, which is designed to operate under atmospheric pressure.

c. A tank, which is designed to operate at or below atmospheric pressures.

d. A tank, which is designed to operate between atmospheric pressure and 28 psig.

124. The term "hot work" under PSM standard includes all of the following operations EXCEPT:

a. Electric.

b. Welding.

c. Brazing.

d. Any operation, which involves temperatures exceeding 1000 degrees Celsius.

125. For existing equipment designed and constructed many years ago with the codes and standard available at that time and no longer in general use, as part of the "process safety information" package of the PSM standard, the employer must do all of the following EXCEPT:

    a. Document the codes and standards that were used.

    b. Change the design or install new equipment in compliance with present codes and standards

    c. Document that the design and construction are still suitable for the intended use.

    d. Document that the testing, inspection and operation are still suitable for the intended use.

126. Selection of a "process hazard analysis" methodology or technique will be influenced by all of the following factors EXCEPT:

    a. The amount of existing knowledge about the process.

    b. The size and complexity of the process.

    c. Maintenance procedures.

    d. Is it a new process or one which has been changed frequently by the inclusion of innovative features?

127. Process chemicals information is part of the "process safety information" package. Which of the following IS NOT expected to be included in the process chemicals information?

    a. Erosion effects.

    b. Explosion characteristics.

    c. Spill cleanup procedures

    d. Corrosion effects

128. Under "process technology information" part of the "process safety information" package, employers are encouraged to use diagrams, which help users understand the process. Which of the following IS NOT one of the three general categories of the recommended diagrams?

    a. Block flow diagrams.

    b. Fault tree diagrams.

    c. Process flow diagrams.

    d. Piping and instrumentation diagrams.

129. OSHA's process safety management standard does not apply to "normally unoccupied remote facilities." Which of the following statements BEST describes this term?

a. A facility which is at least 8- miles away from all cities with a population of 5,000 or more.

b. A facility, which is operated, maintained or serviced by employees who visit the facility only periodically to check its operation and to perform necessary operating or maintenance tasks.

c. A facility which is operated, maintained or serviced by employees who visit the facility no more than once every 6 months to check its operation and to perform necessary operating or maintenance tasks.

d. All of the above.

130. Under OSHA's process safety management standard, the term "highly hazardous chemical" means:

a. A substance possessing toxic, reactive, flammable, or explosive properties and specified by the standard.

b. A substance possessing toxic, reactive, flammable, or explosive properties and specified by the standard and also listed under TSCA.

c. Toxic chemicals with an LD50 of less than 5000 mg/kg, which are specified by the standard.

d. Hazardous chemicals listed by OSHA under Hazard Communication Standard (29 CFR 1910.1200).

131. Which of the following IS NOT an element of process safety management as defined by OSHA?

a. Compliance audits.

b. Trade secrets

c. Hazardous waste management.

d. Contractors.

132. The "employee participation" element of the process safety management standard is required under which of the following legislative acts?

a. CERCLA.

b. Clean Air Act Amendments.

c. HAZWOPER.

d. HAZCOM.

133. Which of the following IS NOT addressed in the "process safety information" element of the process safety management standard?

a. Incident investigation.

b. Process Technology.

c. Process equipment.

d. Process Chemicals.

134. "Process technology information" is a component of the "process safety information" package required by the process safety management standard. Which of the following IS NOT expected to be included in the "process technology information?"

a. Maximum inventory limits for the process chemicals.

b. Limits beyond which would be considered upset conditions.

c. A qualitative estimate of the consequences or results of deviations from the design intent.

d. Determination of toxic, flammable, reactive, and explosive properties of the process chemicals.

135. The "employee training" element of the process safety management standard must cover all of the following areas EXCEPT:

a. Operating procedures and safe work practices.

b. How to interpret chemical labels and Safety Data Sheets.

c. Safety procedures.

d. Routine and non-routine work authorization activities.

136. The training program required under the "employee training" element of the process safety management standard must accomplish all of the following EXCEPT:

a. Define subjects to be covered.

b. Develop a training center within the facility.

c. Define employees to be trained.

d. Define goals and objectives of the training program.

137. Which of the following IS NOT true regarding the team conducting the process hazard analysis required under the process safety management standard?

a. The team needs to understand the hazard analysis methodology that is going to be used.

b. The team can vary in size.

c. The team members must have varied operational and technical backgrounds.

d. At least one member of the team must have a college degree from an accredited institution in a field related to the process.

138. Detailed guidance on the content and application of process hazard analysis methodologies can be obtained from which of the following professional organizations?

a. American Society of Safety Engineers (ASSE).

b. American Institute of Chemical Engineers (AICHE).

c. American Institute of Mechanical Engineers (ASME).

d. American Chemical Society (ACS)

139. The acronym SOP in the process safety management standard is an abbreviation for:

a. Standard Operating Practices.

b. Safety Officer's Program.

c. Safe Operation of Process.

d. Safety of Personnel.

140. Under the "operating procedures" element of the process safety management standard, the employer is required to certify that the operating procedures are accurate and current. This certification must be done:

a. Every 2 years.

b. Every 3 years.

c. Every 5 years.

d. Annually.

141. Employers who use contractors to perform work in and around processes that involve highly hazardous chemicals must do all of the following EXCEPT:

a. Establish a screening process to hire contractors who can accomplish the tasks safely.

b. Evaluate contractor's work methods and experiences.

c. Ensure that the contractor employees have successfully completed the OSHA 40-hour HAZWOPER training.

d. Maintain a site injury and illness log for the contractors.

142. The "pre-startup safety review" component of the process safety management standard requires all of the following EXCEPT:

a. Construction of equipment are in accordance with design specifications.

b. Operating procedures are in place and are adequate.

c. A compliance audit has been conducted on the process.

d. Training has been completed.

143. Which of the following is NOT required under the mechanical integrity program required by process safety management standard?

a. Written procedures to maintain the ongoing integrity of process equipment.

b. Training for process maintenance activities.

c. Inspection and testing.

d. Pre-startup safety review.

144. The "mechanical integrity" element of the process safety management standard requires that a list of process equipment and instrumentation for inclusion in the program be developed. This list must include all of the following EXCEPT:

a. Pressure vessels.

b. Storage tanks.

c. Fire protection system components.

d. Office buildings.

145. Determination of the MTBF for various instrumentation and equipment is helpful in creating a sound mechanical integrity program. MTFB is an acronym for:

a. Mechanical Threshold Based on Fabrication.

b. Mechanical Tension Because of Failure.

c. Mean Time Between Failures.

d. Manufacturer's Testing By Fabrication.

146. Which of the following IS NOT required by the "mechanical integrity" element of the process safety management standard?

a. Investigation of incidents.

b. Preventative maintenance training.

c. Quality assurance.

d. Training for process maintenance activities.

147. Which of the following statements IS NOT TRUE regarding "hot work permit" required under process safety management standard?

a. The permit must document the date(s) authorized for hot work.

b. The permit must identify the object on which hot work is to be performed.

c. The permit must document that the fire prevention and protection requirements in 29 CFR 1910.152 (a) have been implemented prior to beginning the hot work operations.

d. The permit must be kept on file for a period of 5 years

148. Under the "management of change" element of the process safety management standard, the employer is responsible to implement written procedures to manage

changes. These procedures must assure that all of the following issues are addressed EXCEPT:

a. The technical basis for the proposed change.

b. Modifications to operating procedures.

c. Necessary time period.

d. Effect of change on compliance audits program.

149. Which or the following statements IS NOT TRUE regarding the "investigation of incidents" element of the process safety management standard?

a. Incident investigation is the process of identifying and underlying the causes of incidents and implementing steps to prevent similar events from occurring.

b. A report of the findings of the incident investigation team must be shared with the local fire department.

c. Employers need to develop in-house capability to investigate incidents that occur in their facilities.

d. A team needs to be assembled and trained in the techniques of incident investigation.

150. The process safety management standard requires that employers develop and implement an emergency action plan which will facilitate the prompt evacuation of employees due to an unwanted release of a highly hazardous chemical. This plan must address all of the following EXCEPT:

a. Alarm system.

b. Process hazard analysis.

c. Evacuation/relocation.

d. Preplanning for releases.

151. Under provisions of the process safety management standard, it is the responsibility of the employer to certify that they have evaluated compliance with the provisions of this OSHA standard. This certification must be done at least every:

a. 2 years.

b. 4 years.

c. 3 years.

d. 5 years.

152. Under provisions of process safety management standard, the employer is responsible for developing a report of the findings of the compliance audit. Which of the following is true in regard to compliance audit report?

a. Employers must retain each report for a period of at least 3 years.

b. Employers must retain each report for a period of at least 2 years.

c. Employers must retain the two (2) most recent compliance audit reports.

d. Employers must retain each report for a period of at least 4 years.

153. Which of the following IS NOT required by the "compliance audits" element of the process safety management standard?

a. The compliance audit must be conducted by at least one person knowledgeable in the process.

b. A report of findings of the audit must be developed.

c. Employers must retain the two (2) most recent compliance audit reports.

d. Employers must develop complete and accurate written information concerning process chemicals, process technology, and process equipment.

154. Which of the following statements IS NOT TRUE in regard to "trade secrets" element of process safety management standard?

a. Employers must make all information necessary to comply available to those persons responsible for compiling the process safety information and to those assisting in the development of the process hazard analysis without regard to possible trade secret status of such information.

b. Employers must make all information necessary to comply available to those persons responsible for developing the operating procedures and those involved in incident investigations without regard to possible trade secret status of such information.

c. The employer cannot require the persons to whom the information is made available to enter into confidentiality agreements not to disclose the information.

d. Employers must make all information necessary to comply available to those persons responsible for developing emergency planning and response and compliance audits without regard to possible trade secret status of such.

155. Which of the following acts is considered to be "distracted driving"?

a. Talking to a passenger.

b. Eating.

c. Texting.

d. All of the above.

156. The Department of Transportation requires that every commercial motor vehicle be inspected. DOT also requires that the original or copy of the inspection report be retained for a period of _____from the of inspection:

a. 14 months

b. 12 months

c. 6 months

d. 24 months

157. Automatic braking technology used in automobiles uses sensors to detect other vehicles or obstacles. Which of the following is NOT a type of sensor used in this technology?

a. Video

b. Ultrared

c. Infrared

d. Ultrasonic

158. Which of the following statements is NOT true in regard to Anti-lock Braking System (ABS)?

a. ABS allows the wheels on a motor vehicle to maintain tractive contact with the road surface.

b. ABS can significantly decrease braking distance on loose surfaces.

c. Recent versions of ABS not only prevent wheel lock but also electronically control the front-to-rear brake bias.

d. ABS prevents the wheels from ceasing rotation and avoids uncontrolled skidding.

159. Which of the following statements is true in regard to Vehicular Accident Reconstruction (VAR)?

a. It is the scientific process investigating, analyzing, and drawing conclusions about the causes and events during a vehicle collision.

b. The laws of physics and engineering principles are the basis for analysis.

c. Results from accident reconstruction can be useful in developing recommendations for making roads and highways safer.

d. All of the above.

160. Pressure relief systems use which of the following to reduce or depressurize a system:

a. Pressure measurement

b. Comparing the measured value to a set point to generate an error

c. Acting on a final control element to reduce the pressure or depressurize the system

d. All of the above

161. In order to accurately conduct noise measurements, sound level meters should be calibrated:

a. Once a month.

b. Before each use.

c. After each use.

d. Before, during, and after each use.

162. Noise level measurements in a machine shop indicate that the TWA in an 8-hour shift exceed the allowable limits. Management decides to reduce the exposure to four hours by job rotation which in turn brings the exposure down to allowable limits. This is an example of:

a. Engineering control

b. Management of change

c. Administrative control

d. All of the above

163. Which of the following statements is true about confined spaces?

a. Have toxic chemicals in their atmosphere

b. Have limited means for entry or exit

c. Must be equipped with a rescue ladder

d. All of the above

164. In order to represent the real-world use of hearing protection devices, ANSI recommends that the manufacturer's claim for noise reduction:

a. Be reduced

b. Be increased

c. Remains unchanged

d. Be evaluated and adjusted

165. There are four classes of lasers. Which of the following is true for class 1 lasers?

a. Non-hazardous under normal conditions of use

b. Can damage unprotected skin

c. Capable of ionizing the material through which it flows

d. Capable of adversely affecting the DNA

166. Which of the following personal protective equipment (PPE) should be worn when working with electricity?

a. Safety glasses and insulated gloves & clothing.

b. Class B hard hat and insulated gloves & clothing.

c. Tools that are properly grounded and insulated gloves & clothing.

d. Non-conducting ladder and insulated gloves & clothing

167. Which of the following is an example of an **active** safety device?

a. Automobile seat belts.

b. Automatic brake systems.

c. Automobile air bags.

d. Guard rails for fall protection.

168. Which of the following statements is correct regarding Underwriter's Laboratories (UL)?

a. Sets standards for different product categories and tests products to make sure they meet the standards.

b. UL approval is required by law.

c. UL is part of the U.S. Department of Commerce.

d. UL is a non-profit organization.

169. Which of the following best describes the basic strategy of a safe system approach for road traffic safety?

a. To ensure that in the event of a crash, the impact energies remain below the threshold likely to produce either death or serious injury.

b. To apply fault tree analysis to identify and eliminate the events that can lead to an accident.

c. To ensure that the airbags are properly designed and can absorb the force generated as a result of a crash.

d. All the above.

4.4 Example Answers

1. Select (a)

   Hazard control is accomplished by either engineering or administrative (management) control. Generally, any type of control that requires design, construction, or design modifications is categorized as engineering control.

   The best way to eliminate hazards is by means of engineering controls. However, if engineering controls cannot be implemented, then hazards must be controlled by means of administrative controls. Examples of administrative controls include training and reducing the time a worker is exposed to hazards.

2. Select (a)

   Stock insurance companies are profit oriented, and are generally publicly traded firms. The company issues shares that can be purchased by the public in order to raise capital. Stock insurance companies pay their shareholders in capital appreciation, dividends, or both.

3. Select (d)

   In control of any workplace hazard, engineering control must be considered first. Administrative controls such as job rotation and use of appropriate PPE must only be considered when engineering controls are either not feasible or cannot solve the problem.

4. Select (b)

   Local exhaust ventilation is the most effective method of controlling point source airborne contaminants.

   Dilution ventilation involves bringing in clean air to dilute the contaminated air, and then exhausting the diluted air. Dilution ventilation does not eliminate exposure, but should be designed in such a way as to bring the concentration down to a safe level.

5. Select (c)

   Engineering controls are used to permanently eliminate or lessen the severity of a hazardous condition. In this case, use of sound absorbing materials for control of over-exposure to noise is a good example of engineering control.

6. Select (c)

   This type of insurance coverage is for work that is performed away from the company, such as that done by consultants, contractors, and remediation companies.

7. Select (a)

   The preferred angle range for fixed industrial stairs is 30 to 35 degrees. The preferred angle for a ramp is no more than 15 degrees. The preferred angle range for fixed ladders is 75 to 90 degrees.

8. Select (c)

   The number of air changes can be obtained by dividing the volumetric flow rate by the room volume. For example, a ventilation rate of 600 cubic feet per minute in a room of 300 cubic feet will provide 2 air changes per minute.

9. Select (b)

   The correct answer is OSHA.

10. Select (b)

    Placards are used on vehicles carrying hazardous materials. The Department of Transportation has standards and regulations (49CFR) for placards and labels.

11. Select (b)

    "OCP" is an acronym for Owners and Contractors Protection. This type of insurance protects a business owner, property owner, or general contractor against liability due to the negligent act of an independent contractor or subcontractor who performs work on their behalf. The independent contractor or subcontractor purchases the policy. This type of policy covers a specific project at a specific location.

12. Select (d)

    Fire insurance is covered under property insurance. Health insurance is the fourth category.

13. Select (b)

    "Property" covers damage to or destruction of real property. "Perils" are covered causes of loss. "Consequences" covers loss of business income as a result of interruption or partial suspension of business.

14. Select (a)

    GFCIs are fast-acting devices that, once a current leakage has been detected, open the circuit in 0.02 to 0.03 seconds.

    A ground fault is an unintentional electrical path between a power source and a grounded surface. Ground faults most often occur when equipment is damaged or defective, such that live electrical parts are no longer adequately protected from unintended contact. If your body provides a path to the ground for this current, you could be burned, severely shocked, or electrocuted.

15. Select (a)

    Fall arrest systems are usually comprised of a lanyard that is connected to a beam through a choker. The lanyard is connected to an energy absorber that in turn is connected to a full body harness.

16. Select (b)

    Ozone is produced during electric arc welding operations.

17. Select (c)

    Stainless steel contains chromium. Stainless steel can produce trivalent and hexavalent chromium. Hexavalent chromium is much more toxic than trivalent chromium. Toxic hexavalent chromium can be converted to trivalent chromium by a reduction chemical reaction.

18. Select (d)

    In closed ventilation systems, total pressure is equal to the sum of static and velocity pressure: TP = SP + VP.

19. Select (a)

    The CE marking on European products is similar to the UL marking used on many US products.

    The CE marking is mandatory for products sold in the European Economic Area (EEA). By putting the CE marking on their products, manufacturers declare that their products meet the requirements set for by the European Commission (EC).

20. Select (b)

    Per DOT regulations found in 49 CFR, commercial drivers are not allowed to consume alcohol within four hours prior to starting their driving shift.

21. Select (d)

    This type of coverage focuses on the policyholder's alleged failure to perform, cause financial loss, and errors and omissions in the service or product sold.

22. Select (d)

    Course of construction insurance, also known as builders risk insurance, does not cover land value.

23. Select (b)

    CDL drivers are also subject to unannounced random testing for alcohol and drugs.

24. Select (d)

    Privity refers to a one-on-one direct relationship and is not a component of an insurance contract.

    Other components of an insurance contract include the following:

    - The declaration page lists the name of the insurance company, the name of the insured, what is covered under the policy, the amount of coverage, the time that the policy is in effect, and how much premium the insured must pay for the coverage.
    - The definitions section explains the terminology that is used in the policy.
    - The insurance agreement section states what the insurance company promises to do.

- The exclusions section states what risks are not covered under the policy.
- The conditions section specifies those provisions of the policy that are required to be met before the insurance company pays the claim.
- The endorsements section contains amendments to the original policy.

25. Select (b)

Incorporation of safety at the design stage has a clear economic advantage. It is much less expensive to make changes at this stage compared to changes made after construction of a facility.

26. Select (c)

The design team is responsible for understanding the hazards associated with equipment and control of those hazards.

27. Select (a)

The best fail-safe design is depicted in statement (a). This would allow the plant to operate safely and efficiently when the cooling water pump fails. The (b) statement would result in loss of production and additional cost for startup.

28. Select (d)

The energy theory relates the kind and severity of injuries to statements (a), (b), and (c).

The energy theory states that the cause of accidents is energy transfer with enough force to cause bodily or property damage. Therefore, preventing and controlling energy buildup and creating an environment that is not capable of energy conduction can greatly reduce the potential for accidents.

29. Select (a)

A slip meter is a device that measures floor slipperiness. Slip meters measure the static coefficient of friction. The smaller the coefficient of friction, the more chance for people to slip on the floor.

30. Select (d)

Tipping is one of the more commonly encountered hazards for ground supported scaffolds. This can be prevented by attaching the scaffold to a firm structure such as a building.

31. Select (a)

PCB drums must be made of metal and must meet DOT specifications (49CFR).

32. Select (a)

The amount of electric current flowing through a victim's body determines the severity of an electric shock. Since current is dependent on the voltage and resistance of the body, these factors are also important considerations. For example, a

circuit providing a potential difference of 220 volts sends more current through the body as compared to a circuit of 110 volts.

33. Select (b)

In order for the heart to perform its function as a pump, fibers of the heart must contract together in a coordinated manner. Ventricular fibrillation refers to the situation where these fibers contract separately resulting in cease of blood circulation in the body.

34. Select (d)

Interlocks used in electrical equipment must be of the fail-safe type. This means that the device must be designed in such a way to compensate for its failure without creating a safety problem.

35. Select (c)

Fuses and other circuit protective devices automatically open the circuit in the event of overflow of current. This action stops the flow of current.

36. Select (a)

"Arcing" is the flow of electrons through air between two conductors that are not in direct contact with each other. This electron flow generates a visible light.

37. Select (b)

Bonding does not remove the charges; however, it makes the potential difference between the two objects equal so there is no driving force for current flow between the two objects.

38. Select (c)

Hydrogen gas can be produced during charging of lead-acid batteries. If hydrogen reaches its flammable limits, there is a potential for explosion or fire.

39. Select (b)

An electrical system can be considered de-energized only after appropriate tests have been conducted. For example, many electrical circuits having capacitors can store electrical energy for a long time after the system has been shut off. Also, systems that are grounded can have charged capacitors that might cause an electrical shock.

40. Select (c)

Conductive clothing and shoes cause the electrostatic charges to safely flow to the ground.

41. Select (a)

Humidity will increase surface conductivity. Humidity is the ratio of partial pressure of water vapor in air to equilibrium vapor pressure of water at a given temperature.

An increase in temperature results in an increase in equilibrium vapor pressure and a decrease in relative humidity resulting in a decrease in surface conductivity.

42. Select (d)

Statements (a), (b), and (c) are all associated with equipment failure.

43. Select (c)

Plant layout does not take into account the cost of instrumentation.

44. Select (b)

The direction of prevailing wind will determine the location of many pieces of equipment.

45. Select (b)

Flammables should be placed on the downwind side otherwise, it is possible that the wind would carry the vapors from a spill over the plant where they could be ignited.

46. Select (d)

Gravity flow is not a reason, because liquefied petroleum gases (LPG's) turn into gaseous form once the pressure is reduced to atmospheric. Construction of containment areas below grade allows movement of emergency vehicles to and from the spill without creating additional hazards such as fire or explosion.

47. Select (c)

Motor vehicle accidents are the leading cause of work related injuries and deaths in the United States.

48. Select (d)

Light is a wave phenomenon and like other waves it can be absorbed, transmitted, or reflected by a surface.

49. Select (d)

The instrument used for measurement of the quantity of light is called a light meter.

50. Select (d)

The American National Standard Institute ANSI sets forth standards for eye and face protection (ANSI Z87.1). These standards have been adopted by OSHA.

51. Select (c)

Although statements in (a) and (b) are true, most personal fall protection devices are designed to interrupt a fall after its occurrence.

52. Select (c)

Hard hats are personal protective equipment used exclusively for head protection.

53. Select (d)

Personal protective equipment is part of the "engineering control" of hazards.

54. Select (c)

OSHA requires that only able persons be assigned to jobs which require the use of a respirator. This determination must be made by a qualified physician who informs the employer of the results of examination in writing

55. Select (d)

Stress is defined as the value of force divided by the area.

56. Select (b)

Creep is referred to as very slow but permanent deformation of a material that is under a given load.

57. Select (d)

No shoring is required for situations stated in (a) and (b).

58. Select (d)

Situations presented in statements a, b, and c are correct about trenches.

Some OSHA recommended safety tips for trenches are listed below:

- Do not enter an unprotected trench!
- Trench collapses cause dozens of fatalities and hundreds of injuries each year.
- Trenches 5 feet deep or greater require a protective system.
- Trenches 20 feet deep or greater require that the protective system be designed by a registered professional engineer.

Protective systems for trenches are the following:

- Sloping protects workers by cutting back the trench wall at an angle inclined away from the excavation.
- Shoring protects workers by installing aluminum hydraulic or other types of supports to prevent soil movement.
- Shielding protects workers by using trench boxes or other types of supports to prevent soil cave-ins.

59. Select (d)

It is impossible to fully enclose the grinding wheel as some portion of the wheels must be exposed to perform grinding on the part. Guards on grinding wheels must be adjustable to provide adequate protection when the diameter of the wheel decreases.

60. Select (c)

Unfired pressure vessels such as compressed air tanks, steam-jacketed kettles, etc. must follow the ASME code, section VIII, division 1 and 2.

61. Select (d)

Ramps should be constructed using the minimum possible slope. The recommended maximum value for the slope of a ramp is 15 degrees. However, the slope should never exceed 20 degrees.

62. Select (b)

Electric trucks do not generate carbon monoxide and are preferred over other types for indoor operations. LPG powered trucks generate considerably less carbon monoxide compared to gasoline trucks.

63. Select (d)

Injuries to the back are the most common type of injuries resulting from manual materials handling. Many studies indicate that about 25 percent of all worker's compensation claims account for injuries to the lower back.

64. Select (d)

The higher the center of gravity, the greater the potential for a rollover during a turn.

65. Select (c)

A safety inspection usually causes a surge in safety and health activities. However, after a period of time hazards are allowed to accumulate until the next inspection.

66. Select (b)

An external safety audit is normally conducted by outside consultants hired by the organization. The major advantage of an external audit is its "objectivity." The disadvantages include lack of familiarity of the auditor with the facility and the personnel, high cost, and the possibility of no or minimum follow-up.

67. Select (d)

A sound safety management program sets forth provisions to stop unsafe acts as soon as they are discovered and to provide adequate training.

68. Select (b)

Poor management is an example of basic causes of accidents. Unsafe acts or unsafe conditions are indirect causes of accidents. These can lead to direct causes of an accident such as unplanned release of energy which can result in fatality, injury, or property damage.

69. Select (d)

Statement (d) is one of the limitations of fixed guards. Another limitation is the possibility of interference with visibility.

Adjustable guards provide an adjustable barrier. One of the advantages of this type of machine guarding is that it can be constructed to suit many specific applications and stock sizes. Adjustable guards can have the disadvantage of allowing employees' hands to enter the danger zone, may require high maintenance, and they may be made ineffective by the operator.

Interlocked guards turn off the power to the machine if they are removed or pushed out of position. The openings of a self-adjusting guard are determined by the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening which is only large enough to admit the stock. After the stock is removed, the guard returns to the rest position.

70. Select (c)

Self-adjusting guards provide barriers that move according to the size of the stock entering the danger area.

71. Select (d)

The problem of vibrating parts usually does not require guarding and is solved using vibration dampers.

72. Select (d)

These helmets provide very limited voltage protection and are not suitable for electrical work.

73. Select (d)

Class B hard hats must meet ANSI standards. Class B hard hats fall into two different categories: ANSI Type I and ANSI Type II. Type I provides protection from electric shock and falling objects. Type II provides protection from falling and flying objects and electric shock and burns.

74. Select (a)

Class C helmets are designed for comfort. They offer limited head protection. They protect workers against fixed objects but do not protect against falling objects or electric shock.

75. Select (b)

Conductors that are grounded have a white or natural gray covering.

76. Select (a)

The instruments are built on the Wheatstone bridge principle. As the temperature increases, the resistance of the filament also increases, causing a decrease in current flow.

77. Select (c)

In this technique, the sacrificial metal corrodes instead of the protected metal. One of the major uses of cathodic protection is protecting underground storage tanks against corrosion.

78. Select (d)

GFCI does not protect against line to line contact. For example, GFCI does not protect a person holding two hot wires, a hot and a neutral wire in each hand, or contacting an overhead power line.

79. Select (c)

CAD is an acronym for Computer Aided Design. CAD systems are generally comprised of both software and hardware. This combination allows the design of everything from a bridge to a ship. Generally, CAD systems also require a high quality monitor to display graphics. Nowadays, CAD software is readily available for purchase.

80. Select (c)

Word processing and database management is the two most commonly used software in occupational safety and health departments.

81. Select (b)

The old concept was called *caveat emptor* or "buyer beware." By statutory and common laws, this principle turned into *caveat venditor* or "seller beware."

82. Select (b)

In this case the manufacturer can be held liable. All consumer products are also covered under the concept of strict liability. This means that the manufacturer is responsible for damages caused as a result of a defect in his products; no proof of negligence on the part of the consumer is needed.

83. Select (c)

An express warranty exists when statements in regard to certain performance characteristics of a product are made either in writing or orally.

84. Select (c)

It must be understood that the role of a CSP within an organization is advisory in nature both to management and staff. In this case, the best course of action is to notify the supervisor of the infractions and request for corrective action.

85. Select (d)

SQL is an acronym for Structured Query Language. SQL is a programming language that is commonly used to request, add, update, or delete data in a database.

86. Select (b)

CAD/CAM is an acronym for Computer Aided Design/Computer Aided Manufacturing.

87. Select (d)

    Statements (a), (b), and (c) are correct. Statement (d) is not.

    The Internet is a worldwide system of interconnected computers that serves private, public, academic, business, and government networks.

    An intranet is a private network that usually belongs to a company. An intranet's site looks and acts like any other website, except that the firewall surrounding it provides access to only authorized individuals, usually the company's employees.

    An extranet, like an intranet, is a private network. It securely shares information with other parties such as a company's customers and vendors. An extranet can be looked at as part of a company's intranet in that it provides access to authorized users outside the company.

88. Select (d)

    URL is an acronym for Uniform Resource Locator. This is a special code that tells the browser software what kind of site you are visiting. All URLs start with http://.

    URLs are also known as web addresses. In most browsers they are displayed at the top of the page inside an address bar.

89. Select (c)

    HTTP is an acronym for Hyper Text Transport Protocol. HTTP is an application protocol that is used for distributed hypermedia information systems. This protocol is the most critical in communicating data on the World Wide Web.

90. Select (c)

    RealNetworks RealPlayer is a plug-in that can be downloaded from the Internet and be used with the web browser. It plays audio and video content in RealMedia format.

91. Select (b)

    Statement (a) is a characteristic of Adobe Flash Player. Statement (c) is a characteristic of Adobe Shockwave, and statement (d) is a characteristic of RealNetworks RealPlayer.

92. Select (b)

    SeaMonkey Composer is a simple HTML editor for creating and modifying web pages. Mozilla Firefox allows you to display web pages and a variety of web content. Microsoft Meeting Space lets you connect to audio, video, and chat conferences on the Internet.

93. Select (d)

    (a), (b), and (c) are all advantages of creating E-mail in HTML. Compared to plain text, HTML can be customized much more to personal or business needs. This is

a major advantage because it provides the capability of conveying pictures, colors, emphasized text, and quotations.

94. Select (d)

UNIX workstations are generally used for CPU-intensive applications, such as special effects and graphics.

95. Select (d)

Economy, simplicity, and sharing of hardware are all advantages of peer-to-peer networks. Lack of centralized control is considered to be a disadvantage of this type of networks.

96. Select (d)

Statements (a), (b), and (c) are true in regard to a spectrophotometer. This instrument is not used for measuring ionizing radiation.

Spectrophotometers measure the amount of light having a certain wavelength that passes through a medium. The amount of light absorbed is a measure of the concentration of solute present. For example, the concentration of a colored solute in a solution can be determined by the amount of light at a certain wavelength that is absorbed.

97. Select (c)

Statement (c) is a correct description of UNIX operating system.

An operating system allows interaction with all the software and hardware on the computer. With a graphical user interface (GUI) such as Windows, the interaction with the computer is accomplished by using the keyboard and mouse. With Unix operating systems, the user has the option of using command lines as well as the GUI.

Unix operating systems in general provide more flexibility and control as compared to Windows operating systems.

98. Select (d)

Every attempt must be made to solve safety problems by using engineering and/or administrative controls. However, if engineering and/or administrative controls cannot solve the problem, appropriate personal protective equipment that has been matched to the hazards must be selected and used.

99. Select (b)

Use of a GFCI is a good example of engineering control for loss prevention. Loss reduction refers to situations where a loss has already occurred and the measures try to minimize further losses. For example, when emergency personnel respond to an emergency, loss has occurred and the emergency personnel try to minimize further losses.

100. Select (b)

-

101. Select (a)

An increase in incidence of lung cancer has been observed among workers in industries that produce chromate and manufacture pigments containing chromate. Measurement of chromium in urine is used to determine the extent of exposure to chromium. Occupational exposures occur mainly among workers who handle pigments containing dry chromate, spray paints and coatings containing chromate, operate chrome plating baths, and weld or cut metals containing chromium, such as stainless steel. Stainless steel welding involves the greatest exposure to hexavalent chromium.

102. Select (b)

Underwriter's laboratories issue the certification. UL was founded in 1894 by William Henry Merrill. Today, UL provides a wide range of services such as: certification, testing, inspection, and auditing to mention a few.

103. Select (d)

Nanoparticles are able to cross cell membranes and reach the blood and various organs because of their very small size. The degree of toxicity posed by nanoparticles depends on their chemical composition and on the composition of any chemicals absorbed onto their surfaces. Although there is little definitive evidence, the health effects of nanoparticles are likely to also depend on their shape.

104. Select (d)

A combustible dust is defined as any fine material that has the potential to catch fire and explode when mixed with air at proper concentrations. Some of these materials, such as aluminum, are not combustible under normal conditions, but they can catch fire and explode if the particles are the right size and in the right concentration.

105. Select (d)

Dusts can be created during transportation and handling, processing, polishing, and grinding and shaping. Dust explosion is of special concern in grain elevators, metal processing operations, and some food industries.

106. Select (c)

Dispersion or suspension of particles in air and confinement of the dust cloud are two additional elements required for a dust cloud explosion.

107. Select (c)

Matching PPE to the hazard is the most important step in the selection process. Using the wrong kind of PPE can create a false sense of security and increase the probability of an accident.

108. Select (a)

When employee-owned PPE is used in the workplace, the employer is responsible for ensuring that it is safe and of the approved type. It is also the responsibility of the employer to establish adequate measures for maintenance and disinfection of PPE.

109. Select (d)

Any of the actions stated would satisfy the eye protection requirement.

110. Select (b)

The Illuminating Engineering Society (IES) provides recommended values for lighting in different industrial work areas.

111. Select (b)

Goggles with indirect ventilation ports do not allow entry of liquids and are suitable when working with corrosive chemicals.

112. Select (c)

Hard hats must meet the requirements and specifications established by ANSI in Z89.1. These specifications have been adopted by OSHA.

113. Select (a)

In IDLH atmospheres buddy system must be used. This means that the respirator wearer must be watched by another person who is in a position to provide help in an emergency.

114. Select (c)

Air purifying respirators remove the contaminants from air on the bed of a solid. Removal of a component of a gaseous mixture on a solid is called adsorption. "Absorption" refers to the process of removing one or more components of a gas mixture into a liquid.

115. Select (d)

Air purifying respirators do not have their own oxygen source and should not be used in oxygen deficient atmospheres (less than 19.5%). Breakthrough will occur very quickly in an IDLH atmosphere. In the absence of test data, a cartridge respirator cannot be used in an atmosphere where the contaminant of interest does not have a warning property such as odor or taste which allows the user to know that breakthrough has taken place. The odor threshold must be lower than PEL or Action Level.

116. Select (c)

Positive pressure SCBA's provide a positive pressure inside the face mask at all times. This would eliminate the possibility of slightest leaks from the contaminated atmosphere into the face mask. This type of respirator is most effective in atmospheres which are considered to be Immediately Dangerous to Life or Health (IDLH) or oxygen deficient.

117. Select (d)

In qualitative test a harmless agent is injected into the air and the user uses his/her sense to detect any leaks. In a quantitative test, an instrument is placed inside face-mask which actually measures the amount of leakage. In positive pressure, the user exhales into the face-mask and it should remain bulged; in negative pressure the face mask should remain collapsed when inhalation takes place.

118. Select (b)

OSHA requires that SCBA's be inspected at least once every 30 days and after each use (29CFR 1910.133).

119. Select (d)

The concept of solubility parameter is the extension of the old rule that "like dissolves like." The closer the values of the solubility parameters of two chemicals, the more soluble they are in each other. In this case, a chemical with solubility parameter of 47 is the least soluble in butyl rubber with a solubility parameter of 16.

120. Select (c)

Hydrocarbon fuels such as propane used solely for workplace consumption are exempt from this OSHA standard.

121. Select (d)

The process safety management standard is contained in 29 CFR 1910.119. Appendix C of 29 CFR 1910.119 contains non-mandatory compliance for process safety management.

122. Select (d)

This OSHA standard does not apply to retail facilities, oil or gas well- drilling or servicing operations, or normally unoccupied remote facilities. This standard applies to any process which involves a flammable liquid or gas, as defined in OSHA's Hazard Communication Standard in 29 CFR 1910.1200 (c), on site in one location, in a quantity of 10,000 lb or more.

123. Select (a)

"Atmospheric tank" means a storage tank, which has been designed to operate at pressures from atmospheric through 0.5 psig (pounds per square inch gauge). It must be pointed out that pressure can be expressed in two different scales, absolute pressure scale and gauge pressure scale. The relationship between these scales is:

Absolute pressure = Gauge pressure + Atmospheric pressure

124. Select (d)

The term "hot work" means work involving electric or gas welding, cutting, brazing, or similar flame or spark-producing operations.

125. Select (b)

The information pertaining to process equipment design must be documented. In other words, what were the codes and standards relied on to establish good engineering practice.

For existing equipment designed and constructed many years ago in accordance with the codes and standards available at that time and no longer in general use today, the employer must document which codes and standards were used and that the design and construction along with the testing, inspection and operation are still suitable for the intended use. Where the process technology requires a design which departs from the applicable codes and standards, the employer must document that the design and construction is suitable for the intended purpose.

126. Select (c)

Selection of a PHA methodology or technique will be influenced by many factors including:

- The amount of existing knowledge about the process.
- Is it a process that has been operated for a long period of time with little or no innovation and extensive experience has been generated with its use?
- Is it a new process or one which has been changed frequently by the inclusion of innovative features?
- The size and complexity of the process.

127. Select (c)

The information to be compiled about the chemicals, including process intermediates, needs to be comprehensive enough for an accurate assessment of the fire and explosion characteristics, reactivity hazards, the safety and health hazards to workers, and the corrosion and erosion effects on the process equipment and monitoring tools. Current safety data sheet (SDS) information can be used to help meet this requirement which must be supplemented with process chemistry information including runaway reaction and over pressure hazards if applicable.

128. Select (b)

The 3 general categories of recommended diagrams are BLOCK Flow Diagrams (BFD), Process Flow Diagrams (PFD), and Piping and Instrumentation Diagrams (P&IDs).

129. Select (b)

"Normally unoccupied remote facility" means a facility which is operated, maintained or serviced by employees who visit the facility only periodically to check its operation and to perform necessary operating or maintenance tasks. No employees are permanently stationed at the facility. Facilities meeting this definition are not contiguous with, and must be geographically remote from all other buildings, processes or persons.

130. Select (a)

"Highly hazardous chemical" means a substance possessing toxic, reactive, flammable, or explosive properties and specified by this standard.

131. Select (c)

The 14 Elements of process safety management as defined by OSHA are listed below. Hazardous waste management is not an element of the process safety management standard.

(a) Employee participation.

(b) Process safety information.

(c) Process hazard analysis.

(d) Operating procedures.

(e) Training.

(f) Contractors.

(g) Pre-startup safety review.

(h) Mechanical integrity.

(i) Hot work permit.

(j) Management of change.

(k) Incident investigation.

(l) Emergency planning and response.

(m) Compliance audits.

(n) Trade secrets.

132. Select (b)

Section 304 of the Clean Air Act Amendments states that employers are to consult with their employees and their representatives regarding the employer's efforts in the development and implementation of the process safety management program elements and hazard assessments. Section 304 also requires employers to train and educate their employees and to inform affected employees of the findings from incident investigations required by the process safety management program.

133. Select (a)

Incident investigation is a separate element of the process safety management standard and is not part of the "process safety information" package.

134. Select (d)

Determination of fire and explosion characteristics, reactivity hazards, the safety and health hazards to workers, and the corrosion and erosion effects on the process equipment and monitoring tools is part of the "process chemicals information" of the "process safety information" package.

135. Select (b)

Interpretation of chemical labels and SDS's is required under OSHA's Hazard Communication Standard (29 CFR 1910.1200). Under provisions of the process safety management standard all employees, including maintenance and contractor employees, involved with highly hazardous chemicals need to fully understand the safety and health hazards of the chemicals and processes they work with for the protection of themselves, their fellow employees and the citizens of nearby communities. The training must cover the following areas:

- Operating procedures and safe work practices.
- Emergency evacuation and response.
- Safety procedures.
- Routine and non-routine work authorization activities.

136. Select (b)

Development of a training center is not a requirement of this standard. The training program must accomplish the following:

- Define employees to be trained.
- Subjects to be covered.
- Define goals and objectives of the training program.
- Establish means to determine whether the goals and objectives have been achieved.

137. Select (d)

Possession of a college degree in a field related to the process is not a requirement under this standard. The team conducting the PHA, however, needs to understand the methodology that is going to be used. A PHA team can vary in size from two people to a number of people with varied operational and technical backgrounds. The team leader needs to be fully knowledgeable in the proper implementation of the PHA methodology that is to be used.

138. Select (b)

The Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers can provide guidance on process hazard analysis methodologies.

139. Select (a)

SOP is an acronym for Standard Operating Practices.

140. Select (d)

The certification must be done annually.

141. Select (c)

This standard does not require HAZWOPER training for contractor employees. HAZWOPER is covered in 29 CFR 1910.120.

142. Select (c)

Compliance audits are a separate element of the process safety management standard and is not required under pre-startup safety review.

143. Select (d)

Pre-startup safety review is a separate element of the process safety management standard and is not addressed under mechanical integrity.

144. Select (d)

A list of process equipment and instrumentation for inclusion in the program must be developed. This list must include pressure vessels, storage tanks, process piping, relief and vent systems, fire protection system components, emergency shutdown systems, alarms, interlocks, and pumps. This equipment list must be prioritized to denote which pieces of equipment require closer scrutiny than others.

145. Select (c)

MTBF is acronym for Mean Time Between Failures.

146. Select (a)

Incident investigation is a separate of the process safety management and is not required under mechanical integrity program.

147. Select (d)

The permit must only be kept on file until the completion of hot work operations.

148. Select (d)

Effect of change on compliance audits program is not addressed in "management of change" element of the process safety management.

149. Select (b)

This standard does not require that a report of findings of the incident investigation be shared with the local fire department.

150. Select (b)

Process hazard analysis is a separate element of the process safety management standard and is not addressed in the emergency action plan.

151. Select (c)

It is the responsibility of the employers to certify that they have evaluated compliance with the provisions of this OSHA standard at least every three years to verify that the procedures and practices developed under the standard are adequate and are being followed.

152. Select (c)

Employers must retain the two (2) most recent compliance audit reports.

153. Select (d)

These issues are addressed in the "process safety information" element of the process safety management standard.

154. Select (c)

The employer can ask the parties involved to enter into a confidentiality agreement not to disclose the information.

155. Select (d)

An estimated 1 in 4 car crashes involve cell phone use. According to the United States Department of Transportation. Text messaging while driving creates a crash risk 23 times higher than driving while not distracted. Despite these statistics, more than 37% of drivers have admitted to sending or receiving text messages while driving, and 18% admit doing so regularly.

156. Select (a)

The inspection report must be retained by the motor carrier or other entity who is responsible for the inspection for a period of 14 months from the date of inspection.

157. Select (b)

Sensors to detect other vehicles or obstacles can include radar, video, infrared, ultrasonic or other technologies. GPS sensors can detect fixed dangers such as approaching stop signs through a location database.

158. Select (b)

Anti-lock braking system (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding.

ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces for many drivers; however, on loose surfaces like gravel or snow-covered pavement, ABS can significantly increase braking distance, although still improving vehicle control.

159. Select (d)

Vehicular accident reconstruction is the scientific process of investigating, analyzing, and drawing conclusions about the causes and events during a vehicle collision. Reconstruction personnel are employed to conduct in-depth collision analysis and reconstruction to identify the collision causation and contributing factors in different types of collisions, including the role of the driver(s), vehicle(s), roadway and

the environment. The laws of physics and engineering principles such as the conservation of linear momentum, work-energy methods, and kinematics are the basis for these analysis and may make use of software to calculate useful quantities.

Results from accident reconstructions are also useful in developing recommendations for making roads and highways safer, as well as improving safety aspects of motor vehicle designs.

160. Select (d)

Any automatic control system must first measure the parameter to be controlled. The measured value is then compared to a set point value to generate an error. The generated error (deviation from the set point) acts on a final control element such as a valve which is loaded with a spring. The spring causes the valve to open in case of excessive pressure.

161. Select (d)

Statement (d) ensures accurate noise measurements.

162. Select (c)

Engineering controls reduce the hazards permanently, and in many cases, eliminate the need for personal protective equipment (PPE). An example of engineering control in this case would be to place the worker in an enclosure to minimize exposure to excessive noise.

163. Select (b)

A confined space has limited or restricted means for entry or exit and is not designed for continuous occupancy. Examples of confined spaces include tanks, vessels, silos, etc.

164. Select (a)

ANSI recommends that the manufacturer's claim for noise reduction of earmuff hearing protection devices be reduced by 40% to represent the actual noise reduction in real-world work situations.

165. Select (a)

Class 1 lasers are considered to be non-hazardous unless viewed through magnifiers.

166. Select (b)

Class B hard hats provide protection against electric shock and must meet ANSI standards. Class B hard hats and insulated gloves & clothing must be used when working with electricity. The glove rating must match with the work to be performed. Not all gloves can be used to prevent electric shock. Ladders and tools are not personal protective equipment.

167. Select (b)

Active Safety includes set of **safety** features which reduce the chances of an accident or collision in the first place. However, the airbags, seatbelts, and others **passafety** features come into play during an accident. Hence, they are called the **passive safety** systems.

168. Select (a)

UL approval is not legally required. It's only common because many large companies will not buy equipment that has not passed UL's safety tests. UL is not part of any government agencies and is a private safety testing organization. On January 1, 2012, Underwriters Laboratories transformed from a non-profit organization to a for-profit company in the U.S.

169. Select (a)

The basic strategy of a Safe System approach is to ensure that in the event of a crash, the impact energies remain below the threshold likely to produce either death or serious injury. This threshold will vary from crash scenario to crash scenario, depending upon the level of protection offered to the road users involved. For example, the chances of survival for an unprotected pedestrian hit by a vehicle diminish rapidly at speeds greater than 30 km/h, whereas for a properly restrained motor vehicle occupant the critical impact speed is 50 km/h (for side impact crashes) and 70 km/h (for head-on crashes).

Domain V: Emergency Preparedness, Fire Protection, and Security

5.1 Review of Basic Principles and Terminology

Review of Basic Principles and Terminology

- **Combustion**

  Combustion can be defined as the rapid exothermic or heat-producing chemical reaction of oxygen with a fuel. When a fuel is burned, the carbon in the fuel reacts with oxygen to form either carbon dioxide or carbon monoxide:

C + O2 = CO2 + heat

C + 1/2 O2 = CO + heat

- **Heat of combustion**

  The amount of heat released as a result of complete combustion of a fuel. It is usually expressed in units of energy per mass of combustible material.

- **Heat transfer by radiation**

  Electromagnetic mechanism of heat transfer. The amount of heat transfer is proportional to the fourth power of temperature

- **Convection**

  Heat transfer by convection takes place as a result of fluid motion. When a cold fluid comes into contact with a hot surface, the film adjacent to the hot surface picks up thermal energy. This energy, in turn, is transmitted to the bulk of the cold fluid either by natural mixing or as a result of external forces.

  In a fire situation, convective heat transfer takes place as a result of the movement of air and the combustion products. This movement is a critical factor, as it determines the direction in which a fire will spread.

  The rate of convective heat transfer is proportional to the temperature difference and the area of heat transfer: $\mathbf{Q = H\ A\ \Delta\ T}$ Where:

  Q = Rate of convective heat transfer, energy/time

  A = Area of transfer

  ΔT = Temperature difference

  H = Heat transfer coefficient

  The constant of proportionality (H) in the above equation, called the **heat transfer coefficient**, is a function of the physical properties of the fluid.

- **Conduction**

  Conduction is the mechanism of thermal energy transfer from one molecule to another by direct contact. Consider a wall of surface area A and thickness L with one side maintained at a temperature of T_1 and the other side at a lower temperature of T_2. The rate of heat transfer can be assumed to be proportional to the temperature gradient per unit thickness of the wall and the transfer area:

$$Q = K\frac{A}{L}(T_1 - T_2)$$

  The proportionality constant K in the above equation is called the **thermal conductivity**. Different materials have different thermal conductivities; for example, metals have high thermal conductivity and are good conductors of heat, whereas plastics generally have low thermal conductivity and are poor conductors of heat (good insulators).

Elements of Combustion

There are four elements required for combustion. These are oxygen, fuel, source of ignition or sufficient heat, and chemical chain reaction. These four elements make the four corners of what is commonly known as **fire tetrahedron**. In order to extinguish a fire we must remove at least one of these four elements. The more corners of the fire tetrahedron that are removed the more controlled would the situation be.

- **Fuels**

  A fuel is a necessary component of all combustion reactions. The fuel can be present in solid, liquid, vapor, or gaseous form.

- **Solid Fuels**

  Examples of solid fuels that can support combustion are wood, coal, textiles, paper, plastics, and some metals such as magnesium and cesium.

5.2 Flammable and Combustible Liquids

Definition of Flammable and Combustible Liquids

The National Fire Protection Association (NFPA) defines a flammable liquid as any liquid that has a closed cup flash point below 100°F and a vapor pressure not exceeding 40 psia (pounds per square inch absolute) at 100°F. A combustible liquid, on the other hand, is any liquid that has a closed cup flash point at or above 100°F. Flammable liquids are further classified into the groups summarized in Table 5 depending on their flash points and boiling points.

Class	Definition
IA	Flash point below 73°F; boiling point below 100°F.
IB	Flash point below 73°F; boiling point at or above 100°F.
IC	Flash point at or above 73°F, but below 100°F.

Table 5. Definition of Classes of Flammable Liquids

Combustible liquids are also classified into three groups, as summarized in Table 6.

Class	Definition
II	Liquids have flash points at or above 100°F and below 140°F.
IIIA	Liquids have flash points at or above 140°F and below 200°F.
IIIB	Liquids have flash points at or above 200°F.

Table 6. Definition of Classes of Combustible Liquids

Properties of Flammable and Combustible Liquids

- **Flash Point**

  Flash point is defined as the **lowest** temperature at which a liquid can generate enough vapor above its surface to support combustion in the presence of a source of ignition.

- **Vapor Pressure**

  The pressure exerted by a vapor on its liquid at equilibrium is called the vapor pressure of the liquid at the temperature of the system. It should be emphasized that the vapor pressure of a liquid always **increases** with an increase in **temperature**.

- **Fire Point**

  Fire point is the **lowest temperature** at which a flammable liquid in an open container gives off enough vapors to continue to burn once it has been ignited. The fire point usually is higher than the flash point.

- **Explosive or Flammable Range**

  The explosive or flammable range encompasses those concentrations of flammable vapor or gas in air that can ignite in the presence of a source of ignition. The term, **lower flammability limit (LFL)** is used to describe the minimum concentration of vapor in air below which a flame will not propagate through the mixture. The term, **upper flammability limit (UFL)**, is used to describe the maximum concentration of flammable vapor in air above which a flame will not propagate.

  Lower flammability limits for flammable liquids can be calculated from the vapor pressure data at the flash point temperature using the following expression:

$$LFL \times 100 = \frac{P^*}{14.7}$$

  where P* is the vapor pressure of the liquid in psia at its flash point temperature.

  The LFL and the UFL for a material are key factors in determining the amount of safety ventilation needed and the extent to which the venting of explosive pressures may be necessary. A decrease in temperature or pressure raises the LFL and lowers the UFL. An increase in temperature, on the other hand, will lower the LFL and raise the UFL.

- **Auto-ignition Temperature**

  Auto-ignition temperature is the lowest temperature that will produce combustion in the absence of an ignition source.

- **Specific Gravity**

  The specific gravity (sp. gr.) describes the density of a liquid relative to the density of water. Liquids with a specific gravity **less than one** are **lighter** than water. Most flammable liquids are lighter than and insoluble in water, and will float on its surface. A few are heavier and insoluble in water and will sink in it.

- **Vapor Density**

  Vapor density is a measure of the relative densities of vapors and gases compared to air under the same conditions of temperature and pressure. Vapors generated by most flammable liquids are heavier than air (vapor density greater than one), so the ventilation for flammable liquids should be at or near floor level. Most flammable gases, on the other hand, have a vapor density of less than 1 and are lighter than air. Ventilation systems for these flammable gases should be placed above the floor depending on the point of generation.

When the rate of vapor production is high, positive-displacement safety ventilation is required. Fresh air intakes should be located so that they will assist the safety ventilation process.

- **Evaporation Rate**

  The evaporation **rate is the rate at which a liquid is converted to vapor** at a given temperature and pressure. The evaporation rate of most liquids is reported relative to butylacetate (evaporation rate of 1). A liquid with an evaporation rate less than 1 evaporates more slowly than butyl-acetate.

- **Water Solubility**

  Many flammable liquids, such as alcohols, ethers, and ketones, are completely or partially soluble in water, and mixing these liquids with water reduces their flammability and eliminates static hazards.

- **Boiling Point**

  The boiling point of a liquid is defined as the temperature at which the liquid transforms into vapor at a given pressure. It should be understood that boiling point is a strong function of ambient pressure and always **decreases** with a **decrease in ambient pressure**. Boiling point is usually stated at **sea level pressure** (1 atmosphere), which is called **Normal Boiling Point**.

5.3 Flammable Gases

Definition of Flammable Gas

A gas is considered to be flammable if it satisfies either of the following criteria:

- At ambient temperature and pressure it has a UFL of 13% or less by volume.
- At ambient temperature and pressure has a flammability range that is wider than 12%.
- Any gas that will burn in the normal concentration of oxygen in air.

Properties of Flammable Gases

Generally, flammable gases pose the same type of fire hazards as flammable liquids and their vapors.

Flammable gases, such as hydrogen or natural gas, usually have a wider explosive range, as compared to flammable vapors. This should be taken into account when designing the ventilation system and electrical equipment in a flammable gas atmosphere. Although all flammable vapors are heavier than air, most flammable gases are lighter than air. This property would dictate the nature of the design for ventilation systems.

Fire gases

The nature and the toxicity of fire gases strongly depend on the chemical structure of the burning material, the oxygen supply, and the temperature.

- **Carbon Monoxide** As a result of the incomplete combustion of carbon-containing compounds, CO is produced in large amounts during a fire. Although CO is not the most toxic of fire gases, it is 210 times more reactive with blood than oxygen. Thus, CO poisons humans by a form of asphyxiation.
- **Carbon Dioxide** Fires produce large amounts of carbon dioxide (CO2). Carbon dioxide itself is not a toxic gas, its major contribution to death and injury results from its reducing the relative concentration of oxygen in air, i.e., it is a simple asphyxiant.
- **Hydrogen Cyanide** Hydrogen cyanide, a deadly gas, can be produced during fires from the combustion of materials such as wool, silk, acrylonitrile, acrylates, agricultural chemicals, rodenticides, and polyurethane.
- **Sulfur Dioxide** This gas can be produced during fires from the combustion of sulfur-containing materials. A strong irritant, it is intolerable well below lethal concentrations.

- **Ammonia** During fires, ammonia can be generated from the combustion of materials such as wool, silk, fertilizers, explosives, acrylonitrile, and nylon.
- **Hydrogen Chloride** This gas can be generated by the combustion of materials such as polyvinyl chloride (PVC), dyes, perfumes, agricultural chemicals, and some fire-retardant materials.
- **Hydrogen Sulfide** During fires, hydrogen sulfide can be generated as a result of the incomplete combustion of sulfur containing compounds such as wool and rubber.
- **Nitrogen Dioxide** This gas can be generated from the combustion of nitrogen containing compounds such as fabrics, cellulose nitrate, celluloid, catalysts, and polymerization inhibitors.

5.4 NFPA 704 System

The NFPA 704 system divides the fire hazards of a material into four major categories: health, flammability, reactivity, and special. The system uses a number rating system, ranging from 0 to 4, to identify the severity of hazard in each category, with 0 indicating no hazard and 4 indicating the most severe hazard. The health hazard is identified by the color blue, flammability by red, reactivity by yellow, and special instructions by the white color as shown in Figure 1.

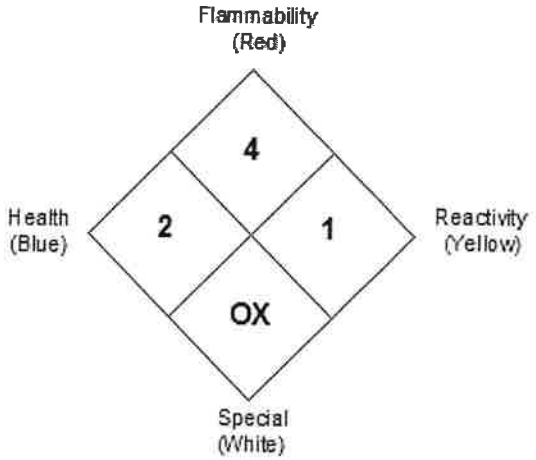


Figure 1. NFPA 704 System for Fire Hazard Identification.

5.5 Fire Extinguishers

- **Carbon Dioxide** Used extensively to extinguish fires in most flammable liquids, ordinary combustibles, and electrical fires, carbon dioxide can put out fires by forming a barrier between the oxygen and the flammable vapors and by diluting the mixture to values below its LFL. It also provides cooling to some extent.
- **Dry Chemicals** Dry chemicals can be classified into the following groups:

  Regular and ordinary chemicals: These agents are effective on flammable liquid and electrical fires (BC). Multipurpose dry chemicals: These chemicals are effective on ordinary materials (Class A), flammable liquid fires (Class B) as well as electrical fires (Class C).

  Dry chemicals can extinguish a fire by a combination of dilution, cooling, radiation shielding, and flame-retardant actions. In the United States the term "dry chemical" should not be confused with "dry powder." The latter refers to an extinguishing agent suitable for combustible metal fires (Class D).

- Regular and ordinary chemicals: These agents are effective on flammable liquid and electrical fires (BC).
- Multipurpose dry chemicals: These chemicals are effective on ordinary materials (Class A), flammable liquid fires (Class B) as well as electrical fires (Class C).
- **Foam** This fire extinguishing agent usually is used on flammable liquid fires (Class B). Foam can be produced by either mechanical or chemical means. Mechanical foam-producing devices inject air into a foam-producing liquid. Foam can extinguish a fire by forming a cooling blanket that prevents the transfer of flammable vapors from the surface of the liquid. Foams are characterized by their expansion ratio and are subdivided into low, medium, or high expansion. Foams are also defined according to their effectiveness on hydrocarbon fuels, water miscible fuels or both.
- **Halogenated Agents** Halogenated fire extinguishing agents are hydrocarbons in which one or more atoms of hydrogen have been replaced by halogen atoms. This substitution not only eliminates the flammability characteristics of the hydrocarbon molecule but also imparts a flame-retardant capability to the halogenated compound. Halon fire extinguishing agents are being phased out because they can deplete the atmosphere ozone layer.
- **Dry Powder** The term "dry powder" is used to describe extinguishing agents suitable for use on combustible metal fires by creating smothering or heat transferring means.

Classification of Fires and Fire Extinguishers

NFPA has divided fires into four different classes, and different extinguishing agents are required for the different classes of fires.

- **Class A** includes fires in ordinary combustible materials such as wood, cloth, paper, rubber, and many plastics. Water can cool this type of fire by bringing the fuel temperature below the ignition point. Dry chemicals can retard combustion, and halogenated agents can interrupt the combustion chain reactions.
- **Class B** includes fires in flammable or combustible liquids, flammable gases, greases, and similar materials. Depending on the properties of the fuel, dry chemicals, carbon dioxide and halons can be used.
- **Class C** includes fires in energized electrical equipment, where the extinguishing agent must be nonconductive to avoid electrical shock. Halons and carbon dioxide are widely used to extinguish electrical fires. It should be noted that a Class C fire can be extinguished using Class A or B extinguishing agents (depending on the properties of the burning material) when the electrical equipment on fire is de-energized.
- **Class D** includes fires in combustible metals such as magnesium, titanium, zirconium, sodium, and potassium. The extinguishing agent should absorb heat without reacting with the metal or create a smothering effect.

Some fire extinguishers can be used on just one class of fire, and some are designated for use on two or three classes. No extinguisher is suitable for all four classes of fire. Thus, extinguishers must be clearly marked as to the class(es) of fire for which they can be used.

Class A and B extinguishers have a numerical rating on their label to indicate the relative effectiveness of the extinguisher. For example, an extinguisher for Class A fires has a numeral that precedes the letter A; this numeral indicates the relative extinguishing capacity of the extinguisher. This means that an extinguisher with an 8-A rating can put out a larger fire than one with 4-A rating, but not necessarily twice as large a fire; the ratings are only relative.

Class B extinguishers are rated based on the amount of flammable liquid in a flat pan that can be extinguished during a laboratory test. An extinguisher rated 20-B can put out a much larger fire than one rated 5-B.

Class C fire extinguishers do not have a numerical rating. The Class C rating indicates that it is safe for use on energized electrical equipment.

Class D dry powder extinguishers do not have a letter or numeral rating because an extinguisher for one metal may not be effective on a different metal fire. These extinguishers carry a plate indicating the type of metal fire against which the extinguisher is effective.

Extinguishers that are effective against more than one class of fire carry multiple letters and numeral ratings to indicate the class of fire and the extinguisher's effectiveness.

Location and Marking of Extinguishers

Extinguisher markings should be durable and visible from 3 feet away. If a pictograph marking system is used, the decal should be visible from the front as the extinguisher hangs. The locations of extinguishers should be marked by painting a red rectangle above them. The signs identifying location of extinguishers must not be obstructed from view.

Distribution of Fire Extinguishers

Extinguishers must be distributed in such a way that the amount of time needed to travel to their location and back to the fire does not allow the fire to get out of control. OSHA requires that the travel distance for Class A extinguishers not exceed 75 feet. The maximum travel distance for Class B extinguishers is 50 feet because flammable liquid fires can get out of control faster than Class A fires. If a Class B extinguisher has a low rating, the travel distance must be reduced accordingly. There is no maximum travel distance specified for Class C extinguishers, but they must be distributed on the basis of appropriate patterns for Class A and B hazards. The maximum travel distance for Class D fire extinguishers should not exceed 75 feet.

- **Hydrostatic testing** Hydrostatic testing of portable fire extinguishers is required to detect corrosion, physical damage, improper assembly of parts, and damage to the mechanical properties of metal parts. OSHA requires that hydrostatic testing of extinguishers be conducted according to the schedule outlined in Table 7.

Extinguisher Type	Test Interval(Years)
Stored pressure water and/or antifreeze	5
Wetting agent	5
Aqueous film-forming foam (AFFF)	5
Dry chemical with stainless steel shell	5
Carbon dioxide	5
Dry chemical, stored pressure, with mild steel, brazed brass or aluminum shell	12
Dry chemical, cartridge or cylinder-operated with mild steel shells	12
Dry powder, cartridge or cylinder-operated, with mild steel shells	12

Table 7. Hydrostatic Test Intervals for Extinguishers.

5.6 Electrical Equipment for Hazardous Locations

Hazardous locations may contain flammable liquids, gases, or vapors, or combustible dusts in sufficient quantities to produce an explosion or fire hazard. In hazardous locations, specially designed equipment and special installation techniques must be used to protect against the explosive and flammable potential of these substances.

Hazardous locations are classified by the National Electric Code (NEC) as Class I, Class II, and Class III, depending on the type of hazardous substance that may be present. In general, Class I locations are those in which flammable vapors and gases may be present; Class II locations are those in which combustible dusts may be found; Class III locations are those in which there may be ignitable fibers.

Each of these classes is divided into two hazard categories, Division 1 and Division 2, depending on the likelihood of the presence of a flammable or ignitable concentration of a substance. In general, the electrical installation requirements for Division 1 locations are more stringent than for Division 2 locations. Division 1 locations are designated as such because a flammable gas, vapor, or dust is normally present in hazardous concentrations. In Division 2 locations, hazardous quantities of these materials are not usually present, but may occasionally exist either accidentally or when material in storage is handled.

Additionally, Class I and Class II locations are subdivided into groups of gases, vapors, and dusts having similar properties.

Bonding and Grounding

When two conducting bodies are connected by a conductor, charges can flow freely between the two bodies and eliminate potential differences and the possibility of sparking. The mechanism of connecting two conducting bodies by means of a conductor is known as bonding. Grounding, on the other hand, provides a conducting path between the charged object and the earth.

Many flammable liquids can build up electrostatic charges when agitated or during transfer; so it is imperative to ensure that proper bonding and grounding procedures have been followed before any attempt is made to transfer a flammable liquid.

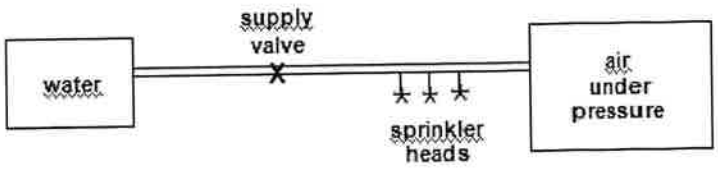
5.7 Sprinkler Systems and Fire Detection Instruments

Fire safety in buildings can be achieved by separating ignitors from ignitable materials, minimizing the impact of fire through building design, and taking measures to control the products of combustion which are flame, heat, smoke, and fire gases. The following is a summary description of some of the more common equipment, instruments, and terminology used in "building" fire prevention and protection:

Sprinkler Systems

Sprinkler Systems fall into six major categories. These are dry pipe, wet pipe, preaction, deluge, combined dry pipe and preaction, and residential sprinklers that are designed for limited water supply systems.

- **Regular dry pipe systems** In this type of sprinkler design, the sprinkler heads are attached to piping which contains air or nitrogen under pressure. When a sprinkler head is opened due to heat from a fire, the air or nitrogen pressure in the dry pipe falls to a point where water on the supply side of the system forces the supply valve to open, and water flows through any sprinkler head which is open.



- **Wet pipe systems** In this system, the sprinkler heads are attached to a piping that contains water under pressure at all times. The sprinkler heads respond to the heat generated from a fire, and water flows through an open sprinkler head.
- **Pre-action automatic sprinkler systems** Pre-action automatic sprinkler systems are designed to control the fire when there is possibility of damage to piping or sprinkler heads and the property is sensitive to water. A water supply valve is added to a standard dry pipe system. This valve is opened by the operation of an automatic fire detection system. The automatic fire detection system is placed in a protected area, and once activated sends water through a supply valve to the sprinkler heads. Once the sprinkler heads are opened due to heat generated by a fire, water flows through them immediately.

- **Deluge systems** In this type of automatic sprinkler system design, the sprinkler heads are open at all times. A fire detecting instrument activates and opens the deluge valve sending water to all sprinkler heads.
- **Combined dry pipe and preaction systems** This type of system combines the essential features of both dry pipe and preaction systems. The piping leading to the sprinkler heads is filled with air or nitrogen and a supplementary fire detecting device trips the dry pipe valve without loss of air pressure, and the air exhauster at the end of the line. This action fills the system piping with water. The system can operate as a regular dry pipe should the supplementary fire detection system fail.
- **Residential sprinkler systems** These systems are designed for use in residences, taking into consideration the limited water supply. Their main purpose in life safety is evacuation.
- **Sprinkler system temperature rating** Table 8 summarizes the color coding for sprinkler heads.

Maximum Ceiling Temperature		Color Code
°C	°F	
38	100	uncolored
66	150	white
107	225	blue
149	300	red
191	375	green
246	475	orange
329	625	orange

Table 8. Color coding for sprinkler heads.

Fire Detection Instruments

- **Fixed temperature thermal detectors** Fixed temperature thermal detectors have a bimetallic element with the two metals having different **coefficient of expansions**. Temperature rises cause the element to bend and close a circuit. Some thermal detectors of this type use a fusible spring loaded element which melts at a certain temperature, causing a circuit to close. There are other thermal detectors which are classified as **continuous-line type**. An example of this type of detector is two conductors separated by a temperature sensitive insulation. The insulation melts at a given temperature causing the two conductors to come into contact with each other closing an electrical circuit.
- **Rate-compensation detectors** Rate-compensation detectors are fire detection devices that respond to a fixed predetermined temperature in the air surrounding the device. These detectors do not take into account the rate of rise of air temperature.
- **Rate-of-rise detectors** Rate-of-rise detectors respond to a predetermined rate of rise of temperature in the air. A typical value is about 12°F per minute.

- **Sealed pneumatic line-type detectors** Pneumatic detectors are completely mechanical and are ideal for locations that due to explosivity of the mixture use of electricity must be avoided. These devices are among thermal detectors and work based on an increase of air pressure inside a bulb due to an increase in temperature. The bulb has a diaphragm which will eventually become deflated as a result of increase in air pressure.
- **Smoke detectors** Photoelectric smoke detectors respond to products of combustion based on the principle of less or more light reaching them. As smoke enters the detector it can absorb light (less light), or it can scatter light (more light). Ionization smoke detectors have a radioactive material that ionize the sensing chamber air, making air conductive and permitting current flow between two charged electrodes. Smoke particles decrease conductance and an alarm is triggered at a predetermined level.
- **Flame detectors** Flame detectors respond to either the ultraviolet or infrared portion of the light generated by the flame. Both are used for fire detection in systems that require very fast response. Infrared detectors can be accordingly tripped due to solar interference.
- **Combustible gas indicators** Combustible gas indicators operate on the principle that the resistance of a heated element increases as it comes into contact with the gases (Wheatstone bridge). This increase in resistance is detected on a galvanometer or a digital or analog meter. Solid state sensors are also being used.

Fire alarms

Fire alarms fall into two broad categories: **type A** (manual) and **type B** (automatic). Type A alarms require an operator to receive the alarm and transmit the alarm to the fire department. In type B the alarm is automatically transmitted to the fire station.

5.8 Useful Concepts in Building Fire Safety

- **Flame spread rating** Flame spread rating is a measure of the burning characteristics of a material. These ratings are used by the NFPA to indicate materials which can be used for finishing purposes in a given area.
- **Fire loading** Fire loading refers to the maximum amount of heat that can be generated in a given area as a result of a fire. In calculations of fire loading, an assumption is made that all combustible materials will burn and release their heat content.
- **Fire proofing** Fire proofing refers to insulating steel in structures from heat that may be generated during a fire. The main reason for fire proofing is that the strength of steels drops sharply at temperatures above 10,000 F. Also, use of "fire proof" or "fire resistive" materials indicate that a building can withstand a burnout of all its content without structural collapse. It is important not to confuse the terms "fire-proof" and "fire-safe." The latter indicates that once a fire has been started in a "fire-safe" area, it can be extinguished without fire being able to spread elsewhere in the structure.
- **Fire doors** Fire doors are most commonly classified by an hourly rating; although alphabetical or a combination of hourly rating and alphabetical rating may also be used. Fire doors are the most accepted means of protecting both horizontal and vertical openings in fire-rated walls and floors. Fire doors may be classified by an hourly rating designation such as three-hour fire doors. NFPA 80 "standards for fire doors and windows" classifies openings as A, B, C, D, and E depending on the type and location of the wall. A three-hour door used in a Class A opening is usually called a Class A door.
- **Hot work permits** Hot work permits require authorization to be obtained before any equipment or device which is capable of igniting combustible materials is used outside areas for which it is designed. The first and most important step in establishing a hot-work permit program is a "policy statement" by the management of the organization.

5.9 Planning and Responding to Workplace Emergencies

Nobody expects an emergency or disaster. Yet emergencies and disasters can strike anyone, anytime, anywhere. OSHA requires that employers should establish effective safety and health management systems and prepare their workers to handle emergencies before they arise.

Planning

Where required by some Occupational Safety and Health Administration standards, firms with more than 10 employees must have a written emergency action plan; smaller companies may communicate their plans orally. Top management support and the commitment and involvement of all employees are essential to an effective emergency action plan. Employers should review plans with employees when initially put in place and re-evaluate and amend the plan periodically whenever the plan itself, or employee responsibilities, change. Emergency procedures, including the handling of any toxic chemicals, should include:

- Escape procedures and escape route assignments.
- Special procedures for employees who perform or shut down critical plant operations.
- Systems to account for all employees after evacuation and for information about the plan.
- Rescue and medical duties for employees who perform them.
- Means for reporting fires and other emergencies.

Chain of Command

OSHA requires that the employer to designate an emergency response coordinator and a backup coordinator. The coordinator may be responsible for plant-wide operations, public information and ensuring that outside aid is called. Having a backup coordinator ensures that a trained person is always available. Employees should know who the designated coordinator is. Duties of the coordinator and employer include:

- Determining what emergencies may occur and seeing that emergency procedures are developed to address each situation.
- Directing all emergency activities including evacuation of personnel.
- Ensuring that outside emergency services are notified when necessary.
- Directing the shutdown of plant operations when necessary.

Emergency Response Teams

Emergency response team members should be thoroughly trained for potential crises and physically capable of carrying out their duties. Team members need to know about toxic hazards in the workplace and be able to judge when to evacuate personnel or when to rely on outside help (e.g., when a fire is too large to handle). One or more team members must be trained in:

- Use of various types of fire extinguishers.
- First aid, including cardiopulmonary resuscitation (CPR) and self-contained breathing apparatus (SCBA).
- Requirements of the OSHA blood-borne pathogens standard.
- Shutdown procedures.
- Chemical spill control procedures.
- Search and emergency rescue procedures.
- Hazardous materials emergency response.

Response Activities

Effective emergency communication is vital. An alternate area for a communications center other than management offices should be established in the plans, and the emergency response coordinator should operate from this center. Management should provide emergency alarms and ensure that employees know how to report emergencies. An updated list of key personnel and off-duty

telephone numbers should be maintained. Accounting for personnel following evacuation is critical. A person in the control center should notify police or emergency response team members of persons believed missing. Effective security procedures can prevent unauthorized access and protect vital records and equipment. Duplicate records of essential accounting files, legal documents and lists of employee relatives – to be notified in case of emergency – can be kept at off-site locations.

Training

Every employee needs to know details of the emergency action plan, including evacuation plans, alarm systems, reporting procedures for personnel, shutdown procedures, and types of potential emergencies. Any special hazards, such as flammable materials, toxic chemicals, radioactive sources or water-reactive substances, should be discussed with employees. Drills should be held at random intervals, at least annually, and should include outside police and fire authorities. Training must be conducted at least annually and when employees are hired or when their job changes. Additional training is needed when new equipment, materials or processes are introduced, when

the layout or design of the facility changes, when procedures have been updated or revised, or when exercises show that employee performance is inadequate.

Personal Protection

Employees exposed to or near accidental chemical splashes, falling objects, flying particles, unknown atmospheres with inadequate oxygen or toxic gases, fires, live electrical wiring, or similar emergencies need appropriate personal protective equipment.

Medical Assistance

First aid must be available within 3 to 4 minutes of an emergency. Worksites more than 3 to 4 minutes from an infirmary, clinic, or hospital should have at least one person on-site trained in first aid (available all shifts), have medical personnel readily available for advice and consultation, and develop written emergency medical procedures. It is essential that first aid supplies are available to the trained first aid providers, that emergency phone numbers are placed in conspicuous places near or on telephones, and prearranged ambulance services for any emergency are available. It may help to coordinate an emergency action plan with the outsider responders such as the fire department, hospital emergency room, EMS providers and local HAZMAT teams.

5.10 Example Questions

1. In the development of emergency response plans, which of the following is the most critical factor that needs to be addressed?
   a. Emergency equipment needed
   b. Emergency personnel
   c. Response to multiple emergencies
   d. How to protect people, property, and the environment
2. Strict liability is the absolute legal responsibility for an injury that can be imposed on the wrongdoer without proof of carelessness or fault. Which of the following IS NOT part of what the plaintiff must prove in product liability cases?
   a. That the item was defective
   b. That the defect proximately caused the injury
   c. That the product did not work as expected
   d. That the defect rendered the product unreasonably dangerous
3. Based on a Factory Mutual Engineering Corporation study of 25,000 fires over a period of 10 years, the leading cause of industrial fires is:
   a. Sparks
   b. Smoking
   c. Electrical
   d. Hot surfaces
4. The leading cause of civilian fires is:
   a. Electrical
   b. Smoking
   c. Candles
   d. Cooking equipment
5. The standards developed by the National Fire Protection Association (NFPA) for fire prevention and protection are called:
   a. NFPA Code of Fire Standards
   b. Uniform Building Fire Code
   c. Fire Safety Standards
   d. National Fire Code

6. Auto-ignition temperature is the minimum temperature at which a material would burn in the absence of an ignition source. This temperature is:

   a. Lower than ignition temperature

   b. Higher than ignition temperature

   c. The same as ignition temperature

   d. Depending on the material, it could be higher or lower than ignition temperature

7. In order for combustion reactions to start and proceed, which of the followings are needed simultaneously?

   a. Fuel, heat, source of ignition, and air

   b. Fuel, spark, oxygen, heat

   c. Fuel, chemical chain reaction, oxygen, source of ignition

   d. Fuel, auto-ignition temperature, air, source of ignition

8. Two cylinders of hydrogen and five 55 gallon drums of gasoline burn completely in a storage area made of non-combustible material. Assuming that the density of gasoline is 4 lbs./gallon, its heating value is 20,000 Btu/lb., and that there are 15 lb of hydrogen in each cylinder with a heating value of 55,000 Btu/lb., the amount of heat released is:

   a. 40×10^6 Btu

   b. 20×10^5 Btu

   c. 23.65×10^6 Btu

   d. 32.56×10^6 Btu

9. A drum of solvent is on fire in a storage room. Assume that heat is transferred from the outer surface of the drum having a temperature of 1,500°F to the wall having a temperature of 1,000°F by convection. If the heat transfer coefficient is 80 Btu/hr/ft^2/°F, the rate of heat transfer is: (Assume a heat transfer area of 50 ft^2.)

   a. 2×10^6 Btu/hr

   b. 96,000 Btu/hr

   c. 8.9×10^6 Btu/hr

   d. 12.7×10^6 Btu/hr

10. A flammable liquid storage area made of 1 foot-thick brick walls having a thermal conductivity of 0.4 Btu/hr/foot/°F is on fire. Assuming that heat is transferred from one of the walls having a temperature of 800°F and an area of 100 ft^2 to the other side of the wall, which has a temperature of 200°F, the rate of heat transfer in Btu/hr is:

a. 80,000

b. 24,000

c. 36,000

d. 8,000

11. A drum of carbon disulfide (CS_2) is on fire. The combustion products would most likely be:

a. Sulfur oxides, carbon monoxide, carbon dioxide

b. Hydrogen sulfide, carbon monoxide

c. Hydrogen sulfide, water, carbon monoxide, carbon dioxide

d. Twice as much hydrogen sulfide as CO and CO_2 combined

12. A water reactive chemical is defined as one that would produce either a flammable gas or a toxic gas when it comes into contact with water or moisture. Which of the following compounds is a water reactive chemical?

a. Potassium chloride

b. Potassium

c. Potassium cyanide

d. Only (b) and (c) above.

13. Which of the following is the most important consideration to prevent fire loss in a flammable liquid storage area?

a. Compatible storage

b. Use of explosion proof devices

c. Availability of firefighting equipment

d. Use of pre-action automatic sprinkler system

14. In most fire situations there is not enough oxygen available for conversion of carbon in the fuels to carbon dioxide, and as a result, large amounts of carbon monoxide are produced. CO has been the primary killer in most fires. This gas can cause fatalities because:

a. It in the most toxic of all gases produced in a fire.

b. It is more reactive with blood than oxygen.

c. It reacts with oxygen in the lungs and causes asphyxiation.

d. Only (b) and (c) above.

15. The gaseous products of combustion have a vapor density of less than 1. This means that air in a fire situation is at:

a. Low spots

b. High spots

c. Mixed with other gases

d. Halfway between floor and ceiling

16. The following data is available for vapor pressure of acetone as a function of temperature.

Temperature, °F: 130° 120° 110° 100° 90°

Vapor Pressure, mm Hg: 760 740 720 700 695

When atmospheric pressure is 740mm Hg, the vapor pressure of acetone is also 740mm Hg at 120°F. This means that the boiling point of acetone at 740mm Hg is:

a. Equal to 120°F

b. Higher than 120°F but less than 130°F

c. Lower than 120°F but more than 110°F

d. Vapor pressure is a measure of the volatility of a liquid and has nothing to do with boiling point.

17. Acetone is a highly flammable liquid (flash point = 0°F) and has a specific gravity of 0.79. From the data presented, and in the absence of other information, which of the following statements is true regarding a mixture of acetone and water?

a. Acetone would float on top of water.

b. Acetone would sink in water.

c. The mixture has a flashpoint of less than 0°F.

d. Data presented is not sufficient to determine whether acetone would float or sink in water.

18. Water has a vapor pressure of 20mm Hg at room temperature and acetone has a vapor pressure of 180mm Hg at room temperature. This indicates:

a. Water evaporates faster than acetone.

b. Water evaporates more slowly than acetone.

c. At a given pressure, acetone has a lower boiling point compared to water.

d. Only (b) and (c) above.

19. Fire point is defined as the lowest temperature at which enough vapor is generated to support continuous combustion in presence of an ignition source. Fire point is:

a. Lower than flash point

b. Higher than flash point

c. Same as flash point

d. Depending on the material can be higher, lower, or the same as flash point

20. Mishandling of flammable liquids and gases have been responsible for approximately 18 per cent of all industrial fires. In order to safely handle these materials, one has to understand their properties. Flammable liquids are incompressible while flammable gases are compressible. A container with a volume of 100 ft^3 is filled with gasoline. The container is under 100 psi pressure. If this container breaks, the volume of gasoline spilled is approximately:

a. 100,000 ft^3

b. 10,000 ft^3

c. 100 ft3

d. 10 ft^3

21. A cylinder of hydrogen having a volume of 5 ft^3 is under 1,000 psig pressure. The valve on the cylinder breaks releasing hydrogen to atmosphere. The volume of hydrogen released is approximately:

a. 5 ft^3

b. 5,000 ft^3

c. 345 ft^3

d. 456 ft^3

22. A Lower Flammability Limit (LFL) of 10% for a gas or vapor means that the gas would support combustion at:

a. Concentrations with air below 10%

b. Concentrations above 10% but below the UFL

c. Concentrations 10% above UFL

d. Only (b) and (c) above

23. Fifty gallons of gasoline is spilled from a drum. The specific gravity of gasoline is 0.8 and its vapor density is 2.5. The volume of vapor that can be generated from the spill is approximately:

a. 1,776 ft^3

b. 1,025 ft^3

c. 125 ft^3

d. 652 ft^3

24. Methyl alcohol has a vapor volume of 80 ft^3 per gallon and a lower flammability limit of 6% by volume in air. A bottle of methyl alcohol containing 0.5 gallon of

methyl alcohol liquid breaks in a room with dimensions of 15 × 15 × 10 feet. The content of the room is:

a. Above LFL

b. Flammable

c. Below LFL

d. Only (a) and (b) above

25. Materials that are classified as oxidizers must be separated form flammables because:

a. They can produce heat and act as a source of ignition.

b. If mixed with flammables may cause a fire in the absence of a source of ignition.

c. They can release oxygen or catalyze the combustion reactions.

d. Only (b) and (c) above.

26. Fire resistance rating is a rating for buildings that:

a. Is based on laboratory tests.

b. Determines how long a structure withstands a fire.

c. Has units of minutes or hours.

d. All of the above.

27. A storage area made of concrete stores 20 drums of gasoline each containing 200 lb of gasoline. The heat of combustion for gasoline is 20,000 Btu/lb. The fire load for this storage area is:

a. 4×10^6 Btu

b. 8×10^7 Btu

c. 6×10^7 Btu

d. 2×10^7 Btu

28. Fixed temperature heat detectors are not suitable for fires that have the potential for developing quickly because:

a. They can only respond to rate of rise of temperature.

b. The air reaches a higher temperature before the device.

c. In a quick fire heat does not transfer to the device properly.

d. They can only detect heat coming from a fixed temperature.

29. Most fixed temperature heat detectors use:

a. Fusible metal

b. Continuous wires separated by insulation

c. Bimetallic strips or disks

d. All of the above

30. Rate of rise fire detectors:

a. Are suitable for fast developing fires

b. Respond to changes in ambient temperature and pressure

c. Are classified as heat detectors

d. Only (a) and (c) above

31. Which of the following statements best describe the operation of a rate compensation fire detector?

a. Responds to a fixed temperature

b. Is more sensitive to thermal lag than a fixed temperature device

c. Temperatures that rise rapidly are detected sooner

d. Only (a) and (c) above.

32. Ionization fire detectors respond to:

a. Smoke particles

b. Flame

c. Heat

d. Ions produced during a fire

33. A dry powder fire extinguishing agent can be used on:

a. Class A, B, C fires

b. Metal fires

c. Class C and D fires

d. All of the above

34. Which of the following gases is expected to be produced from use of Halon 1202 on a fire?

a. HBr, HF

b. HCl, HBr, HF

c. HCl, HF

d. HI, HCl, HBr, HF

35. The main parameter characterizing mechanical foam agents is:

a. Viscosity

b. Heat resistant blanket rating

c. Expansion rating

d. Vapor sealing film activity

36. Foam fire extinguishing agents can put out a fire in a flammable liquid spill by:

a. Forming a blanket on the liquid and removing oxygen

b. Interfering with the chemical chain reaction necessary for combustion reactions

c. Cooling

d. Only (a) and (c) above

37. Foam fire extinguishing agents should never be used on:

a. Class A fires

b. Class C fires

c. Class B fires

d. Class A and B fires

38. The primary mechanism by which carbon dioxide fire extinguishing agents put out a fire is by:

a. Reducing the oxygen concentration in the atmosphere surrounding the fire.

b. Forming a blanket and eliminating oxygen.

c. Removing the fuel.

d. Only (b) and (c) above.

39. Carbon dioxide extinguishing agents should not be used on which of the following materials on fire?

a. Gasoline

b. Organic peroxides

c. Magnesium

d. Only (b) and (c) above.

40. Considering that helium and nitrogen are both inert gases with thermal capacities of 5.0 and 7.8 Btu/mole/°F respectively, which of the following statements is correct?

a. Helium would be more effective than nitrogen as an extinguishing agent on a fire to provide inerting.

b. Nitrogen would be more effective than helium in extinguishing a fire.

c. A 50/50 mixture of nitrogen and helium would be better than either helium or nitrogen alone.

d. Helium or nitrogen cannot extinguish a fire.

41. Ordinary dry chemical fire extinguishing agents can be used on which of the following classes of fires:?

a. Class B

b. Class A and C fires

c. Class B, C, and D fires

d. Class A, B and D fires

42. One of the major problems associated with use of large quantities of dry chemical agents on a fire is:

a. Production of toxic gases

b. Breakage of foam layer causing re-ignition

c. Interference with visibility

d. Depletion of the protective ozone layer in the atmosphere

43. A dry powder extinguishing agent can:

a. Put out all metal fires

b. Also be used on Class C fires

c. Not be designed for radioactive metal fires

d. Put out those metal fires for which it is designed

44. Which of the following are examples of class D fire extinguishing agents?

a. Graphite powder

b. Talc

c. Sand

d. All of the above.

45. All of the following extinguishing agents can be used to extinguish a Class A fire EXCEPT:

a. Dry powder

b. Dry chemical

c. Carbon dioxide

d. Halon

46. Which of the following are types of gas-sensing fire detector systems?

a. Automatic and manual

b. Semiconductor and catalytic

c. Pressure-temperature and volume systems

d. Ionization and photoelectric

47. The major reason behind unsatisfactory performance of sprinkler system has been:

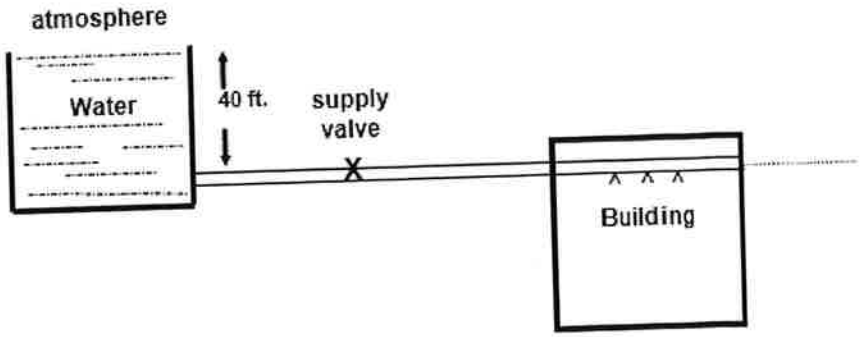
a. Human error

b. Rupture in main waterline

c. Clogged sprinkler heads

d. Water supply tank empty

48. Water is delivered by gravity to a sprinkler main supply line as shown in the diagram. When the supply valve is closed, the gauge pressure in the main supply line is: (density of water = 62.4 lbm/ft3)



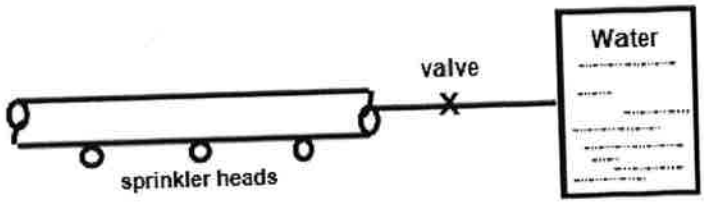
a. 17.3 psig

b. 2,400.0 psig

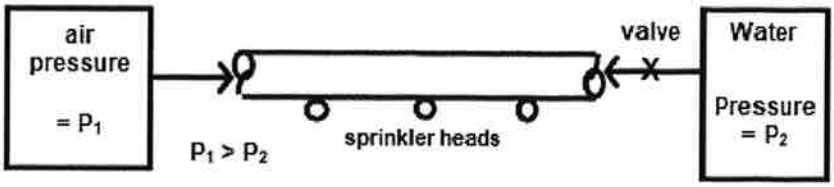
c. 123.5 psig

d. 628.0 psig

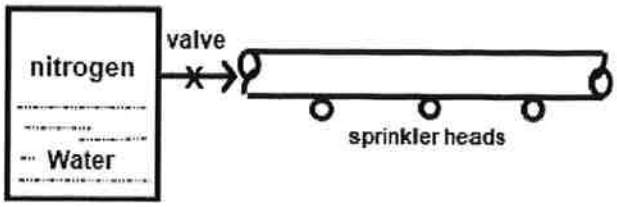
49. Which of the following diagrams demonstrates the operation of a regular dry pipe sprinkler system?



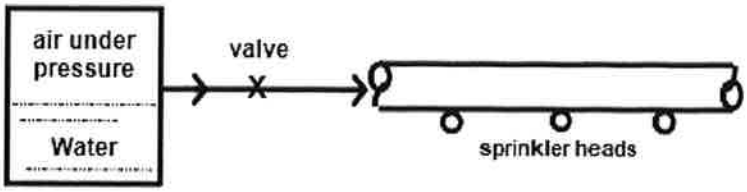
a.



b.



c.



d.

50. Which of the following statement(s) is (are) true regarding deluge type automatic sprinkler systems?

    a. Sprinklers are opened in response to pressure reduction in air or nitrogen tank.

    b. Use 15% carbon dioxide to deluge the protected area.

    c. All sprinkler heads are open at all times.

    d. Only (a) and (b) above.

51. Fire extinguishment by water spray is accomplished by:

    a. Cooling and smothering

    b. Emulsification

    c. Dilution

    d. All of the above

52. The total pressure loss due to friction in 1,000 ft. of a pipe which has an inside diameter of 8 inches and a coefficient of friction of 150 with a flow rate of 1,000 gpm is approximately:

    a. 10 psi

    b. 6 psi

c. 15 psi

d. 8 psi

53. An automatic sprinkler system has an orifice discharge coefficient of 4.2. At a system pressure of 60 psi, the amount of water delivery is:

a. 60.8 gpm

b. 42.5 gpm

c. 32.5 gpm

d. 53.6 gpm

54. The K-factor for an orifice in a sprinkler system which delivers 60 gpm at 80 psi is:

a. 5.2

b. 4.8

c. 7.6

d. 6.7

55. An orifice in a sprinkler system has a K-factor of 4.9. When water delivery through the head is 60 gpm, the water pressure is equal to:

a. 120.5 psi

b. 490.3 psi

c. 149.9 psi

d. 68.3 psi

56. Water with a density of 62 lb per cubic foot is flowing through an 8 inch diameter horizontal piping system. The head loss across a 1,000 ft. section of this piping system is 70 ft. The residual pressure at point A is 50 psi and the velocity at point A is 6 ft/sec. If the velocity at point B is 45 ft/sec, the value of residual pressure at point B is:

a. 60.3 psi

b. 100.5 psi

c. 6.5 psi

d. 90.4 psi

57. The design of a sprinkler system requires 2,000 gpm at 50 psi. The gpm requirement at 60 psi is:

a. 1,560 gpm

b. 2,875 gpm

c. 1,475 gpm

d. 2,190 gpm

58. If the pressure at the top of the riser in a sprinkler system is increased by 50%, the increase in the gpm requirement will increase by:

a. 22%

b. 25%

c. 50%

d. 100%

59. Water is flowing through a 10 inch inside diameter pipe at a rate equal to 2,000 gpm. The velocity pressure in the pipe is equal to:

a. 0.448 psi

b. 0.200 psi

c. 0.753 psi

d. 0.176 psi

60. If the velocity pressure in a 6 inch diameter pipe is equal to 0.630 psi the flow rate through the pipe is approximately equal to:

a. 360 gpm

b. 853 gpm

c. 562 gpm

d. 749 gpm

61. The velocity pressure in a pipe is equal to 0.5 psi. If 1,000 gpm is flowing through this pipe, the pipe diameter is approximately equal to:

a. 14 inches

b. 21 inches

c. 7 inches

d. 4 inches

62. Which of the following is the correct classification for flammable liquids?

a. Class 1A, 2B, 3C

b. Class 1A, 1B, 1C

c. Class 1A, 2B

d. Class 1A

63. The maximum amount of Class 1A flammable liquid that can be stored in a laboratory unit with a sprinkler system is:

a. 2,000 gallons

b. 500 gallons

c. 1,500 gallons

d. 1,200 gallons

64. Not more than _____ gallons of Class I, Class II, and Class IIIA liquids shall be stored in an approved flammable storage cabinet.

a. 40

b. 50

c. 120

d. 100

65. All of the following are true in regards to a jockey pump EXCEPT:

a. A jockey pump is a small pump used to keep a pressure on a fire main.

b. The jockey pump keeps a high positive pressure on the discharge side of fire pumps.

c. It is a spare pump used to provide cooling for highly-exothermic chemical reactions.

d. If you put packing in the stuffing box of a fire pump, the pump will run almost continually to compensate for the packing leakage.

66. A fire water supply system delivers 8,000 gallons per minute (gpm) when the pressure drops from 85 psig to 40 psig. What is the flow rate if the pressure drops from 85 psig to 25 psig?

a. 8,700 gpm

b. 5,200 gpm

c. 9,344 gpm

d. 16,000 gpm

67. Sodium azide solution can result in serious explosion hazards if the waste is disposed in a sink made of _____.

a. Brass

b. Lead

c. Copper

d. All of the above

68. Fire detection and alarm systems use distinctly different signals that are automatically transmitted to an approved central station, remote supervising station, or pro-

prietary supervising station. Which of the following is NOT a signal used in these systems?

a. Supervisory

b. Electromagnetic

c. Alarm

d. Trouble

69. Which of the following is NOT a mode of heat transfer?

a. Conduction

b. Convection

c. Combustion

d. Radiation

70. Hazardous locations are classified by the National Electric Code (NEC) as Class I, Class II, and Class III locations. Class III locations are those in which there may be:

a. Flammable vapors

b. Flammable gases

c. Flammable liquids

d. Ignitable fibers

71. Which of the following color coding is used for a sprinkler head designed for a maximum ceiling temperature of 300°F (149°C)?

a. White

b. Green

c. Red

d. Orange

72. Which of the following is NOT true in regard to Halon fire extinguishing agents?

a. Halons are made by halogenating a hydrocarbon.

b. Halons stop the spread of fire by chemically disrupting combustion.

c. The only disadvantage of Halons is that they leave a residue on the equipment after putting out the fire.

d. Halon is rated for Class B and Class C fires, but is also effective on Class A fires.

73. The term *boiling liquid expanding vapor explosion* (BLEVE) refers to which of the following?

a. An explosion caused by a flammable liquid at its boiling point

b. The failure of a container holding a liquid above its boiling point, which may result in an explosion

c. The volume of vapor expanding over the surface of a flammable liquid, which may result in an explosion

d. All of the above

74. Which of the following statements is true in regard to ionization smoke detectors?

a. They have a small amount of radioactive material between two electrically charged plates.

b. They ionize the air and cause current to flow between the plates.

c. Smoke disrupts the flow of ions, thus reducing the flow of current, which in turn activates the alarm.

d. All of the above.

75. Which of the following statements BEST describes the term hypergolic?

a. The ignition of a fuel when it comes into contact with an oxidizer without the presence of an outside source of ignition

b. A flammable liquid that can create a hyperbola-shaped fireball when on fire.

c. An above-standard goal-oriented safety, health, and environmental program

d. The angle of incidence of a hyperbola-shaped dome in construction safety

76. Which of the following is NOT a pyrophoric material?

a. Metal hydrides

b. White phosphorus

c. Alkyl lithiums

d. Iron oxides

77. The first step in responding to spills of hazardous material should be to:

a. Contain the spill

b. Protect people

c. Identify the substance

d. Read SDS

78. Employees who use portable fire extinguishers can often put out small fires or control a fire until additional help arrives. Before an emergency occurs, employers must decide whether employees are authorized to use fire extinguishers or must immediately evacuate (29 CFR 1910.38). Which of the following statements is NOT true in regard to portable fire extinguishers intended for emergency response?

a. Selection and distribution of portable fire extinguishers must be based on the class, size, and degree of workplace fire hazards.

b. Mounting, location, and identification of the extinguishers must be done in such a way so they are readily accessible in an emergency and will not subject employees to potential injury.

c. Ensure that the travel distance from employee to the nearest extinguisher is 100 feet or less.

d. Maintain fire extinguishers. Maintenance includes monthly visual inspections, hydrostatic testing, annual internal examinations, and all associated documentation.

79. In an Emergency, employee alarm systems alert employees to begin implementing emergency action. All of the following are true in regard to alarm systems EXCEPT:

a. Provide a distinctive and perceivable alarm system for emergency action.

b. Ensure that all equipment used for alarm systems is approved.

c. Ensure that all equipment used for alarm systems has spare components.

d. Test alarms once a week. Follow special safety requirements for testing.

80. To prepare for any contingency, an emergency action plan establishes procedures that prevent fatalities, injuries, and property damage. Possible emergency scenarios based on the nature of the workplace and its surroundings must be identified. A written emergency action plan must also be prepared. The plan must include all of the following EXCEPT:

a. The fire and emergency reporting procedures

b. Procedures for emergency evacuation, including the type of evacuation and exit routes.

c. Procedures for those who remain to operate critical operations prior to Evacuation.

d. The name, telephone number, and other relevant information of outside emergency personnel who are expected to respond to onsite emergencies.

81. Process safety management (PSM) of highly hazardous chemicals focuses on preventing or minimizing consequences from a catastrophic release of toxic, reactive, flammable, or explosive chemicals. Successful PSM emergency planning relies on implementing requirements from 29 CFR 1910.38 and/or 1910.120(q). all of the following are elements of a sound PSM emergency plan EXCEPT:

a. Conduct a reliability analysis for each component of covered processes, and update and revalidate the analysis every 2 years.

b. Incorporate emergency shutdown actions and operations into the written operating procedures for each process.

c. Implement an emergency action plan for the facility as described in 29 CFR 1910.38.

d. Maintain the mechanical integrity of PSM emergency systems and alarms.

82. Emergency planning and response are required safety and health program elements that help minimize employee exposure and injury in hazardous waste sites. All of the following are elements of a sound emergency response plan for hazardous waste site emergencies EXCEPT:

a. If employees are to immediately evacuate in an emergency, develop an emergency action plan in accordance with 29 CFR 1910.38.

b. Identify emergency response personnel and responsibilities in the site program's organizational structure.

c. Identify the name and telephone numbers of federal, state, and local emergency response personnel.

d. Identify personal protective equipment (PPE) and other equipment for emergency response in the emergency response plan.

83. In responding to hazardous substance emergencies, if the employer has decided that employees may assist in handling the emergency, a written emergency response plan must be developed and implemented. This plan must include all of the following EXCEPT:

a. Pre-emergency planning and coordination

b. Personnel roles, lines of authority, training, and communication

c. Emergency recognition and prevention

d. Exclude employees with disability from taking part in emergency operations

84. When an employer establishes a fire brigade to respond to workplace fires, it must meet organizational, training, and personal protective equipment requirements. All of the following are procedural, program, and/or equipment requirements that the employer must meet except:

a. Prepare and maintain a fire brigade written organizational statement and document fire brigade member training information in the organizational statement.

b. Ensure employees expected to fight fires are physically capable to perform assigned duties.

c. Inspect and maintain fire- fighting equipment monthly. Inspect respirators and fire extinguishers annually. Remove and replace damaged equipment.

d. Supply protective clothing with components to protect the head, body, and extremities at no cost to the employees.

85. All of the following are true in regard to emergency respirators EXCEPT:

a. Clean and disinfect emergency respirators at least once every six months.

b. Select and provide respirators suitable for the intended purpose.

c. When respirators are required, establish and implement a written respiratory protection program that includes procedures for proper respirator use in emergency.

d. Ensure that emergency respirators are properly stored and inspected.

86. Which of the following is true in regards to workplace violence?

a. Workplace violence is any act or threat of physical violence, harassment, intimidation, or other threatening disruptive behavior.

b. It ranges from threats and verbal abuse to physical assaults and even homicide.

c. In most workplaces where risk factors can be identified, the risk of assault can be prevented or minimized.

d. All of the above.

87. A comprehensive crime prevention assessment should ask all of the following EXCEPT:

a. What is the prevailing attitude toward security?

b. Who is responsible for the overall security program?

c. How are security policies enforced?

d. What kind of physical safety systems are presently used in other organizations?

88. All of the following are guidelines that can increase security except:

a. Install key-card access systems at main entrances and on other appropriate doors.

b. Issue access control badges, with recent photographs, to all employees and authorized contractors.

c. Upgrade perimeter control systems with intercoms and closed circuit monitoring devices.

d. Provide master and extra keys to all employees

89. According to OSHA regulations, companies with ——— or more employees must have a written emergency action plan.

a. 5

b. 10

c. 1

d. 20

90. Emergency procedures, including the handling of any toxic chemicals, should include all of the following EXCEPT:

a. Escape procedures and escape route assignments.

b. Special procedures for employees who perform or shut down critical plant operations.

c. Systems to account for all employees after evacuation and for information about the plan.

d. Procedures for segregation of toxic chemicals based on their toxicity level.

91. OSHA requires that the employer designates an emergency response coordinator and a backup coordinator. Duties of the coordinator and employer include all of the following EXCEPT:

a. Determining what emergencies may occur and seeing that emergency procedures are developed to address each situation.

b. Directing all emergency activities including evacuation of personnel.

c. Ensuring that outside emergency services are notified when necessary.

d. Ensuring that a member of the local fire department and police serve on the emergency committee.

92. You are a supervisor in the manufacturing department of a company. you observe an employee ignoring the department's safety rules. Which of the following is the most effective disciplinary action against the employee?

a. Immediately inform the HR department in writing

b. Suspend the employee and provide training

c. Provide the employee with a written warning

d. Use verbal reprimand first, and if the behavior continues, issue a written warning followed by suspension and eventual termination.

93. A rating of four in the blue section of NFPA 704 system indicates:

a. Highly flammable material.

b. Extremely high health hazard.

c. Moderate reactivity.

d. Highly ignitable oxidizer.

94. In fire-fighting operations, water can extinguish a fire by which of the following mechanisms?

a. Blocking oxygen

b. Stopping chemical chain reactions

c. Cooling

d. All of the above

95. The most important step in prevention of workplace violence is:
    a. A clear non-harassment policy by the management.
    b. Training.
    c. Random drug and alcohol testing.
    d. Isolation of employees who have a tendency to harass others.
96. Which of the following is the BEST tool for minimizing loss of life during a fire?
    a. Compatible storage of flammables.
    b. Use of fire resistant materials.
    c. Fire proofing of structural systems
    d. Automatic sprinkler systems.
97. When transferring flammable or combustible liquids between containers, which of the following safety measures must be undertaken?
    a. Provide electrical grounding for the larger container.
    b. Ground both containers.
    c. Bond the containers with an electrical conductor.
    d. The only safety measure to follow for this situation is elimination of all sources of ignition.
98. which of the following represents the BEST classification for welding and cutting operations?
    a. Friction producing work
    b. Heat producing work
    c. Hot work
    d. Mechanical spark producing work
99. Which of the following organizations mandates lockout/tagout programs for service or maintenance of certain types of equipment?
    a. NIOSH
    b. OSHA
    c. FEMA
    d. CPSC

5.11 Example Answers

1. Select (d)

   The most important factor to consider is how to protect life, property, and the environment. Although emergency equipment, personnel, and response to multiple emergencies must be addressed in the plan, none of them is the most important factor in the development of the emergency response plan.

2. Select (c)

   This statement is related to implied warranty. Implied warranty is the assurance that a product will work if it is used for a reasonably expected purpose.

3. Select (c)

   This study indicated that about 23% of all industrial fires are electrical in nature.

4. Select (b)

   An estimated 35% of civilian fires are caused with cigarettes as their ignition source.

5. Select (d)

   NFPA standards for fire protection are called National Fire Code. Life Safety Code is an element of the National Fire Code.

   The NFPA 101 Life Safety Code is designed with the goal of protecting people in case of a fire in a building. It takes into account the building's construction, occupancy, and protection features. This NFPA code has provisions for means of egress, fire protection features, alarms, sprinkler systems, emergency lighting, and smoke barriers for all types of occupancies.

6. Select (b)

   Auto-ignition temperature is higher than ignition temperature. This phenomenon occurs as a result of oxidation of fuel which would generate heat and raise the temperature. Higher temperatures would cause higher oxidation rates and even more heat would be generated. This process would continue until the material reaches its auto-ignition temperature. Paint and oil soaked rags have caused many fires in this way. Flammables should never be exposed to temperatures above their auto-ignition temperature.

7. Select (c)

   Fuel, air, and ignition source are obvious elements of combustion. However, we also need chemical chain reaction (formation of free radicals) for the combustion reactions to take place. Actually, halon and dry chemical fire extinguishing agents put out a fire by stopping the chemical chain reactions.

8. Select (c)

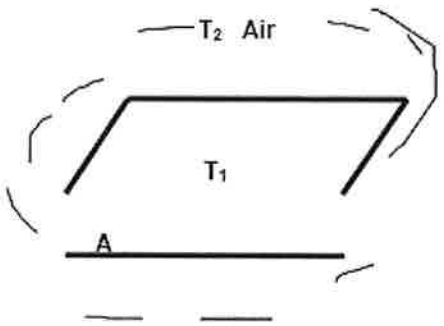
5 drums × 55 gal/drum × 4 lb/gal 20,000 Btu/lb = 22 × 10^6 Btu released from gasoline

2 cylinders × 15 lb/cylinder × 55,000 Btu/lb = 1,650,000 Btu released from combustion of H_2

Total Btu released = 23.65 × 10^6

9. Select (a)

Convection is the mechanism of interphase heat transfer, i.e., heat transfer between two different phases. If we have a surface at temperature T_1 that is transferring heat to the surrounding air at a temperature T_2 (as shown in the diagram), this heat is transferred by convection because the transfer is between a solid phase and a gaseous phase.



$Q = HA\ (T_1 - T_2)$

Where:

Q is the rate of heat transfer A is area T is temperature H is called the heat transfer coefficient.

For the problem at hand:

$Q = 80\ (50)\ (1{,}500 - 1{,}000)$ $Q = 2 \times 10^6$ Btu/hr

10. Select (b)

The equation for heat transfer by conduction is:

$Q = K\frac{A}{L}(T_1 - T_2)$

where

Q is the rate of heat transfer

K is thermal conductivity

A is area through which heat is being transferred

T_1, T_2 are temperatures.

For the problem at hand:

$Q = \frac{0.4(100)}{1}(800 - 200)$

Q = 24,000 Btu / hr

11. Select (a)

    Most carbon in the fuel is converted to carbon monoxide and carbon dioxide. Sulfur in the fuel is oxidized to mostly sulfur oxides.

12. Select (d)

    Potassium reacts with water and produces hydrogen gas which is highly flammable. Potassium cyanide reacts with water and generates hydrogen cyanide which is a highly toxic gas.

13. Select (a)

    Although statements (b), (c) and (d) are important considerations in fire prevention and protection, the most important consideration is compatible storage such as separating ignitors from ignitables.

14. Select (b)

    Carbon monoxide which is produced during a fire as a result of incomplete combustion of carbon containing materials is about 210 time more reactive with blood than oxygen. Therefore, CO deprives the body of oxygen and causes death by a form of asphyxiation. Inhalation of air containing 0.4% carbon monoxide can cause death in less than one minute.

15. Select (a)

    Vapor density is defined as the ratio of density of a gas or vapor to the density of air at a given temperature. A vapor density of less than 1 indicates that the gas is lighter than air and would rise in air, a vapor density of greater than 1 indicates that the gas is heavier than air and would sink in air. For the problem at hand, fire gases rise in air, and therefore, air would be collected at the low spots.

16. Select (a)

    Boiling takes place at the temperature where liquid vapor pressures equals the ambient (atmospheric) pressure. Vapor pressure of a liquid always increases with an increase in temperature.

17. Select (d)

    Gases have relatively high values of diffusion coefficient. Therefore, vapor density alone would dictate whether a gas would rise or sink in air. In dealing with liquids, however, we need two pieces of information in order to decide whether a liquid would float or sink in water. The information required is specific gravity and solubility.

    Specific gravity is the ratio of density of a liquid to the density of water. If two liquids are insoluble in each other, the liquid with the smaller value of specific gravity would float on top of the other liquid. However, when two liquids are soluble in each

other, they become dissolved and form a uniform solution regardless of their specific gravities.

18. Select (d)

    Vapor pressure is a measure of force exerted by the vapor to the inside surface of its container. Vapor pressure is also a measure of the volatility of a liquid. The higher the vapor pressure, the more volatile the liquid. Boiling takes place when atmospheric pressure and vapor pressure are equal.

19. Select (b)

    Flash point is the lowest temperature at which a liquid gives off enough vapor to support combustion. The liquid would not continue to burn at its flash point. Fire point temperature requires sustained combustion and is always higher than flash point temperature.

20. Select (c)

    Liquids are incompressible. This means that pressure changes have very little effect on the liquid volume.

21. Select (c)

    $P_1 = 1{,}000$ psig

    $V_1 = 5$ ft^3

    $P_2 = 14.7$ psia

    $P_1V_1 = P_2\ V_2$

    $P_1 = 1{,}000 + 14.7$ psia (We have to use absolute pressure)

    $(1{,}014.7)\ (5) = 14.7V_2$

    $V_2 = 345$ ft^3

    Note 1: Gases are compressible which means that the volume of gas is a very strong function of pressure. Note that due to pressure reduction the volume increased from 5 ft^3 to 345 ft^3.

    Note 2: In using gas laws be sure to use absolute pressure (gauge pressure + atmospheric pressure) and absolute temperature.

22. Select (b)

    LFL is defined as the lowest concentration by volume of a gas in air which would support combustion. UFL is the highest concentration of a gas in air (by volume) that would support combustion. A gas or vapor can only support combustion at concentrations with air that fall between its LFL and UFL. It should be pointed out that both LFL and UFL are functions of ambient pressure and temperature.

23. Select (a)

    Vapor volume can be estimated from

$V = \frac{(\text{S.G.})(111)}{(\text{V.D.})}$

Where:

V is volume of vapor generated per gallon of liquid vaporized in cubic feet

G is liquid specific gravity

$V.\ D.$ is vapor density.

$V = \frac{(0.8)(111)}{(2.5)} = 35.5 \frac{\text{ft}^3}{\text{gal}}$

$35.5 \frac{\text{ft}^3}{\text{gal}} \times 50 \text{ gal} = 1,776 \text{ ft}^3$

24. Select (c)

Vapor generated $= 0.5 \times 80 = 40 \text{ ft}^3$

Volume of room $= 15 \times 15 \times 10 = 2{,}250 \text{ ft}^3$

Partial volume of methyl alcohol $= \frac{40}{2250+40}$

Concentration $= 1.74 \times 10^{-2}$ or 1.74% (which is below LFL)

25. Select (d)

Compounds which are classified as oxidizers are those which can either release oxygen or catalyze the combustion reactions (such as chlorine). In either case, oxidizers would make an ongoing fire much worse and must be separated from flammables. They can also react with flammables and raise the temperature to above ignition temperature.

26. Select (d)

"Fire resistance rating" is an indication of how long a given structure can withstand a fire to give the occupants a chance to evacuate the building before commencement of fire fighting procedures.

27. Select (b)

$20 \times 200 \times 20{,}000 = 8 \times 10^7$ Btu

In calculating the fire load, it is assumed that all combustibles will burn and release their heating value.

28. Select (b)

There is a time lag before the device temperature reaches the temperature of air surrounding it. Due to this limitation these fire detectors are not suitable for fast developing fires.

29. Select (d)

Fusible metal is selected to melt at a given temperature. This would activate an alarm or sprinkler system. The insulation in continuous wire detector is selected in such a way to melt at a given temperature. This closes an electrical circuit which

could initiate other actions. Bi-metallic strips consist of two metals with different coefficient of thermal expansion. This would cause the metal to expand at different rates resulting in bending of the strip which can initiate other actions.

30. Select (d)

    Rate of rise detectors respond to how fast temperature in the surrounding would rise. These detectors are suitable for fires that can develop rather quickly.

31. Select (d)

    These detectors respond to temperatures that rise rapidly and have exceeded a pre-set fixed temperature.

    A rate compensated detector operates when the ambient air temperature reaches a predetermined level, regardless of the rate at which it increases. The detector will operate at its design temperature during slow-building fire conditions or will respond promptly during rapid fire buildup.

32. Select (a)

    Ionization detectors ionize the air and make it conductive. Smoke particles decrease this conductivity and initiate a subsequent action such as alarm or activation of sprinkler system.

33. Select (b)

    The term "dry powder" refers to extinguishing agents designed for metal fires (class D). It should be pointed out that a given dry powder is not suitable for all metal fires. Therefore, class D fire extinguishers must have a plate on the extinguisher that specifies what type of metal fires the extinguishing agent is suitable for.

34. Select (a)

    Halon 1202 has two atoms of fluorine and 2 atoms of bromine and its use on a fire would most probably produce hydrogen fluoride and hydrogen bromide.

    The four-digit rating of Halon fire extinguishers defines the makeup of the molecule as follows:

    - The first numeral is the number of carbon atoms
    - The second numeral is the number of fluorine atoms
    - The third numeral is the number of chlorine atoms
    - The fourth numeral is the number of bromine atoms

    Therefore, Halon 1202 has one carbon atom, two fluorine atoms, and two bromine atoms. This indicates that Halon 1202 can be made from methane (CH4, a highly flammable gas) by substituting two hydrogen atoms with fluorine and the remaining two hydrogen atoms with bromine (CF2Br2).

35. Select (c)

Mechanical foams are defined by their expansion ratio which is the final volume of foam to original foam solution volume prior to addition of air. Foams are further subdivided into: low expansion up to (20:1), medium expansion (20 to 200:1), and high expansion (200 to 1000:1).

36. Select (d)

    Foams form a vapor seal blanket on the surface of the flammable material. The water used in foams provides cooling.

37. Select (b)

    Foam should never be used on class C (electrical) fires because many foams are conductors of electricity and the user may receive injury or fatal shock.

38. Select (a)

    CO_2 extinguishing agent dilute the atmosphere immediately surrounding the fire to concentrations below its Lower Flammability Limit (LFL).

39. Select (d)

    Carbon dioxide is not effective on fires in materials that contain their own source of oxygen such as organic peroxides. Fires involving reactive metals such as magnesium, sodium, and potassium can not be extinguished by CO_2 because, CO_2 becomes decomposed.

40. Select (b)

    Inert gases such as nitrogen and helium extinguish a fire by combination of two mechanisms. By reducing the concentration of oxygen to values below the LFL and also by reducing the temperature of the flame/vapor mixture to values below the adiabatic flame temperature. In this case both nitrogen and helium would contribute equally to the first mechanism (inerting). However, nitrogen due to its higher value of the thermal capacity contributes more than helium to reduction of the flame temperature, and therefore, is more effective in putting out a fire compared to helium.

41. Select (a)

    "Ordinary Dry Chemical" agents are designed for use on Class B (flammable liquids, gases, and greases). On the other hand, "Multi-purpose Dry Chemicals" are suitable for use on Class A, B, and C fires.

42. Select (c)

    Dry chemical extinguishing agents are made of non-toxic chemicals. Use of large quantities of these agents on fire could cause temporary breathing difficulty and serious interference with visibility.

43. Select (d)

    Dry powder fire extinguishing agents can only be used for extinguishing fires in the metals for which they are designed.

44. Select (d)

All have been used to smother metal fires.

45. Select (a)

Dry powder can only be used on metal fires. Dry chemical can stop a Class A fire by both cooling and interfering with the chemical chain reactions. Halon can extinguish a Class A fire by interfering with chemical chain reaction. Carbon dioxide dilutes the mixture of fuel vapor and oxygen to values below LFL.

46. Select (b)

The semiconductor fire-gas detectors respond to gases which have either oxidizing or reducing capabilities by creating electrical charges in a semiconductor. The catalytic type has an element which catalyzes oxidation of combustible gases and detects the resulting temperature rise associated with the oxidation reactions.

47. Select (a)

Approximately 35% of sprinkler failures have been caused by shutting the water supply to them during a fire.

48. Select (a)

$P = \rho \frac{g}{g_c} h$

Where:

P is pressure

g is acceleration of gravity (32.2 ft/sec^2)

g_c is a factor which is equal to 1 in the metric system and 32.2 in the American Engineering system.

h is the height of the liquid.

$P = 62.4 \times \frac{32.2}{32.2} \times 40 = 2496 \frac{\text{lbf}}{\text{ft}^2}$

$P = \frac{2496}{144} = 17.3$ psig (pounds per square inch gauge)

49. Select (b)

Regular dry pipe automatic sprinkler systems are connected to a supply of air or nitrogen under pressure. Heat from a fire causes a value to open and reduce the pressure on air or nitrogen supply to a value that water pressure on the supply side of the system causes the valve to open and establish flow of water to the sprinkler heads.

50. Select (c)

In "deluge" type sprinkler systems the sprinkler heads are open at all times. The deluge valve responds to a fire detection system. When the valve is opened the water flows into and out of the sprinklers deluging the protected area.

51. Select (d)

Water spray provides cooling and smothering by steam. Emulsification and dilution are also contributing factors.

52. Select (b)

The formula for calculation of frictional losses in a piping system is:

$$\boxed{P_d = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}}}$$

where:

P_d is pressure loss due to friction in psi/ft.

Q is flow rate in gpm

d is pipe inside diameter in inches

C is coefficient of friction

For the problem at hand, we have:

$P_d = \frac{4.52(1000)^{1.85}}{150^{1.85} \times 8^{4.87}} = 6.04 \times 10^{-3}$ psi/ft.

For 1,000 ft. of piping, the total loss is:

$1{,}000 \times 6.04 \times 10^{-3} = 6.04$ psi

53. Select (c)

The formula for orifice flow is:

$P = (Q/K)^2$

where:

P is pressure expressed in units of psi

K is orifice discharge coefficient

Q is rate of flow expressed in gallons per minute (gpm)

For the problem at hand we have:

$K = 4.2$

$P = 60$ psi

$Q = ?$

$60 = (Q/4.2)^2$

$Q = \sqrt{60 \times (4.2)^2}$

$Q = 32.5$ gpm

54. Select (d)

$P = (Q/K)^2$

$P = 80$ psi

$Q = 60$ gpm

$K = ?$

$80 = \left(\frac{60}{K}\right)^2$

$80\ K^2 = 3{,}600$

$K^2 = 45$

$K = 6.7$

55. Select (c)

$P = (Q/K)^2$

$P = ?$

$Q = 60$ gpm

$K = 4.9$

$P = \left(\frac{60}{4.9}\right)^2 = 149.9$ psi

56. Select (c)

This problem is solved by Bernoulli's Theorem:

$$\boxed{\frac{V_A^2}{2g} + \frac{P_A}{\rho} + Z_A = \frac{V_B^2}{2g} + \frac{P_B}{\rho} + Z_B + h_L}$$

where:

V is velocity

P is residual pressure

ρ is density

Z is elevation

h_L is head loss

g is acceleration of gravity

For the problem at hand we have:

$\frac{6^2}{2\times32.2} + \frac{50\text{psi}}{62} \times \frac{144\ \text{in}^2}{1\ \text{ft}^2} + 0 = \frac{45^2}{2\times32.2} + \frac{P_B}{62} + 0 + 70$

or

$0.559 + 116.129 = 31.444 + \frac{P_B}{62} + 70$

$P_B = 945$ psf

or

$P_B = 6.5$ psi

57. Select (d)

The following relationship applies to this problem:

$$\boxed{\frac{Q_1}{Q_2} = \frac{\sqrt{P_1}}{\sqrt{P_2}}}$$

where:

Q is gallons per minute (gpm)

P is pressure in psi

For the problem at hand we have:

$Q_1 = 2{,}000$ gpm

$Q_2 = ?$

$P_1 = 50$ psi

$P_2 = 60$ psi

$\frac{2000}{Q_2} = \frac{\sqrt{50}}{\sqrt{60}}$

$Q_2 = 2{,}190.89$ gpm

58. Select (a)

For this problem we have

$\frac{P_2}{P_1} = 1.5$ (50% increase over p_1)

or

$\frac{P_1}{P_2} = 0.666$

$\frac{Q_1}{Q_2} = \sqrt{0.666} = 0.816$

or

$\frac{Q_2}{Q_1} = 1.22$

This means that the gpm requirements will increase by approximately 22 percent when pressure has increased by 50 percent.

59. Select (a)

The relationship between velocity pressure, pipe diameter, and flow rate is:

$$\boxed{P_v = \frac{Q^2}{891d^4}}$$

where:

P_v = velocity pressure expressed in psi

Q = flow rate expressed in gpm

d = pipe diameter expressed in inches

For the problem at hand, we have:

d = 10 inches

Q = 2,000 gpm

P_v = ?

$P_v = \frac{(2000)^2}{891(10)^4}$

P_v = 0.448 psi

60. Select (b)

$P_v = \frac{Q^2}{891d^4}$

$Q^2 = 891\ p_v d^4$

$Q = \sqrt{891 p_v d^4}$

$Q = \sqrt{891 \times 0.630 \times 6^4}$

Q = 853 gpm

61. Select (c)

$P_v = \frac{Q^2}{891d^4}$

$d^4 = \frac{Q^2}{891P_v} = \frac{10^6}{891 \times 0.5}$

$d^4 = 2{,}244.67$

$d^2 = \sqrt{2244.67} = 47.38$

$d = \sqrt{47.38}$

d = 6.88 inches

62. Select (b)

Class	Definition
IA	Flash point below 73°F; boiling point below 100°F
IB	Flash point below 73°F; boiling point at or above 100°F
IC	Flash point at or above 73°F, but below 100°F

Combustible liquids are also classified into three groups:

Class	Definition
II	Flash points at or above 100°F and below 140°F
IIIA	Flash points at or above 140°F and below 200°F
IIIB	Flash points at or above 200°F

63. Select (d)

    Only NFPA 45-approved amounts of flammable liquids shall be stored in laboratory units outside of flammable liquid storage rooms.

64. Select (c)

    The correct answer is 120 gallons. Also, no more than 60 gallons of the total shall be Class I and Class II liquids.

65. Select (c)

    Statements (a), (b), and (d) are all true in regards to jockey pumps. The purpose of a jockey pump is to maintain water pressure in the pipes in a predetermined range when there is no fire. This helps the main fire pump to not run all the time and also prevents the sprinklers go off randomly.

66. Select (c)

    The formula to solve this problem is:

    $Q_2 = Q_1 \left[\frac{(S-R_2)^{0.54}}{(S-R_1)^{0.54}}\right]$

    Where:

    Q_2 is the final flow rate

    Q_1 is the initial flow rate

    S is the initial pressure

    R_1 is the initial residual pressure

    R_2 is the final residual pressure

    For the problem at hand:

    $Q_2 = 8000 \left[\frac{(85-25)^{0.54}}{(85-40)^{0.54}}\right]$

    Q_2 = 9,344.52 gpm

67. Select (d)

    Sodium azide solution in contact with brass, lead, or copper can cause serious explosion hazards.

68. Select (b)

    The three types of signals used in fire detection are supervisory, alarm, and trouble.

69. Select (c)

Conduction is the mechanism of thermal energy transfer from one molecule to another, usually in one phase.

$Q = KA\left(\frac{T_1 - T_2}{L}\right)$

Q is the amount of heat transfer from surface area A at T_1 through thickness L at temperature T_2.

K is the thermal conductivity of the medium through which heat is transferred.

Heat transfer by convection takes place as a result of fluid motion:

$Q = HA\Delta T$

Q is the amount of heat transfer, H is heat transfer coefficient, A is the area, and ΔT is the temperature difference.

Heat transfer by radiation is the electromagnetic mechanism of heat transfer and is proportional to the fourth power of absolute temperature:

$Q \propto T^4$

70. Select (d)

Hazardous locations are classified by the NEC as Class I, Class II, and Class III, depending on the type of hazardous substance that may be present. In general, Class I locations are those in which flammable vapors and gases may be present; Class II locations are those in which combustible dusts may be found; and Class III locations are those in which there may be ignitable fibers.

Each of these classes is divided into two hazard categories, Division 1 and Division 2, depending on the likelihood of the presence of a flammable or ignitable concentration of a substance. In general, the electrical installation requirements for Division 1 locations are more stringent than for Division 2 locations. Division 1 locations are designated as such because a flammable gas, vapor, or dust is normally present in hazardous concentrations. In Division 2 locations, hazardous quantities of these materials are not usually present, but may occasionally exist either accidentally or when material in storage is handled.

Additionally, Class I and Class II locations are subdivided into groups of gases, vapors, and dusts having similar properties.

71. Select (c)

The following table summarizes the color coding for sprinkler heads.

Maximum Ceiling Temperature		Color Code
°C	°F	
38	100	Uncolored
66	150	White
107	225	Blue
149	300	Red
191	375	Green
246	475	Orange
329	625	Orange

72. Select (c)

Halons are made by halogenating hydrocarbons. Although hydrocarbons are flammable, the halogenated hydrocarbons lose their flammability characteristic as they become more halogenated.

Halons are especially effective for electrical fires in sensitive electronic equipment, because they leave no residue and therefore do not damage the equipment.

73. Select (b)

BLEVE is best described by statement (b). The consequences of BLEVE include overpressure blast wave, fireball, and vessel fragment hazards.

74. Select (d)

Another type of smoke detector is photoelectric. This type aims a light source into a sensing chamber at an angle away from the sensor. Smoke enters the chamber, reflecting light onto the light sensor, triggering the alarm.

75. Select (a)

Oxidizers, such as hydrogen peroxide, have excess oxygen in their molecules and can release this excess oxygen. If the reaction between an oxidizer and fuel can generate enough heat to raise the mixture temperature to above its auto-ignition temperature, no outside source of ignition is needed to cause a fire. Flammables must be separated from oxidizers.

76. Select (d)

Pyrophoric materials are substances that ignite instantly upon exposure to oxygen. No source of ignition is needed. They can also be water-reactive, which produces heat and hydrogen.

77. Select (b)

Although identifying the substance determines the most effective clean up procedure and protective equipment needed, the first step is to ensure that people are protected. This includes both responders and other people.

78. Select (c)

The Occupational Safety and Health Administration require the following for portable fire extinguisher to be used in an emergency (29 CFR 1910.157):

- Select and distribute portable fire extinguishers based on the class, size, and degree of workplace fire hazards.
- Mount, locate, and identify the extinguishers so they are readily accessible in an emergency and will not subject employees to potential injury.
- Provide only approved portable fire extinguishers.
- Maintain fire extinguishers. Maintenance includes monthly visual inspections, hydrostatic testing, annual internal examinations, and all associated documentation.
- Ensure that the travel distance from employee to the nearest extinguisher is appropriate for the fire class. The travel distance for class A extinguishers cannot exceed 75 feet. The maximum travel distance for class B is 50 feet and there is no maximum travel distance specified for class C extinguishers.

79. Select (d)

Employee alarm systems alert employees to begin implementing emergency action. OSHA requires the following:

- Provide a distinctive and perceivable alarm system for emergency action or safe evacuation.
- Ensure that all equipment used for alarm systems is approved and spare components are available.
- Test alarms at the frequency required. Follow special safety requirements for testing or restoring alarms.

80. Select (d)

OSHA requires the employer to:

- Identify possible emergency scenarios based on the nature of the workplace and its surroundings.
- Prepare a written emergency action plan. The plan does not need to be written and may be communicated orally if there are 10 or fewer employees. At a minimum, the plan must include:

  The fire and emergency reporting procedures; Procedures for emergency evacuation, including the type of evacuation and exit routes; Procedures for those who remain to operate critical operations prior to evacuation; Procedures to account for employees after evacuation; Procedures for employees performing rescue and medical duties; and Names of those to contact for further information or explanation about the plan.

- The fire and emergency reporting procedures;

- Procedures for emergency evacuation, including the type of evacuation and exit routes;
- Procedures for those who remain to operate critical operations prior to evacuation;
- Procedures to account for employees after evacuation;
- Procedures for employees performing rescue and medical duties; and
- Names of those to contact for further information or explanation about the plan.

81. Select (a)

OSHA's Process Safety Management Standard (29 CFR 1910.119) requires the employer to:

- Conduct a Process Hazard Analysis (PHA) for each covered process, and update and revalidate the PHA every 5 years.
- Incorporate emergency shutdown actions and operations into the written operating procedures for each process. Include conditions that require emergency action and the qualified operator responsible for performing these procedures.
- Implement an emergency action plan for the facility as described in 29 CFR 1910.38.
- Maintain the mechanical integrity of PSM emergency systems and alarms.
- If employees are expected to handle an emergency release rather than promptly evacuate, implement an emergency response plan according to 1910.120(q).
- Provide proper response and personal protective equipment for emergency responders under the plan.

82. Select (c)

OSHA requires the employer to do the following:

- If employees are to immediately evacuate in an emergency, develop an emergency action plan in accordance with 29 CFR 1910.38.
- If employees may assist in handling the emergency, then the following requirements apply:

  As a separate section of the site safety and health plan, develop a written emergency response plan. The plan must be implemented before site operations begin and should be integrated with those of other local, state, and Federal agencies. Identify emergency response personnel and responsibilities in the site program's organizational structure. Include emergency response training details in the comprehensive site work plan. Identify personal protective equipment (PPE) and other equipment for emergency response in the emergency response plan. Install alarm systems that meet requirements of 29 CFR 1910.165. Share site-specific

emergency response procedures with contractors and subcontractors. Under certain circumstances, emergency response personnel may qualify for the medical surveillance program.

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- Identify emergency response personnel and responsibilities in the site program's organizational structure.
- Include emergency response training details in the comprehensive site work plan.
- Identify personal protective equipment (PPE) and other equipment for emergency response in the emergency response plan.
- Install alarm systems that meet requirements of 29 CFR 1910.165.
- Share site-specific emergency response procedures with contractors and subcontractors.
- Under certain circumstances, emergency response personnel may qualify for the medical surveillance program.

83. Select (d)

Depending on the type of emergency and disability, some employees with disability may be able to help in handling an emergency.

84. Select (c)

The employer must do the following:

- Prepare and maintain a fire brigade written organizational statement. Document fire brigade member training information in the organizational statement.
- Ensure employees expected to fight fires are physically capable to perform assigned duties.
- Inspect and maintain fire- fighting equipment annually. Inspect respirators and fire extinguishers monthly. Remove and replace damaged equipment.
- Supply protective clothing with components to protect the head, body, and extremities at no cost to the employee.
- Ensure fire brigade members are provided with and use compliant respirators.

85. Select (a)

OSHA requires the employer to do the following:

- Select and provide respirators suitable for the intended purpose.
- When respirators are required, establish and implement a written respiratory protection program that includes procedures for proper respirator use in emer-

gency situations. Update the program when changes in workplace conditions affect respirator use.

- Clean and disinfect emergency respirators after each use. Ensure that emergency respirators are properly stored and inspected. Certify emergency-only respirators by a certification tag or other proper documentation method.
- For entry into Immediately Dangerous to Life and Health (IDLH) environments, provide retrieval equipment or equivalent means for rescue of employees. Maintain required personnel and communications for emergency rescue.
- For interior structural firefighting, ensure that at least two employees who remain in contact with one another enter the structure.

86. Select (d)

Workplace violence is any act or threat of physical violence, harassment, intimidation, or other threatening disruptive behavior that occurs at the work site. It ranges from threats and verbal abuse to physical assaults and even homicide. It can affect and involve employees, clients, customers and visitors.

In most workplaces where risk factors can be identified, the risk of assault can be prevented or minimized if employers take appropriate precautions. One of the best protections employers can offer their workers is to establish a zero-tolerance policy toward workplace violence. This policy should cover all workers, patients, clients, visitors, contractors, and anyone else who may come in contact with company personnel.

By assessing their worksites, employers can identify methods for reducing the likelihood of incidents occurring. OSHA believes that a well written and implemented Workplace Violence Prevention Program, combined with engineering controls, administrative controls and training can reduce the incidence of workplace violence in both the private sector and Federal workplaces.

87. Select (d)

Other pertinent questions include:

- What is your target potential?
- What resources are available locally and how rapid are the response times for fire, police and ambulance?
- What kind of physical security systems and controls are presently used?
- Do the available security resources, policies and procedures meet the potential threat?

88. Select (d)

The master and extra keys should be locked in the security office. Other guidelines that can increase security include the following:

- Issue access control badges, with recent photographs, to all employees and authorized contractors.
- Upgrade perimeter control systems with intercoms and closed circuit monitoring devices.
- Keep master and extra keys locked in a security office.

89. Select (b)

OSHA requires that companies with 10 or more employees develop a written emergency action plan. Smaller companies may communicate their emergency action plan to their employees orally.

90. Select (d)

Emergency procedures must also address rescue and medical duties for employees who perform them as well as means for reporting fires and other emergencies.

91. Select (d)

The emergency response coordinator must also be able to direct the shutdown of plant operations when necessary.

92. Select (d)

This would be the best course of action to follow.

93. Select (b)

In NFPA 704 system, red indicates flammability, blue indicates health hazards, yellow indicates reactivity, and the color white is reserved for communicating special information such as a material being an oxidizer or water reactive. In each section, there is a rating between zero and four with zero indicating no hazards and four indicating extreme hazards.

94. Select (c)

Water has an excellent evaporative cooling effect on a fire. Water should never be used on certain class B (flammable liquids), class D (metal fires), and class C (electrical) fires. If a flammable liquid is insoluble in water and also lighter than water, it would float on top of the water and spread the fire. Use of water on electrical fires could pose a fatal shock hazard.

95. Select (a)

Management commitment and a clear non-harassment policy is the most important step in prevention of workplace violence.

96. Select (d)

Use of automatic sprinkler systems has proven to minimize loss of life during fires.

97. Select (c)

Bonding the containers together does not eliminate the buildup of static charges. However, it makes the potential difference between the containers equal so there is no driving force for the flow of static charges which could act as a source of ignition.

98. Select (c)

Hot work is any work that involves burning, welding, using fire, or spark-producing tools, or that produces a source of ignition. Examples of hot work include welding and cutting operations.

99. Select (b)

The correct answer is OSHA.

Domain VI: Occupational Health and Ergonomics

6.1 Introduction

"Occupational Health Engineering addresses the application of engineering techniques to eliminate or control exposures to environmental agents or stresses arising in work or other environments which may result in impaired health."

The Board of Certified Safety Professionals (BCSP) divides this portion of the examination into the following six major areas:

1. Process Design Parameters deals with "design of industrial processes, selection of materials, selection and use of protective clothing and equipment, and related considerations for the elimination or control of harmful exposures."
2. Industrial Ventilation deals with "design and use of ventilation as a method of eliminating or controlling harmful exposures."
3. Noise Control Methods deals with "design of equipment, design of enclosures, application of acoustical materials, and other engineering methods of eliminating or controlling exposures to noise."
4. Radiation Protection Design Parameters deals with "design of facilities, equipment, and procedures to eliminate or control exposures to ionizing and non-ionizing radiation."
5. Personal Protective Clothing addresses the analysis and selection of personal protective clothing and administration of PPE programs.
6. Chemical Hazard Protection deals with evaluation of chemical hazards and design of equipment, facilities, and processes to eliminate, minimize and control chemical hazards and exposure to hazardous chemicals.

In the following, we have provided examples along with their solutions and/or discussion dealing with the above areas. These examples are designed in such a way to familiarize the reader with the formulae in the Examination Information booklet published by the BCSP. These formulae will also be provided to the candidates at the time of the certification examination.

We believe that familiarity with these formulae and topics will greatly enhance a candidate's chance for passing the certification examination. Additional example questions along with their answers are provided at the end of this section.

6.2 Industrial Ventilation

Example 1

Calculation of general ventilation air flow rate

In an operation 8.0 pints of acetone are evaporated per hour. Acetone has a TLV of 2.0 per cent by volume in air and a specific gravity of 0.79. The chemical formula for acetone is $(CH_3)_2$ CO. The atomic weight of carbon is 12, H is 1 and oxygen is 16. What is the value of general ventilation air flow rate to keep the concentration of acetone to values below its TLV using a factor of safety of 6?

a. 16,465 ft^3/hr.

b. 13,173 ft^3/hr.

c. 8,641 ft^3/hr.

d. 1,680 ft^3/hr.

Select (b)

Solution

The formula for calculation of general ventilation air flow rate is:

$$Q = \frac{(403)(S.G.)\times 10^6 P \times K}{(M.W.)(L)}$$

Where:

Q is the required air flow in ft^3/hr.

S.G. is the specific gravity of solvent

P is number of pints evaporated every hour

K is the factor of safety

M.W. is the molecular weight of solvent

L is maximum concentration allowed; for example LFL or TLV in parts per million.

Molecular Weight of acetone = (15) × 2 + 12 + 16 = 58

$$Q = \frac{(403)(0.79)\times 10^6 \times 8 \times 6}{(58)(2)\times 10^4}$$

Q = 13,173 ft^3 / hr

Note: The value of L in the above formula must be in parts per million. Since the TLV is given in percent (2), we have converted this to parts per million.

$(2 \times 10^{-2})\ (10^6) = 2 \times 10^4$

Relationships among rate of generation of air contaminants, ventilation rate, concentration of contaminants after a certain period of time and the volume of a given room (assumes perfect mixing).

$Ln\left[\frac{G-QC}{G}\right] = \frac{Qt}{V}$

$C = \frac{G}{Q}\left[1 - e^{Qt/V}\right]$

$Ln\frac{C_2}{C_1} = \frac{-Q}{V}(t_2 - t_1)$

Where:

G is the rate of generation of air contaminants in ft^3/min

Q is the ventilation rate in ft^3/min

C is the concentration of contaminants after t minutes

V is the volume of room in ft^3

t is the time in minutes

Note: If C is given in parts per million (ppm), we should divide it by 1 million (10^6) before using it in the above equations. If you are calculating C from the above equations, multiply it by 1 million (10^6) to get the answer in ppm.

Example 2

A solvent is evaporating at the rate of 0.9 ft^3/min in a room having dimensions of 200 $\times$ 15 $\times$ 10 ft. The ventilation rate in the room is 1,500 ft^3/min The concentration of solvent vapor in the room after one hour is:

a. 300 ppm.

b. 1,600 ppm.

c. 570 ppm.

d. 0.5 ppm.

Select (c)

Solution

$C = \frac{G}{Q}\left[1 - e^{Qt/V}\right]$

$C = \frac{0.9}{1500}\left[1 - e^{-\frac{(1500)(6)}{30000}}\right]$

$C = 570\ ppm$

Note: In order to get the value of concentration (C) in ppm, we must multiply the calculated value of C by 1 million (10^6).

Example 3

The concentration of acetone in a laboratory is 3,000 ppm. If we start the general ventilation in the lab at the rate of 3,000 ft^3/min and the lab has a volume of 10,000 ft^3, the concentration of acetone after 20 minutes is:

a. 11.0 ppm.

b. 7.4 ppm.

c. 16.2 ppm.

d. 24.7 ppm.

Select (b)

Solution

The following equation can be used to solve this problem

$Ln\frac{C_2}{C_1} = \frac{-Q}{V}(t_2 - t_1)$

Where:

C_2 is concentration after t_2 minutes form start of ventilation

C_1 is concentration at the start of ventilation

Q is rate of ventilation in ft^3/min

V is the volume of room in ft^3

$Ln\frac{C_2}{3000} = \frac{-3000}{10{,}000}(20)$

$Ln\frac{C_2}{3000} = -6$

$\frac{C_2}{3000} = exp(-6)$

$C_2 = 7.4$ppm.

Note:

If Ln (x) = a: then

x = exp (a)

Where:

Ln is the natural logarithm

exp is the exponential function on your calculator.

In the above example we had

$Ln\frac{C_2}{3000} = -6$

Since we want to calculate C_2, we say:

$\frac{C_2}{3000} = exp(-6)$

The relationship between total pressure, static pressure and velocity pressure in duct flow of fluids

$$\mathbf{TP = SP + VP}$$

Where:

TP is total pressure

SP is static pressure

VP is velocity pressure.

Relationship between fluid velocity and velocity pressure is

$$\mathbf{V = 4{,}005\ (VP)^{1/2}}$$

Where:

V is velocity in feet per minute

VP is the velocity pressure expressed in inches of water.

Note: The above relationships assume air at standard temperature (0°C, 32°F) and standard pressure (1 atmosphere) which is called STP conditions.

Example 4

Air (at STP) is flowing in a hood at the rate of 1,000 feet per minute. The hood static pressure is -2.0 inches of water. The total pressure is:

a. -2.6 inches of water.

b. -1.9 inches of water.

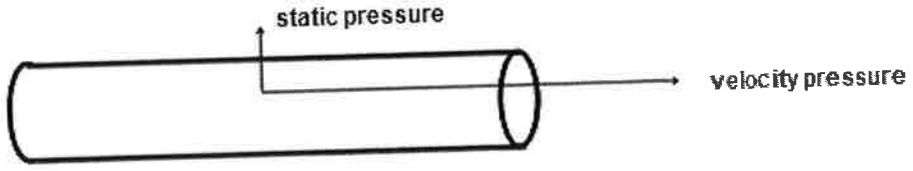
c. +2.6 inches of water.

d. -0.8 inches of water.

Select (b)

Solution

In fluid flow, the total fluid pressure has two components, static pressure and velocity pressure. The static pressure is the pressure exerted on the walls of the piping system if the fluid was stationary. Velocity pressure is the pressure due to motion of the fluid and is exerted in the direction of fluid flow as shown in the diagram.



The relationship between Total Pressure (TP), Static Pressure (SP), and Velocity Pressure (VP) is:

TP = SP + VP.

The relationship between air velocity and velocity pressure is

V = 4,005 (VP) ^{½} at STP

Where:

V is air velocity in feet per minute

VP is velocity pressure in inches of water

For the problem at hand

$VP = \frac{(1000)^2}{(4005)^2} = 0.06$ *inches of water*

TP = - 2.0 + 0.06 = - 1.94 inches of water

Note: It should be pointed out that static pressure can have a positive or negative value. Velocity pressure, on the other hand, always has a positive value.

Relationship between volumetric flow rate, velocity and area of flow.

Q = VA

Where:

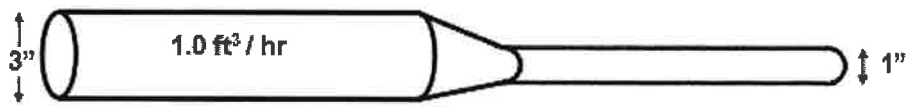
Q is the volumetric flow rate expressed in units of volume per time

V is the velocity

A is the area of flow.

Example 5

Air flows through two sections of a piping system as shown in the diagram. What is the air velocity in the 1 inch diameter pipe?



$Q = V_1 A_1 = V_2 A_2 = 1$ ft^3/hr

Let's call the velocity in the 1 inch diameter pipe V_2 and the area A_2. We can write:

$1.0 = V_2 A_2$

$A_2 = \frac{\pi(1)^2}{4\times144} = 5.45 \times 10^{-3} ft^2$

$V_2 = \frac{1.0}{5.45\times10^{-3}} = 183 \text{ ft / hr}$

6.3 Industrial Noise Control

- **Sound**

  Sound is a wave phenomenon produced as a result of small pressure variations in the atmosphere.

- **Amplitude**

  The amplitude refers to the maximum value of a sinusoidal wave (see Figure 2).

- **Frequency**

  The frequency of sound describes the rate at which complete cycles of high and low pressure regions are produced by the sound source. Frequency is measured in units of cycles per second which is also called Hertz.

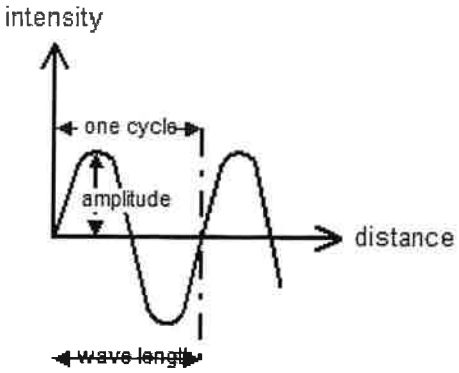


Figure 2 - Sinusoidal Wave.

Types of Noise Exposure

- **Continuous:**

  broadband noise of approximately constant level and spectrum, to which an employee is exposed for a period of eight hours per day or 40 hours per week.

- **Intermittent:**

  a given broadband sound pressure level that occurs several times during a normal workday.

- **Impact Type:**

  a sharp burst of sound, generally less than one-half second in duration and does not repeat more often than once per second.

Wavelength

The sound wavelength is defined as the distance required to complete one wave cycle (see Figure 2). The relationship between the wavelength, frequency, and speed of sound can be described by the following expression:

$$F = \frac{V}{\lambda}$$

Where:

F is the frequency

V is the speed

λ is the wavelength

Sound Intensity

The intensity of sound is defined as the amount of energy transmitted by the source per unit time through a unit area perpendicular to the direction of sound propagation. Intensity usually is expressed in units of joules per second per square meter (joules / sec $\cdot$ m2).

Sound Pressure

The instantaneous values of pressures are squared, the mean of the squares are obtained and the square root of mean is called Root Mean Square (RMS) of the sound pressure.

Period

The amount of time required for a complete wave cycle to take place is called the period. Frequency is the number of cycles per unit time, and period is the reciprocal of the frequency, normally measured in seconds.

$T = \frac{1}{F}$

Where:

T is the period

F is the frequency

Example 1

A sound wave has a frequency of 5,000 hertz. The amount of time required for one complete cycle (in units of seconds) is:

a. 3.

b. 2×10^{-4}.

c. 3×10^{-5}.

d. 5.

Select (b)

Solution

$T = \frac{1}{F}$

$T = \frac{1}{5000} = 2 \times 10^{-4}$ seconds

Decibels

The decibel (abbreviated dB) is the unit for expressing the sound pressure level relative to 2×10^{-10} atmosphere. In the metric system, this reference pressure is 2×10^{-5} newton/m^2. The unit termed "pascal" is defined as 1 N/m^2; so the sound pressure level reference is expressed as 2×10^{-5} pascal or 20 micropascals. Thus, to be technically correct, one should say, "The sound pressure level is 75 decibels relative to 20 micropascals." As this is a universally recognized pressure base, it often is not stated, however, and one usually says, "The sound pressure level is 75 dB."

The sound pressure level (SPL) for any measured sound is defined by:

$$\text{SPL}(in\ decibels) = 10\ log \frac{(rms\ sound\ pressure\ measured)^2}{(20\ micropascals)^2}$$

or

$$= 20\ log \frac{(rms\ sound\ pressure\ measured)}{(20\ micropascals)}$$

If we show the sound pressure level (in decibels) with Lp, the rms sound pressure measured with P, and our reference pressure (20 micropascals) with P_0, we can write:

$$L_P(in\ decibels) = 20log \frac{P}{P_0}$$

Example 2

The sound pressure level of a sound wave is 6.3×10^5 micropascal. The decibel value of this sound wave relative to 20 micropascal is

a. 63.

b. 72.

c. 90.

d. 85.

Select (c)

Solution

$L_P(in\ decibels) = 20log\frac{P}{P_0}$

$L_P(in\ decibels) = 20log\frac{6.3\times10^5}{20}$

$L_P = 89.96$ dB

Sound Measuring Instruments

Noise measurement instruments are classified into sound level meters (SLM), integrating sound level meters (ISLM), and spectrum analyzers (SA). The SLM, which is the most common instrument for the measurement of sound levels, can be Type 1 for precision measurements or Type 2 for general-purpose use. The ISLM instruments are designed for situations where there is a need to measure the average sound levels over a period of time. Spectrum analyzers identify the distribution of sound levels in frequency.

Decibel Addition

Table 9 can be used for accurate decibel addition. Approximate decibel addition relies on a few simple rules. When decibels are measured on A-scale, they are referred to as dBA.

1. When two decibel levels are equal or within 1 dB of each other, their sum is 3 dB higher than the higher individual level. For example, 80 dBA + 80 dBA = 83 dBA; 100 dBA + 101 dBA = 104 dBA.
2. When two decibel levels are 2 or 3 dBA apart, their sum is 2 dBA higher than the higher individual level. For example, 87 dBA + 85 dBA = 89 dBA; 75 dBA + 77 dBA = 79 dBA.
3. When two decibel levels are 4 to 9 dBA apart, their sum is 1 dBA higher than the higher individual level. For example, 80 dBA + 86 dBA = 87 dBA; 32 dBA + 36 dBA = 37 dBA.

4. When two decibel levels are 10 or more dBA apart, their sum is the same as the higher individual level. For example, 80 dBA + 95 dBA = 95 dBA.

Note: for every doubling of the distance from the source, the sound intensity is reduced by approximately 6 decibels. For example, if the sound intensity at 10 ft. from a source is 96 dB, the intensity at 20 ft. is approximately 90 dB.

Difference between Two Decibel Levels to be Added (dB)	**Amount to be Added to Larger Level to Obtain Decibel Sum (dB)**
0	3.0
1	2.6
2	2.1
3	1.8
4	1.4
5	1.2
6	1.0
7	0.8
8	0.6
9	0.5
10	0.4
11	0.3
12	0.2

Table 9. Obtaining Decibel Sum of Two Decibel Levels.

This table is, in essence, a summary of adding logarithms.

In situations where several sound levels have to be added to obtain the combined effect, the following procedure can be used:

1. Add the two lowest decibel levels.
2. Add the result of step 1 to the next higher level.
3. Continue until all decibel levels have been added.

Example 3

Assume that five machines are operating in a machine shop, and each is generating a sound level as summarized below:

Machine 1: 79 dBA

Machine 2: 85 dBA

Machine 3: 87 dBA

Machine 4: 95 dBA

Machine 5: 93 dBA

In order to calculate the combined sound level, we proceed as follows:

79 dBA + 85 dBA = 86 dBA

86 dBA + 87 dBA = 90 dBA

90 dBA + 93 dBA = 95 dBA

95 dBA + 95 dBA = 98 dBA

Therefore, the combined effect from all five machines operating simultaneously is equivalent to a sound level of 98 dBA.

Sound Absorption Coefficients

The sound absorption coefficient of a material is an indication of the amount of sound absorbed by the material at a given frequency. For example, a material with a coefficient of 0.75 absorbs 75% of the sound reaching it. The remainder is reflected.

The term "noise reduction coefficient" (NRC) refers to the arithmetic average of the absorption coefficient at frequencies 250, 500, 1,000 and 2,000 Hz.

Sound Transmission Loss Materials

The term "sound transmission loss" (STL) refers to the sound isolation properties of a material. The STL is a measure of the amount of sound energy transmitted through a material relative to the amount flowing toward the material. Mathematically the STL is defined by the following expression:

$$STL = 10\, log \frac{E_i}{E_t}$$

Where:

Ei: is the incident energy

Et: is the transmitted energy.

The STL increases with increasing frequency at a rate of about 5 dB for each doubling of frequency.

OSHA Allowable Times for Noise Exposure

The allowable time that a worker can be exposed to a continuous noise can be obtained from:

$t = \frac{8}{2^{(L-90)/5}}$

Where:

t is the allowable exposure time in hours

L is the sound intensity expressed in decibels.

Example 4

The allowable time that a worker can be exposed to a continuous noise level of 95 decibels in hours is:

a. 5.

b. 3.

c. 4.

d. 2.

Select (c)

Solution

$t = \frac{8}{2^{(95-90)/5}} = 4$ hours

Sound Level Meters A, B, C Response

An SLM can measure sound on either A, B, or C scales depending on the frequency of sound. OSHA regulations require A-scale noise measurement for assessment of noise exposure to employees because this **scale most closely resembles the response of the human ear**. Other scales such as B or C may be utilized for evaluation of noise as part of engineering control or design along with spectrum analysis.

Physiology of Hearing

Sound vibrations are transferred through ear canal to the eardrum and into the middle ear. The middle ear contains three bones called the "**ossicles**" which transmit sound waves to the inner ear. The hearing part of the inner ear is called "**cochlea**."

The adverse effect of noise on hearing can be classified into:

a. **Conductive impairment**

   Any condition which interferes with the transmission of sound waves to the cochlea.

b. **Sensorineural impairment**

   This is an irreversible hearing loss caused by damage to the organ of "corti" and degeneration of the neural elements of the auditory nerve.

c. **Mixed impairment**

Excessive noise can cause both conductive and sensorineural (mixed) impairment.

d. **Central impairment**

Refers to lack of ability of a person to interpret what is heard.

Noise Induced Hearing Loss (NIHL)

This type of hearing loss can occur as a result of over-exposure to noise over a relatively long period of time. Over-exposure to noise can initially cause a Temporary Threshold Shift (TTS) in hearing. However, a TTS can be transformed into a Permanent Threshold Shift (PTS) if over-exposure continues.

A high frequency noise is more harmful to human ear than a low frequency noise having the same amount of sound energy.

Hearing Protection Equipment

Hearing protective devices can be classified into three general categories:

1. Ear plugs, or insert-type devices, which fit within the ear canal.
2. Ear muffs, which are devices that fit around the ears and are supported either from a hard hat or from a head band that connects the individual muffs.
3. Canal Caps, which cover the entrance to the ear canal and are supported similarly to ear muffs.

The noise reduction capability of hearing protective devices is a very important factor which should always be considered.

Example 5

The root mean square sound pressure for a sound wave is 0.4 pascals. The sound pressure level in decibels is:

a. 80.

b. 90.

c. 75.

d. 86.

Select (d)

The following relationship can be used to calculate the decibel value of a sound wave from root mean square values P.

$(\text{decibels}) = 20\, log\frac{P}{20}$

where P is in micropascals and 20 micropascals is our reference point.

$\text{dB} = 20\, log\frac{0.4\times10^6}{20} = 86$

Relationship between noise dose and OSHA allowable times

In many workplace situations, an individual may be exposed to different levels of noise during an 8-hour workday. The concept of noise dose is used to determine whether OSHA allowable exposure times have been exceeded for a time varying noise level exposure. Noise dose can be calculated from

$$D = 100\sum_{i=1}^{n}\frac{c_i}{t_i}$$

Where:

D: is the noise dose

C_i: actual exposure times

t_i: allowable times.

When noise dose is calculated using the above relationship, we can say that allowable time has been exceeded if noise dose is greater than 1. Otherwise allowable time is not exceeded. The following relationship can be used to calculate allowable times:

$t = \frac{8}{2^{(L-90)/5}}$

Where:

t is the allowable time in hours.

L is the sound pressure level in decibels.

We demonstrate how to use the above relationships with an example.

Example 6

What is the noise dose for a worker who is exposed to a 95 dB source for a period of 5 hours?

a. 165%.

b. 125%.

c. 93%.

d. 315%.

Select (b)

The noise dose can be calculated from

$D = 100 \sum_{i=1}^{n} \frac{c_i}{t_i}$

where C_i is the exposure time and t_i the allowable time. The allowable time can be calculated from

$t = \frac{8}{2^{(L-90)/5}}$

where L is the exposure in decibels.

For the problem at hand:

$t = \frac{8}{2^{(95-90)/5}} = 4$ hours

$D = 100\left(\frac{5}{4}\right)$

D = 125%

Relationship between noise reduction, perimeter and cross sectional area of a duct

In many buildings, noise generated by a given source can be transmitted to other locations through ventilation or heating ducts. In many instances ducts are lined with a sound absorbing material. The amount of Noise Reduction (NR) expressed in decibels per foot length of the duct can be obtained from the following relationship:

$$NR = \frac{12.6P\alpha^{1.4}}{A}$$

Where:

NR is the sound absorption coefficient in decibels per foot.

P is the perimeter of the duct in inches

A is the cross sectional area of the duct in square inches

α is is the absorption coefficient of the lining material.

Example 7

A square ventilation duct 2 feet on each side connects two rooms through a 20 feet length of the duct. The sound absorption coefficient of the lining material is 0.2.The Noise Reduction in dB/foot is:

a. 0.9.

b. 0.6.

c. 1.1.

d. 0.2.

Select (d)

We use the following equation

$NR = \frac{12.6 \times 8 \times 12 \times 0.2^{14}}{4 \times 144}$

$\text{NR} = 0.2\ dB\ /\ foot$

6.4 Radiation

The following is a brief summary of some basic principles and terminology in the field of radiation. The relevant formulae which will be available to candidates at the time of the examination are discussed using examples.

- **Ionizing Radiation**

  Ionizing radiation, in general, is any electromagnetic or particulate radiation capable of producing ions either directly or indirectly as a result of interaction with matter. The biological effects of ionizing radiation represent the effort of the living organism to deal with the excess energy left in it after interaction of its atoms with an ionizing ray or particle.

- **Isotopes and Radioactive Decay**

  In some elements, atoms that have the same atomic number can have a different atomic mass; that is the number of protons is the same in all the atoms, but the number of neutrons varies. These different species of the element are called the isotopes of that element. Some isotopes, called stable isotopes, have enough binding energy in their nucleus to hold the nucleus particles together. Sometimes, however, the amount of nucleus binding energy within the nucleus of an isotope is not enough to hold the nuclear particles (protons and neutrons) together, and as a result part of the nucleus is lost in a process of nuclear disintegration called radioactive decay. Those isotopes of a given element that do not have enough nucleus binding energy to hold the particles together are unstable species called radioisotopes.

Types and Origins of Ionizing Radiation

- **Alpha particle (alpha ray, alpha radiation)**

  A small electrically charged particle of very high velocity thrown off by many radioactive materials, including radium and uranium. It is made up of two neutrons and two protons. Its electric charge is positive. Alpha particles have a relatively low penetrative power and high ionization potential.

- **Beta particle (beta radiation)**

  A small electrically charged particle thrown off by many radioactive materials. It is identical with the electron. Beta particles emerge from radioactive materials at high speeds, and are more penetrating than alpha particles.

- **X-Ray**

  Highly penetrating radiation similar to gamma-rays. Unlike gamma rays, X-rays do not come from the nucleus of the atom but from the surrounding electrons. They are produced by electron bombardment. When these rays pass through an object, they give a shadow picture of the denser portions.

- **Neutron**

  A constituent of the atomic nucleus. The neutron weighs about the same as a proton, and, as its name implies, has no electric charge. Neutrons make effective atomic projectiles for the bombardment of nuclei.

Units of Measurement

- **Curie (Ci)**

  A measure of the activity of the radioactive material, one curie is equivalent of 3.7 x 1010 disintegrations per second.

- **Rad**

  The rad is a measure of the dose of ionizing radiation to the body in terms of energy absorbed per unit mass of tissue. One rad corresponds to the absorption of 100 ergs per gram of tissue (the erg being the unit for measuring energy in the CGS system). It must be pointed out that at 100 rads most people show no immediate effects.

- **Roentgen**

  A special unit used for measuring exposure to radiation, one roentgen equals 2.58 x 10-4 coulomb per kilogram of air.

- **Rem**

  The rem is a measure of the dose of any ionizing radiation to the body tissue in terms of its estimated biological effect relative to a dose of one roentgen. The relation of the rem to other dose units depends on the biological effects under consideration and on the conditions for irradiation.

  Each of the following is considered to be equivalent to a dose of one rem:

  A dose of one roentgen due to X or gamma radiation. A dose of one rad due to X-ray, gamma, or beta radiation. A dose of 0.1 rad due to neutrons or high energy protons. A dose of 0.05 rad due to particles heavier than protons with sufficient energy to reach the lens of the eye.

- A dose of one roentgen due to X or gamma radiation.
- A dose of one rad due to X-ray, gamma, or beta radiation.
- A dose of 0.1 rad due to neutrons or high energy protons.
- A dose of 0.05 rad due to particles heavier than protons with sufficient energy to reach the lens of the eye.

Non-ionizing Radiation

- **Ultraviolet Radiation**

  The over exposure of unprotected skin or eyes could result in tissue inflammation; also long term effects may develop as a result of repeated over-exposures.

  Over-exposure of unprotected skin to ultraviolet radiation may give rise to a condition called erythema which is commonly known as sunburn. Exposure of the unprotected eye can cause inflammation of the cornea, giving rise to conditions known as keratitis and conjunctivitis.

- **Infrared Radiation**

  Infrared radiation can damage the unprotected eye or skin by releasing energy and producing a heating effect. Over-exposure of unprotected eyes to infrared radiation could give rise to cataracts.

- **Laser Radiation**

  Lasers can be produced in a variety of forms, including continuous and pulsed outputs of both visible and invisible radiation. High power pulsed laser manufacturing units could be extremely hazardous, as high power laser beams are capable of tissue destruction at the point of contact. One source of laser radiation commonly encountered is fiber optical lines used for communication.

  The American National Standard Institute (ANSI) has classified lasers into four classes. This classification ranges from low power Class I lasers to high power Class IV lasers.

- **Microwave Radiation**

  Microwave radiation wavelengths can vary from 10 meters to about 1 mm. Microwave-producing devices may pose the normal hazards associated with all electrical equipment as well as the danger of local burns caused by contact with the work-coil or heat produced in conductors such as watches and rings.

Other Useful Concepts in Radiation Control

- Workplace exposure to ionizing radiation is regulated by OSHA, and Nuclear Regulatory Commission (NRC). NRC regulations were revised in 1991 to reduce allowable exposure to employees.
- Radiation caution signs and labels use a purple or magenta color on a yellow background. These signs are required by OSHA, DOE and NRC in radiation areas.

- Doses of radiation for employee exposure in the workplace are typically measured in rems. A dose of one roentgen due to X-ray or gamma radiation is equivalent to one rem.
- Radiation exposures which exceed prescribed regulatory limits must be reported to OSHA within 24 hours of the incident. A written report of the incident must be submitted no later than 30 days from the occurrence of the incident. It must be pointed out that NRC has different reporting criteria and requirements.
- Radiation follows the inverse square law. This means that the energy of the radiation source is inversely proportional to the square of the distance. We can write:

$$\mathbf{I_1 d_1^2 = I_2 d_2^2}$$

Where:

I_1 is the energy at distance d_1 from the source

I_2 is energy at distance d_2 from the source.

- Employee exposure to radiation can be controlled by means of "shielding" the source, distance from the source (inverse square law), and reducing the time of exposure.

Typical shielding materials for alpha particles are paper, aluminum sheets, and even ordinary clothing. Aluminum and water are examples of effective shielding materials for beta radiation. Gamma rays can be shielded by materials such as concrete, water, lead, and iron. Among all types of ionizing radiation, the alpha particles are the least penetrative and X-rays and the gamma rays are the most penetrative.

- **Half-Life**: Half-life for a radioactive material is defined as the length of time required for that material to lose 50 percent of its original activity.
- **Radiation measurement**: Several instruments and devices are designed for measuring the amount of radiation emitted from a given source. Examples are ionization chambers and Geiger Mueller (GM) radiation detectors. The advantage of GM detectors is that it can be used to measure various types of ionizing radiation (alpha, beta, gamma, and X-rays) for which it is calibrated.

Example 1: Atomic mass and atomic number

Which of the following statements is true regarding Radon $_{222}Rn^{86}$?

a. It has 86 protons and 222 neutrons.

b. It has 86 electrons and 222 neutrons.

c. It has 86 protons and 222 electrons.

d. It has 86 protons and 136 neutrons.

Select (d)

222 is the atomic mass which is the number of protons (which is equal to number of electrons) plus the number of neutrons. 86 is the number of protons in the nucleus which is equal to number of electrons.

number of neutrons = atomic mass - number of protons

222 - 86 = 136

Example 2: The concept of half-life

The half-life of Radon $_{222}Rn^{86}$ is 3.8 days. If we start with one gram of radon, how many days would it take to reduce the weight to 1/16 of a gram?

a. 7.6

b. 11.4

c. 15.2

d. 19.0

Select (c)

days	gram
0	1
3.8	1/2
7.6	1/4
11.4	1/8
15.2	1/16

The relationship between activity of a radioactive material at a given time, the decay constant and initial activity.

$$I = I_0 e^{-\mu x}$$

where:

I is activity after time x

I_0 is initial activity

μ is the decay constant.

Example 3

The decay constant for a radioactive material is 2.0×10^{-10} sec^{-1}. How long would it take to reduce the activity of this material to 15 percent of its original value?

a. 600 years

b. 300 years

c. 100 years

d. 1,000 years

Select (b)

$I = I_0 e^{-\mu x}$

In the above equation I is activity after time x, and I_0 is the initial activity. Activity of 15 percent of original means:

$I = 0.15\ I_0$

Substitute for I:

$0.15\ I_0 = I_0 e\text{-}2\times10^{-10}x$

Or

$0.15 = e^{-2\times10\text{-}10}x$

In order to find x (time) from the above equation, we note that if we take the natural logarithm of an exponential variable, we end up with the value of variable itself. Mathematically, we can say:

$$\boldsymbol{Ln\ (e^x) = x}$$

In our equation for calculation of time, we take the natural logarithm of both sides of the equation. Remember that if two numbers are equal, their natural logs are also equal to each other.

Take the natural logarithm of both sides:

$Ln\ 0.15 = LN\ e^{-2\times10\text{-}10}x = -2 \times 10^{-10}x$

$x = 9{,}485{,}599{,}924$ seconds $= 300$ *years*

The relationship between radiation intensity and distance.

$I_1 {d_1}^2 = I_2 {d_2}^2$

Where:

I_1 is radiation intensity at distance d_1

I_2 is radiation intensity at distance d_2.

Example 4

The amount of radiation emitted by a source at 2 feet away from the source is 0.06 rem. What level of radiation we expect to measure at 6 feet away from the source.

a. 0.02 rem.

b. 6.66×10^{-3} rem.

c. 0.12 rem.

d. 0.18 rem.

Select (b)

Radiation intensity follows the inverse square law $I_1 {d_1}^2 = I_2 {d_2}^2$.

For the problem at hand:

$(0.06)\ (2)^2 = I_2\ (6)^2$

$I_2 = 6.66 \times 10^{-3}$ rem

6.5 Chemical Hazard Protection and Toxicology

Review of Basic Principles and Terminology

Toxic material

A toxic material is one which has an adverse effect on normal human physiological function.

Toxic substances can produce two types of toxic effects in humans; acute and chronic. **Acute toxicity** is experienced in a relatively short time span, while **chronic toxicity** is the result of repeated exposure over a relatively long period of time.

Route of entry

Toxic chemicals may enter the body by ingestion, inhalation, skin absorption, eye absorption, or injection.

Dosage

Dosage is the amount of chemical administered per unit of body weight.

Dose threshold

Dose threshold is the minimum dosage of a chemical that can produce a measurable adverse effect.

Lethal dose

Lethal dose (LD) is the dosage of a chemical that can produce death in a certain percentage of selected laboratory animals. For example, lethal dose 50 or LD_{50} is the dosage of a chemical that can produce death in 50 per cent (half) of selected laboratory animals when the route of entry is usually by **ingestion or skin absorption**.

When the route of entry is by inhalation of a toxic chemical, lethal dose is expressed as **lethal concentration (LC)**. For example, LC_{50} is the dosage of a toxic chemical that can produce death in 50 per cent of selected laboratory animals when the route of entry is by **inhalation**.

LD_{50}'s are expressed in weight of chemical divided by weight of organism and LC_{50}'s are usually expressed in parts per million (ppm).

Corrosives

Corrosives are chemicals that can cause irreversible alteration of living tissue. Chemical corrosivity is determined by conducting skin tests on laboratory animals or in studies using synthetic skin.

Asphyxiants

Asphyxiants are substances that can cause suffocation by preventing oxygen from reaching the tissues.

Asphyxiants have been classified into two general categories; simple asphyxiants and chemical asphyxiants.

- **Simple asphyxiants** are those gases or vapors that are not toxic by themselves but can cause suffocation as a result of reducing the oxygen concentration by diluting the air.
- **Chemical asphyxiants**, on the other hand, interfere with the body's capability to absorb oxygen into the blood stream.

  Carbon monoxide and hydrogen cyanide are examples of chemical asphyxiants while hydrogen and nitrogen are examples of simple asphyxiants.

Target organ chemicals

Target organ chemicals are chemicals that attack specific organs regardless of the route of entry into the body. For example, halogenated compounds attack the kidneys when absorbed into the blood stream either by inhalation of vapors or by skin absorption; CCl4 is a strong liver toxin regardless of the route of entry into the body.

Chemicals that attack the liver are called **hepatotoxins**; chemicals that attack the central nervous system are called **neurotoxins**.

Hematopoietic system hazards

Hematopoietic system hazards are chemicals that interfere with blood forming organs and which can stop or decrease the hemoglobin function of the red blood cells, resulting in body tissues being deprived of oxygen. For example, benzene reduces hemoglobin availability by damaging the hematopoietic cells of the bone marrow, even though it does not act directly on the hemoglobin. However, carbon monoxide interferes with the hemoglobin's ability to combine with oxygen.

Carcinogens

Carcinogens are chemicals that have the potential to cause cancer in humans. Most carcinogens have been proven to cause cancer in animals. Frequently, animal data is extrapolated to humans.

Sensitizers

Sensitizers are chemicals that can cause an allergic reaction in the body usually after repeated exposures.

Irritants

Irritants are chemicals that can cause inflammation of living tissue as a result of a chemical reaction.

Reproductive toxins

A reproductive toxin is any chemical that interferes with the reproductive process. They can produce an adverse effect in the reproduction process by the creation of mutations or by teratogenesis.

- **Mutagens** are chemicals that cause permanent changes to genetic material (DNA), such that the changes have a potential for propagation through generational lines.
- **Teratogens** are chemicals that cause damage to a developing fetus, but the damage does not propagate across generational lines.

Threshold Limit Values (TLV's)

Threshold Limit Values (TLV's) are airborne concentrations of substances at which it is believed that most workers may be repeatedly exposed day after day without adverse health effects.

TLV's can be categorized into:

- **TLV-TWA (Time Weighted Average)** The time-weighted average, in an 8-hour workday and a 40-hour work week, at which most workers may be repeatedly exposed without adverse health effects.
- **TLV-C (Threshold Limit Value Ceiling)** The maximum concentration of a chemical that should not be exceeded at any time.
- **TLV-STEL (Threshold Limit Value Short Term Exposure Limit)** The maximum allowable concentration of a chemical for exposures not exceeding 15 minutes.

Gaseous mixture TLV's

In many workplace situations, two or more chemicals may be present at the same time. Under these circumstances, the mixture TLV of mixture must be calculated. When two or more compounds are present in the atmosphere, the mixture TLV has been exceeded if:

$$\sum_{i=1}^{n} \frac{C_i}{(TLV)_i} > 1$$

Where:

C_i is the measured atmospheric concentration of component i

$(TLV)_i$ is the Threshold Limit Value for component i expressed in parts per million (ppm) or milligram per cubic meter (mg/m^3).

Note: It should be pointed out that in the calculation of a mixture TLV in this manner, the assumption is made that each component has similar effects on a given organ.

Liquid mixture TLV's

When the source of contaminant is a liquid mixture, the atmospheric composition is assumed to be similar to the liquid mixture, and that all of the liquid eventually evaporates, the TLV for the mixture can be calculated from the following relationship:

$$(TLV)_{mixture} = \frac{1}{\sum_{i=1}^{n} \frac{f_i}{(TLV)_i}}$$

Where:

f_i is the weight fraction composition of component i in the liquid mixture

$(TLV)_i$ is the TLV for component i expressed in mg/m^3.

TLV conversion calculations

In calculations dealing with TLV's, it may become necessary to convert from mg/m^3 to ppm or vice versa. The following relationships can be used for this purpose

$$ppm = \frac{C\left(\frac{mg}{m^3}\right)(24.45)}{M.W.} \quad and \quad \frac{mg}{m^3} = \frac{(C\ in\ ppm)(M.W.)}{24.45}$$

Where:

C is concentration of contaminants

ppm is Parts Per Million

mg / m^3 is milligrams per cubic meter

M.W. is molecular weight.

6.6 Ergonomics and Human Factors Engineering

Introduction

Ergonomics is the science that studies the compatibility between task requirements and human capabilities in order to increase work efficiency and safety. The following knowledge areas are required for a comprehensive understanding of ergonomic subjects:

- human senses (vision, hearing, kinesiology)
- information processing (perception, attention, decision-making)
- musculoskeletal system (biomechanics, anthropometry, physiology)
- design concepts (modeling, tools, checklists)
- environmental stressors (noise, lighting, vibration, heat/cold)
- management (organization design and leadership, training, team work, compensation)
- control/display compatibility

Application Areas

- Visual display terminals
- Office ergonomics
- Workplace design
- Manual material handling
- Hand tool and equipment design
- Cumulative trauma disorders
- Job and environmental stress
- Job design
- Work methods

Principles of Control-Display Compatibility

- Controls should be positioned close to their associated displays
- Controls and their associated displays should be grouped according to their functions
- Control/display functional groupings should be similar in all parts of the plant

- Control/display movement compatibility (e.g., rotary control clockwise means display "on," move to right, move up, or increase in value)

Example 1

In equipment design, which of the following statements best describes the correct positioning or movement of controls and displays?

a. Controls must be positioned opposite to displays.

b. The movement of controls should follow the principle of non-congruity.

c. If the display moves to the right, the control should move counterclockwise.

d. Displays should generally move in the same direction as the movement of the controls.

Select (d)

See description above.

Example 2

Some industrial tasks may cause tendonitis, bursitis, or carpal tunnel syndrome. Which one of the following is more likely to cause these diseases?

a. One-time lifting of a very heavy object.

b. Frequent lifting of a heavy object

c. A static load on hand and shoulder.

d. Frequent twisting in low back area.

Select (c)

Even in jobs that involve light to moderate workloads, the presence of **static loading** may cause or aggravate disorders such as tendonitis, bursitis, or carpal tunnel syndrome.

Example 3

Which one of the following variables is less likely to be considered in studying the hazards caused by tasks requiring pushing and pulling?

a. Friction between human skin and materials.

b. Vertical height of the object's handle.

c. Worker body positioning.

d. Floor and shoes coefficient of friction.

Select (a)

The act of manually handling objects (e.g. lifting, pushing, pulling, etc.) has been the cause of billions of dollars of workers' compensation claims. In general, a comprehensive and systematic program is necessary to prevent overexertion, which may result in musculoskeletal problems. This systems approach involves several factors, such as:

- Container (material) features
- Job (task) design
- Work practices
- Worker characteristics
- Work environment influences

Pushing and Pulling Loads

It is estimated that approximately 20% of musculoskeletal injuries are caused by pushing or pulling objects inappropriately. Some injuries classified as slip and fall also have causal contributions from pushing and pulling objects. The most important variables in the study of force exertion for pushing or pulling are: vertical height of handle, direction of exertion, body weight and positioning, and floor coefficient of friction (COF). Healthy young males can only exert a mean force of approximately 44 pounds if the COF is about 0.3. With a COF greater than 0.6, the mean push or pull strength increases to 66 pounds for the same group.

To minimize the stresses caused by pulling or pushing objects, the following is recommended:

- Appropriate handle design for the container
- Position of the handle should be between about the worker's waist and shoulder height
- Floor surface should be dry with a high COF
- Body position should take advantage of gravity force on objects
- Pushing is preferred over pulling
- Awkward body position and posture (e.g. bend and twist sideways) should be minimized
- Preventive maintenance of wheels
- Size and quality of wheels

NIOSH Revised Lifting Equation

Introduction

According to the National Safety Council, about 31% of all occupational injuries are caused by overexertion. In 1991, the National Institute for Occupational Safety and Health (NIOSH) revised their earlier lifting equations developed in 1981. The revised equations allow for evaluation of asymmetrical lifting tasks as well as the effects of couplings between the object and worker's hands.

The Revised Lifting Equation

The principal products of the revised lifting equation are the Recommended Weight Limit (RWL) and the Lifting Index (LI). The RWL indicate the weight of the load that nearly all healthy workers can lift during a given period of time (e.g. 8 hours) without increasing their risk of developing lower back problems. The RWL is defined as the following equation:

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

NIOSH defines the terms in the above equation both in the metric system of units as well as the U.S. customary units.

Load Constant (LC)

The value of LC in the metric system is 23 kilograms and the U.S. Customary units are 51 pounds.

Horizontal Multiplier (HM)

The value of HM to the metric system is:

$25/H$

and in U.S. Customary Units is:

$10/H$

where H is the horizontal distance of hands away from the midpoint between the ankles. If you are using the metric system, H is measured in centimeters. If you are using the U.S. Customary units, H is measured in inches.

H: measured in cm in the metric system.

H: measured in inches in the U.S. Customary units.

Vertical Multiplier (VM)

The value of VM in the metric system can be obtained from:

VM = 1 - (0.003|V - 75|)

The value of VM in the U.S. Customary units can be obtained from:

VM = 1 - (0.0075|V -30|)

Note: |V - 75| and |V -30| in the above equations represent absolute values i.e. regardless of the sign of the quantities calculated, we use a positive value.

V in the above equations is called the Vertical Location. It to the distance on the hands above the floor. If you are using the metric system of units V is measured in centimeters (cm). If you are using the U.S. Customary units, V is measured in inches.

Distance Multiplier (DM)

The value of DM in the metric system of units can be calculated from:

DM = 0.82 + (4.5/D)

If you are working with the U.S. Customary units, the value of DM can be calculated from:

DM = 0.82 + (1.8/D)

D in the above relations is called the Vertical Travel Distance which is the difference in height from the destination to origin. D is measured in centimeters in the metric system, and in inches in the U.S. Customary units.

Asymmetric Multiplier (AM)

The Asymmetric Multiplier (AM) takes into account those situations when a worker has to begin a lift in a twisted position and/or lift a load and turn to place it at its destination. AM has a value of 1.0 when the load is lifted directly in front of the body. The value of AM in both metric as well as U.S. Customary units can be obtained from:

AM = 1 - (0.0032A)

where A is the asymmetry angle. For example, when a worker lifts a load directly in front of the body, the value of A is zero and AM = 1.0. However, if the value of A is 15 degrees then:

AM = 1 - (0.0032 × 15) = 0.95

Frequency Multiplier (FM)

The Frequency Multiplier (FM) takes into account the effects of number of lifts per unit time. The value of FM can be obtained from the following table. Note that the value of FM is tabulated for different work durations. Also note that the value of FM, for a given work duration, depends on whether the vertical distance, V, is less than 75 cm (30 inches), or greater than, 75 cm.

Example 6

What is the value of the Frequency Multiplier (FM) for a lifting frequency of 4 lifts per minute for 3 hours with a Vertical Location (V) of 25 inches?

Solution

From the sixth column from the left (see table below), we obtain a value of 0.45.

FM = 0.45

Frequency	Work Duration (Continuous)					
	More than 2 hours but ≤ 8 hours	More than 2 hours but ≤ 8 hours	More than 1 hour but ≤ 2 hours	More than 1 hour but ≤ 2 hours	Less than or equal to 1 hour	Less than or equal to 1 hour
Lifts/Minute	V<75	V≥75	V<75	V≥75	V<75	V≥75
0.2	0.85	0.85	0.95	0.95	1	1
0.5	0.81	0.81	0.92	0.92	0.97	0.97
1	0.75	0.75	0.88	0.88	0.94	0.94
2	0.65	0.65	0.84	0.84	0.91	0.91
3	0.55	0.55	0.79	0.79	0.88	0.88
4	0.45	0.45	0.72	0.72	0.84	0.84
5	0.35	0.35	0.6	0.6	0.8	0.8
6	0.27	0.27	0.5	0.5	0.75	0.75
7	0.22	0.22	0.42	0.42	0.7	0.7
8	0.18	0.18	0.35	0.35	0.6	0.6
9	0	0.15	0.3	0.3	0.52	0.52
10	0	0.13	0.26	0.26	0.45	0.45
11	0	0	0	0.23	0.41	0.41
12	0	0	0	0.21	0.37	0.37
13	0	0	0	0	0	0.34
14	0	0	0	0	0	0.31
15	0	0	0	0	0	0.28
>15	0	0	0	0	0	0

Coupling Multiplier (CM)

The Coupling Multiplier (CM) takes into account the nature of the gripping method and hand-to-load coupling. The coupling type is classified into "Good," "Fair," and "Poor." The values of the CM can be obtained from the following table:

The Coupling Multiplier Table:

Couplings	V<75 cm (30 inches)	V ≥ 75 cm (30 inches)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

The following table summarizes the values of different parameters in the revised NIOSH lifting equation:

		Units Selected	
Parameter	**Abbreviation**	**U.S. Customary**	**Metric**
Load Constant	LC	51 lbs	23 kg
Horizontal Multiplier	HM	(10/H)	(25/H)
Vertical Multiplier	VM	1-(0.0075|V-30|)	1-(0.003|V-75|)
Distance Multiplier	DM	0.82 + (1.8/D)	0.82 + (4.5/D)
Asymmetric Multiplier	AM	1-(0.0032A)	1-(0.0032A)
Frequency Multiplier	FM	From Table	From Table
Coupling Multiplier	CM	From Table	From Table

Substituting the values from the above table in our original equation:

$\text{RWL} = \text{LC} \times \text{HM} \times \text{VM} \times \text{DM} \times \text{AM} \times \text{FM} \times \text{CM}$

we obtain two equations, one for the metric system and one for the U.S. Customary units.

The revised NIOSH lifting equation in the metric system assumes the following form:

$RWL(kg) = (23)(25/H)[1 - 0.003|V - 75|]$

$[0.82 + (4.5 / D)](1 - 0.0032A)(FM)(CM)$

The revised NIOSH lifting equation in the U.S. Customary units assumes the following form:

$RWL(lbs) = (51)(10/H)[1 - 0.0075|V - 30|]$

$[0.82 + (1.8 / D)](1 - 0.0032A)(FM)(CM)$

Where:

H: is the horizontal Location, which is the distance of the hands from the midpoint between the ankles. H is measured in centimeters (cm) in the metric system and it is measured in inches in the U.S. Customary units.

V: is the Vertical Location, which is the distance from the floor to the location of the hands above the floor. In the metric system V is measured in cm, and in U.S. Customary units, it is measured in inches.

D: is the Vertical Travel Distance, which is the distance between the destination and the origin of the load. Like H and V, D is measured in cm in the metric system and it is measured in inches in the U.S. Customary units.

A: is the Asymmetric angle measured in degrees.

The Lifting Index (LI)

The LI can be calculated from the following equation:

LI = Weight of Load / RWL

LI is a measure of the relative amount of physical stress associated with a particular lifting task.

Example 7

A worker lifts finished products from an assembly line which is 20 inches above the floor and places them in boxes that are located 35 inches above the floor. The weight of each product is 15 lbs. For each lift, the distance of hands away from mid-point between ankles is 12 inches. In order to properly place the load at its destination, the worker needs to turn 45 degrees. The worker places 5 finished products in boxes every minute. The coupling type is classified as "Good." Calculate the RWL and LI for 3 hours of continuous work.

Solution

The lift must be analyzed at both the origin and destination of the lift:

Mult.	Origin	Destination
HM	10/H = 10/12 = 0.833	10/H = 10/12 = 0.833
VM	1-(0.0075|20 - 30|) = 0.925	1-(0.0075|20 - 30|) = 0.925
DM	0.82 + (1.8/15) = 0.940	0.82 + (1.8/15) = 0.940
AM	1 – (0.0032 × 0) = 1.000	1 – (0.0032 × 45) = 0.856
FM	0.35 (from Table)	0.35 (from Table)
CM	1.00 (from Table)	1.00 (from Table)

RWL (origin) = 51 × 0.833 × 0.925 × 0.940 × 1.000 × 0.35 × 1.00

RWL (origin) = 13 lbs.

LI = 15/13 = 1.15 RWL

RWL (destination) = 51 × 0.833 × 0.925 × 0.940 × 0.856 × 0.35 × 1.00

RWL (destination) = 11.06 lbs.

LI = 15/11.06 = 1.355

Discussion

Since LI exceeds unity (1.0) at both the origin and the destination of the lift, this lifting is considered to be hazardous. The lift at the destination, with a Lifting Index of

1.4, is more hazardous than the lift at its origin. The lift's destination is therefore the part on the lift that deserves greatest attention.

NIOSH recommends that ergonomic redesign be used to engineer the hazards out of the lifting situation. However, in this case, the lifting could be improved (in order of importance) by these administrative controls:

- Reducing the frequency of lifting.
- Reducing the work duration from 3 hours to less than two hours of continuous lifting by shift ration.

These changes can bring the LI down to 0.57

Ergonomic redesign is also important, and much more desirable than depending upon administrative controls:

- By raising the line to 30 inches, and positioning the load closer, the LI is reduced to less than half of unity (0.49), significantly increasing the safety of the workers at this workstation.

Then, if the workers revert to the more hazardous lifting technique of twisting to place the load, the LI still remains at just above half of unify (0.57) and their safety has not been compromised.

Example 8

Based on anthropometric data, the design features of a workstation should accommodate which of the following range of measurements?

a. 0 to 100 percent of population.

b. 5th to 95th percentile.

c. 10th to 90th percentile.

d. 50th percentile.

Select (b)

Anthropometry is the study of sizes, weights and lengths of various human body members for the design of equipment and work stations. Using anthropometric data, the design features of a work station should normally accommodate from the 5th percentile female to the 95th percentile male worker.

There are four general rules for considering design recommendations using anthropometry:

- Design opening and access areas for the largest population percentile possible
- Design reach envelopes based on the smallest population percentile possible
- For the greatest user population, incorporate adjustability into every feature of the design

- Design for function

Example 9

To consider the hazardous nature of materials, product components, equipment use, procedures and work practices, which one of the following provides the most cost efficient hazard prevention approach?

a. Design stage

b. Research and development

c. Production

d. Actual use

Select (a)

The most important element of ergonomic design for safety professionals is the concept of design for safety (DFS). DFS is a relatively new methodology which emphasizes the following considerations:

- The hazardous nature of materials, product components, equipment, procedures and work practices at the earliest stage of the design process;
- The available anthropometrics, biomechanics, and epidemiological data for each potentially hazardous source;
- The user target group characteristics;
- The potential patterns of misuse;
- Eliminating the hazards in the system from cradle-to-grave: design, development, production, use, and disposal;
- Applying engineering and/or administrative controls. Some of these techniques are:

  Eliminate the source of the hazard (e.g., not using potential carcinogens). Reduce the degree of hazard severity (e.g., use low voltage electricity). Provide barriers or blocks to prevent transfer of hazards to the user (e.g., use interlock gates). Consider fail-safe design approaches (e.g., machine parts do not move if power fails). Warn the user about potential hazards (e.g., warning signs, labels and alarms). Provide administrative controls such as periodic training, rotations, rest cycles, etc.

- Eliminate the source of the hazard (e.g., not using potential carcinogens).
- Reduce the degree of hazard severity (e.g., use low voltage electricity).
- Provide barriers or blocks to prevent transfer of hazards to the user (e.g., use interlock gates).
- Consider fail-safe design approaches (e.g., machine parts do not move if power fails).
- Warn the user about potential hazards (e.g., warning signs, labels and alarms).

- Provide administrative controls such as periodic training, rotations, rest cycles, etc.

Heat Stress

Wet Bulb Globe Temperature (WBGT)

Wet Bulb Globe Temperature (WBGT) is used to measure the environmental factors which effect deep body temperature. WBGT values can be calculated by using the following equations:

outdoors with solar load

$$\mathbf{WBGT = 0.7\ NWB + 0.2\ GT + 0.1\ DBT}$$

indoors or outdoors with no solar load

$$\mathbf{WBGT = 0.7\ NWB + 0.3\ GT}$$

Where:

WBGT = Wet Bulb Globe Temperature

NWB = Natural Wet Bulb Temperature

DBT = Dry Bulb Temperature

GT = Globe Temperature.

Permissible heat exposure

The permissible heat exposure Threshold Limit Values in WBGT have been developed by the American Conference of Governmental Industrial Hygienists (ACGIH) and are summarized in the following table.

	Type Of Work		
Description Of Work	**Light**	**Moderate**	**Heavy**
Continuous	30.0	26.7	25.0
75% work25% rest each hour	30.6	28.0	25.9
50% work50% rest each hour	31.4	29.4	27.9
25% work75% rest each hour	32.2	31.1	30.0

Table 1. Heat Exposure Threshold Limit Values WBGT In Degrees Celsius

Source ACGIH 94-95 TLV booklet

Example 10

A worker is performing a "moderate" task with 75 percent work and 25 percent rest each hour. The task is performed indoors with no solar load on a day when the Natural Wet Bulb temperature is 22°C and the Globe Temperature is 27°C. Determine whether this worker is exposed to excessive heat.

Solution

WBGT = 0.7(22) + 0.3(27)

WBGT = 23.5°C

From the table above the permissible WBGT for "moderate" work with 75 percent work and 25 percent rest each hour is 28°C. Therefore, we have not exceeded the permissible WBGT and this worker is not exposed to excessive heat.

Psychrometric Chart

DEFINITIONS

Air Temperature

Air temperature is a measure of heat content of the air. Three different measurements of air temperature are used in the psychrometric chart.

1. **Dry Bulb (DB)** is the air temperature measured by an ordinary thermometer. This is the temperature reported in the weather reports. The Dry Bulb temperature is located at the base of the psychrometric chart. Vertical lines indicate lines of constant Dry Bulb temperature.
2. **Wet Bulb (WB)** temperature the cooling effect of evaporating water on the temperature. Wet Bulb temperature is determined by passing air over the base of a thermometer that has been wrapped with a small amount of moist cloth. The cooling effect of the evaporating water causes a lower temperature compared to the Dry Bulb temperature. The Wet Bulb temperature scale is located along the curved upper left portion of the chart. The sloping lines indicate lines of constant Wet Bulb temperature.
3. **Dew Point (DP)** temperature, also called saturation temperature, is the temperature below which moisture condenses out of the air. The Dew Point temperature scale is located along the same curved portion of the chart as Wet Bulb temperature scale. However, horizontal lines indicate constant Dew Point temperature.

Relative Humidity (RH)

Air at a given temperature can hold certain amount of moisture. Any attempt to put more moisture in the air than the maximum amount results in condensation. Relative

Humidity is a measure of how much moisture is present compared to the maximum amount of moisture that the air can hold at that temperature. Relative Humidity is expressed as a percent. The curved lines that extend from the lower left to the upper right of the Psychrometric chart represent lines of constant Relative Humidity. The saturation line (100 percent Relative Humidity) corresponds to the Wet Bulb and the Dew Point temperature scale line. The Dry Bulb temperature scale line also represents the line for zero percent Relative Humidity.

Vapor Pressure (VP)

Vapor Pressure is the pressure corresponding to a given saturation temperature. Vapor Pressure is a strong function of temperature. The Vapor Pressure scale is located on the vertical line to the far right of the chart.

Moisture Content of the Air

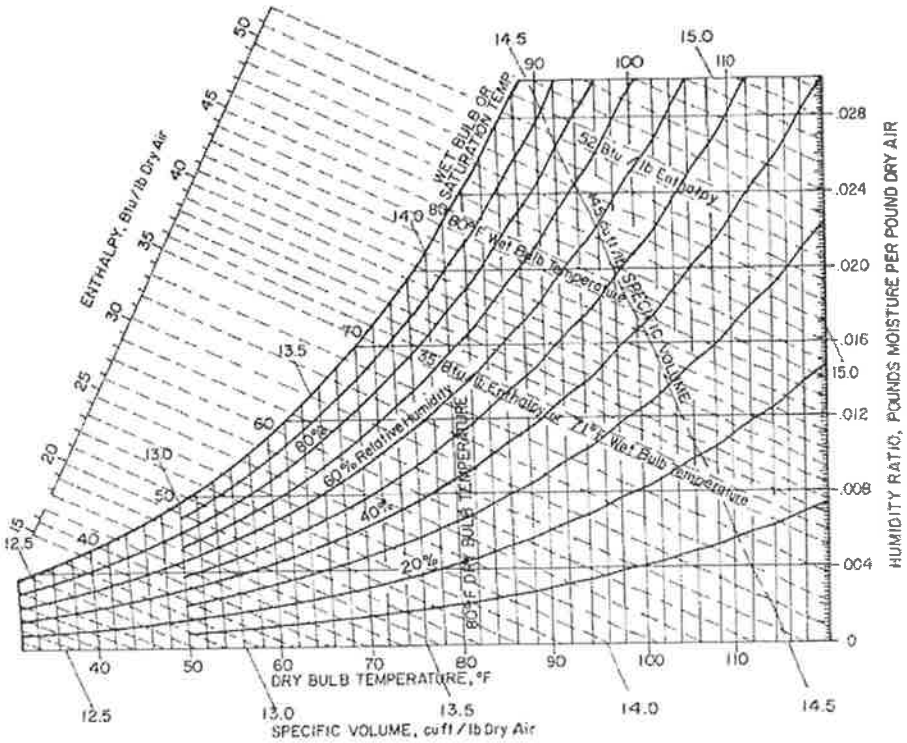
The scale for the moisture content of the air is located on the vertical line on the right side of the chart.

Example

The weather report indicates a dry bulb temperature of 80 °F and a relative humidity of 50%. What is the value of wet bulb temperature, dew point temperature, and moisture content of the air?

Solution

On the psychrometric chart below, First locate the point where the vertical line corresponding to 80 °F dry bulb temperature and the of 50% relative humidity intersect. From that point move along a horizontal line to the dew point temperature (59 °F), and along a sloped line to the wet bulb temperature (67 °F). From the point on the chart draw a horizontal line to right to read the moisture content, which is 0.012 lb of water per pound of dry air.



Psychrometric Chart

6.7 Example Questions

1. Which of the following is the most common occupational disease?
   a. Siderosis
   b. Asbestosis
   c. Dermatitis
   d. Glanders
2. Exposure to petroleum products, greases, and solvents account for the most probable cause of which of the following occupational disease?
   a. Dermatitis
   b. Carpal Tunnel Syndrome
   c. Glanders
   d. Siderosis
3. Which of the following statements BEST describes Cumulative Trauma Disorders (CTD)?
   a. Disorders caused as a result of repeated movement of body parts.
   b. Disorders caused as a results of exposure to chemicals over a relative long period of time.
   c. Mental and psychological disorders developed over a period of time as a result of work related stress.
   d. Any disorder, physical or psychological, which is work related and has a cumulative effect over a given period of time.
4. Assuming that the NIOSH Recommended Weight Limit (RWL) is 16 lb, what is the Lift Index (LI) for lifting a 22 lb weight?
   a. 1.375
   b. 0.727
   c. 1.896
   d. 2.749
5. A pocket dosimeter is a device that is used to measure employee exposure to which of the following?
   a. Radiation
   b. Noise
   c. Vibration

d. Airborne hazardous chemicals concentration

6. A container has dimensions of 20 × 20 × 10 feet and contains nitrogen. Assume that 18.9 ft^3 of carbon dioxide (CO_2) is released into this container. The concentration of CO_2 expressed in volume fraction is:

   a. 2.3

   b. 0.006

   c. 0.0047

   d. 0.65

7. In the control of heat stress, an increase in air velocity:

   a. Increases heat transfer rates by convection

   b. Decreases heat transfer rates by convection

   c. Heat transfer is only dependent on the temperature of air

   d. Increases heat transfer rate by conduction

8. Dilution ventilation is best suited for which of the following situations?

   a. When highly flammable gases are present

   b. When highly toxic air contaminants are present

   c. When air contaminants are not highly flammable or toxic and are not produced at high rates

   d. When contaminants that are toxic or flammable are produced by a fixed source

9. Although widely used in the past, the use of air changes per hour as a measure of dilution ventilation has been eliminated from most ventilation standards. The main reason for this is:

   a. It is difficult to calculate

   b. It does not take into account the actual dilution of contaminants

   c. It relies on older technology no longer available

   d. It cannot be measured

10. In an operation 8 pints of acetone is evaporated per hour. Acetone has a TLV of 2 per cent by volume in air and a specific gravity of 0.79. The chemical formula for acetone is $(CH_3)_2$ CO. The atomic weight of carbon is 12, hydrogen is 1, and oxygen is 16. The value of general ventilation air flow rate to keep the concentration of acetone at 1.5 percent using a factor of safety of 6 is:

    a. 16,465 ft^3/min

    b. 17,565 ft^3/min

    c. 8,641 ft^3/min

d. 1,680 ft^3/min

11. A 55 gallon drum of gasoline has been spilled in a storage area and is evaporating at the rate of 8.0 pints per hour. Assuming that the chemical formula for gasoline is C_8 H_{18}, and that gasoline has a specific gravity of 0.7, what is the required rate of air flow to keep the concentration of gasoline in the air at 1 volume percent? Since gasoline is highly flammable, use a factor of safety of 8 (atomic weight of carbon is 12 and that of hydrogen is 1.)

    a. 16,173 ft^3/min

    b. 1,462 ft^3/min

    c. 875 ft^3/min

    d. 15,837 ft^3/min

12. A solvent is evaporating at the rate of 0.9 ft^3/min in a room having dimensions of $20 \times 15 \times 10$. The ventilation rate in the room is 1,500 ft^3/min. Assuming STP conditions, the concentration of the solvent vapor in a room after two hours is:

    a. 300 ppm

    b. 600 ppm

    c. 0.06 ppm

    d. 0.5 ppm

13. The concentration of acetone in a laboratory is 3,000 ppm. If we start the general ventilation in the lab at the rate of 3,000 ft^3/min and the lab has a volume of 10,000 ft^3, the concentration of acetone after 20 minutes is:

    a. 11.0 ppm

    b. 7.4 ppm

    c. 16.2 ppm

    d. 24.7 ppm

14. How long would it take to reduce the concentration of contaminants from 1,000 ppm to 50 ppm in a room which has a volume of 15,000 ft^3 and a general ventilation rate of 2,500 ft^3/min?

    a. 24 minutes

    b. 12 minutes

    c. 18 minutes

    d. 35 minutes

15. The rate of dilution ventilation to reduce the concentration of contaminants from 5,000 ppm to 50 ppm in 10 minutes in a room having a volume of 7,000 ft^3 is:

    a. 6,745 ft^3/min

b. 3,223 ft^3/min

c. 5,462 ft^3/min

d. 7,293 ft^3/min

16. When designing or operating a local exhaust system, one important factor is:

a. That the system fails if any fugitive emissions occur.

b. Design to remove all emitted contaminants.

c. The exhaust air volume flow rate must be proportional to the contaminant generation rate.

d. Local exhaust systems do not provide dilution ventilation.

17. Air is flowing in a ventilation duct with a velocity of 1,000 feet per minute. The hood static pressure is -2.0 inches of water. The total pressure is:

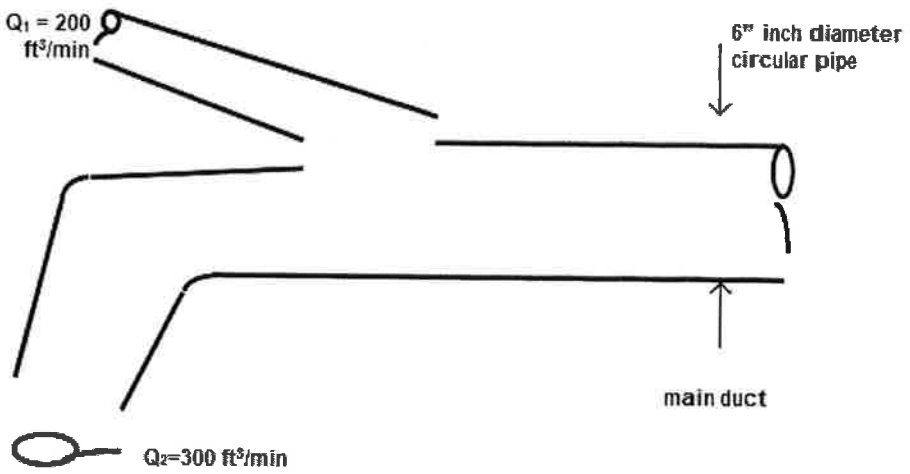
a. -2.60 inches of water

b. -1.94 inches of water

c. +2.60 inches of water

d. -0.80 inches of water

18. In the diagram shown below, the velocity pressure in the 6 inch duct is (assume STP):



a. -0.302 inches of water

b. +0.762 inches of water

c. -0.108 inches of water

d. +0.404 inches of water

19. The root mean square sound pressure for a sound wave is 0.4 pascals. The sound pressure level in decibels relative to 20 micropascals is:

a. 80

b. 90

c. 75

d. 86

20. What is the noise dose for a worker who is exposed to a 95 dBA source for a period of 5 hours?

a. 165%

b. 125%

c. 93%

d. 315%

21. A worker is exposed to noise level of 110 dBA for one hour, 95 dBA for 3 hours, and 90 dBA for 3 hours. The noise dose for this worker is:

a. 500%

b. 275%

c. 425%

d. 312%

22. Two machines each generate a noise level of 80 dBA. When both machines work simultaneously, the noise level is approximately:

a. 85 dBA

b. 83 dBA

c. 86 dBA

d. 160 dBA

23. In a machine shop, a worker is exposed to the following levels of noise:

Noise level, dBA	Duration, hours
91	3
105	1
98	2

The noise dose expressed in percentage of the OSHA permissible exposure is:

a. 423 %

b. 87 %

c. 219 %

d. 215 %

24. A square ventilation duct 2 feet on each side connects two rooms through a 20 feet length of the duct. A noise reduction of 0.2 dB/ft of duct is required. What should the sound absorption coefficient of the lining material be?

    a. 0.9176

    b. 0.612

    c. 0.526

    d. 0.186

25. What is the noise reduction in decibels per foot of a 2 ft. diameter circular duct lined with a material having a sound absorption coefficient of 0.75?

    a. 1.4

    b. 2.3

    c. 3.8

    d. 2.9

26. A sound absorbing material with an absorption coefficient of 0.8 is used as lining in a circular duct and provides a noise reduction of 3.0 dB per foot. The diameter of the circular duct is:

    a. 24 inches

    b. 6 inches

    c. 15 inches

    d. 12 inches

27. A sound wave has a sound pressure level of 95 dB with respect to 20 micropascals. The root mean square sound pressure of this wave expressed in units of pascal is:

    a. 9,500

    b. 5.2

    c. 1.12

    d. 0.8

28. The cochlea is the main element of the:

    a. Inner ear

    b. Middle ear

    c. Outer ear

    d. Tympanic membrane

29. Noise Induced Hearing Loss (NIHL) results from over-exposure to high levels of noise. NIHL depends on sound intensity and the exposure time. Which of the following statements is generally true regarding NIHL?

    a. High frequency noise is more damaging

    b. Low frequency noise is more damaging

    c. NIHL depends only on the sound intensity and time of exposure

    d. Only (b) and (c) above

30. Temporary Threshold Shift (TTS) in hearing is caused as a result of damage to which of the following?

    a. Cochlea

    b. Incus

    c. Organ of corti

    d. Tympanic membrane

31. In a machine shop, a worker is exposed to the following levels of noise:

Noise level, dBA	Duration
90	1 hour
110	5 minutes
95	2 hours

    Which of the following statements is true?

    a. The shop is not in compliance with OSHA noise exposure requirements.

    b. We need additional data to calculate 8-hour TWA sound level for OSHA requirements.

    c. The shop is in compliance with OSHA requirements.

    d. The shop is not in compliance with OSHA requirements. However, use of hearing protectors would bring the shop in compliance.

32. Raynaud's Syndrome is an occupational disease caused as a result of:

    a. Over-exposure to excessive noise

    b. Over-exposure of hands to vibration

    c. Repetitive movement of back muscles

    d. Over-exposure to ultraviolet radiation.

33. Which of the following statements is true regarding radioisotopes of a given material which are capable of radioactive decay?

    a. Same atomic number but different atomic mass

b. Same atomic number and same atomic mass

c. Different atomic number, different atomic mass

d. Different atomic number, same atomic mass

34. Which of the following statements is true regarding Radon $_{222}Rn^{86}$?

a. It has 86 protons and 222 neutrons

b. It has 86 electrons and 222 neutrons

c. has 86 protons and 222 electrons

d. has 86 protons and 136 neutrons

35. The half-life of Radon $_{222}Rn^{86}$ is 3.8 days. If we start with one gram of radon, how many days would it take to reduce the weight to 1/16 of a gram?

a. 7.6

b. 11.4

c. 15.2

d. 19.0

36. The half-life of Radon $_{222}Rn^{86}$ is 3.8 days. The decay constant for radon expressed in units of sec^{-1} is:

a. 2.1×10^{-6}

b. 6.3×10^{-5}

c. 8.4×10^{-7}

d. 7.3×10^{-4}

37. The decay constant for a radioactive material is 2.0×10^{-10} sec^{-1}. How long would it take to reduce the activity of this material to 15 percent of its original value?

a. 600 years

b. 300 years

c. 100 years

d. 1,000 years

38. The decay constant for a radioactive material is 1.4×10^{-8} sec^{-1}. The half-life of this material is:

a. 3.52 years

b. 7.89 years

c. 12.63 years

d. 1.57 years

39. The amount of radiation emitted by a source at 2 feet away from the source is 0.06 rem. What level of radiation we expect to measure at 6 feet away from the source?

    a. 0.02 rem

    b. 6.66×10^{-3} rem

    c. 0.12 rem

    d. 0.18 rem

40. The level of radiation at 2 feet from an X-ray machine is A rem. At what distance from the source would the radiation level drop to 0.1A?

    a. 40 ft

    b. 12 ft

    c. 6 ft

    d. 20 ft

41. A Geiger-Mueller radiation measuring instrument is suitable for measuring which of the following types of ionizing radiation?

    a. Gamma rays

    b. Alpha rays

    c. Beta rays

    d. All of the above

42. Luminescent radiation detectors are suitable for measuring which type of ionizing radiation?

    a. Beta rays

    b. Gamma rays

    c. Laser radiation

    d. Alpha rays

43. Which of the following (s) is (are) examples of somatic effects of ionizing radiation?

    a. Cancer

    b. Reddening of skin

    c. Cataracts

    d. All of the above.

44. Which of the following is most likely to affect the radioactive properties of a radioactive material?

    a. Nuclear reaction

b. Boiling

c. Melting

d. Sublimation

45. Erythema is caused by:

a. Over-exposure to beta rays

b. Over-exposure to sensitizers

c. Over-exposure to materials having high flash point

d. Over-exposure to sunlight

46. Scotoma which is loss of vision in a portion of the visual field is most likely to be caused by which of the following types of non-ionizing radiation?

a. RF radiation

b. Microwave

c. Infrared

d. Ultraviolet

47. LD_{50} is:

a. The chemical dosage which causes death in 50 per cent of a selected population of laboratory animals.

b. Used only for toxicity representation when the route of entry of the chemical is by ingestion or skin absorption.

c. Expressed in units of chemical weight per body weight.

d. All of the above.

48. When the route of entry of a chemical into the body is by the inhalation of a gas or vapor, the toxicity information is expressed as:

a. LD_{50} and PEL

b. LC_{50}

c. Toxicity by inhalation (TI)

d. Route of entry has no effect on presentation of toxicity data

49. Simple asphyxiants are those chemicals which:

a. Can interfere with normal hemoglobin function and deprive the body of oxygen.

b. Cause suffocation by reducing oxygen concentration.

c. Are inert gases but once in the body are more reactive with blood than oxygen.

d. Only (a) and (c) above.

50. Chemicals that attack the liver upon entry into the body are called:

    a. Kiverosis

    b. Nephrotoxins

    c. Neurotoxins

    d. Hepatotoxins

51. If the air contains 500 ppm of acetone (TLV, 750 ppm), and 50 ppm of MEK (TLV, 200 ppm):

    a. A Self Contained Breathing Apparatus (SCBA) must be used.

    b. The mixture TLV is above the recommended values.

    c. The concentration of the mixture is below recommended values of TLV.

    d. Only the TLV of the most hazardous component must be taken into account.

52. Air contains 700 ppm of methane (CH_4). How many grams of methane are in a room that has a volume of 25 cubic meters?

    a. 16

    b. 21

    c. 11.5

    d. 5

    The atomic weight of carbon is 12 and that of hydrogen is 1.

53. If the wavelength of an electromagnetic radiation is 10 mm, its period is:

    a. 1×10^{-9} sec

    b. 3×10^{-6} sec

    c. 4.2×10^{-8} sec

    d. 3.3×10^{-11} sec

54. The exposure rate from a radiation source is 4 mrem/hr. In order to reduce exposure, 4 inch of shielding with a buildup factor of 3.00 and an attenuation coefficient of 0.6 cm^{-1} is added to the source. The intensity of attenuated radiation is:

    a. 3.126 mrem/hr

    b. 6.725 mrem/hr

    c. 0.027 mrem/hr

    d. 8.623 mrem/hr

55. A source is emitting electromagnetic radiation with a wavelength of 5 cm and an average power of 3,000 W. If the antenna has an area equal to 1 m^2, the power density at 100 meters from the antenna is:

a. 300 W/m^2

b. 120 W/m^2

c. 30 W/m^2

d. 600 W/m^2

56. A gamma source with energy of 3.5 MeV has a Curie strength of 400 millicurie. The expected radiation level at a distance of 1 ft. from this source is equal to:

a. 6.2 R/hr

b. 2.3 R/hr

c. 12.5 R/hr

d. 8.4 R/hr

57. The sound pressure level at a distance of 4 ft. from a sound source is 96 decibels. The sound pressure level at 12 ft. away from this sound source is:

a. 90 decibels

b. 82 decibels

c. 86 decibels

d. 94 decibels

58. If the distance from a sound source is doubled, the reduction in sound pressure level is:

a. 4 decibels

b. 8 decibels

c. 12 decibels

d. 6 decibels

59. In industrial noise control, every attempt must be made to reduce noise level by means of engineering controls. One way to accomplish this is treatment of ceilings with sound absorbing materials such as fiberglass. In a machine shop with a ceiling area of 6,000 ft^2 and sound absorption coefficient of 0.04, the ceiling was treated with a sound absorbing material which has a coefficient of absorption of 0.8. The amount of noise reduction in this machine shop is:

a. –13 decibels

b. 48 decibels

c. 24 decibels

d. 8 decibels

60. The time weighted average noise exposure for a worker is 95 decibels in a shift. The noise dose is:

a. 120%

b. 199%

c. 50%

d. 190%

61. The average velocity pressure in the duct of a hood is 0.70 inches of water gauge. If the hood static pressure measures 1.30 inches of water gauge, the hood entry coefficient is equal to:

a. 9.1

b. 0.91

c. 0.80

d. 0.73

62. The velocity pressure for a hood which has a coefficient of entry equal to 0.85 and a static pressure equal to 1.1 inches of water is:

a. 0.25

b. 0.79

c. 0.40

d. 0.65

63. The velocity pressure for a hood with a coefficient of entry of 0.70 measures 0.90 inches of water. The static pressure for this hood is:

a. 1.84 in. water

b. 0.63 in. water

c. 1.28 in. water

d. 0.73 in. water.

64. In a manufacturing facility a chemical with a TLV of 200 ppm is vaporized at the rate of 0.5 cfm. In order to keep the concentration of this chemical at or below the TLV level, the minimum dilution ventilation rate must be:

a. 100 cfm

b. 400 cfm

c. 4,000 cfm

d. 2,500 cfm.

65. A volatile chemical with a TLV of 50 ppm is used in a laboratory which has an effective dilution ventilation rate of 4,000 cfm. The maximum allowable vapor generation for this chemical is:

a. 0.8 cfm

b. 0.5 cfm

c. 0.2 cfm

d. 0.9 cfm

66. In a manufacturing facility the ventilation system is designed to generate an effective dilution ventilation rate of 3,000 cfm. The rate of vapor generation of a chemical is expected to be 0.75 cfm. The TLV of this chemical must not exceed:

a. 50 ppm

b. 250 ppm

c. 1,000 ppm

d. 750 ppm.

67. The effective ventilation rate for an actual ventilation rate of 16,000 cfm with a factor of safety of 8 is:

a. 128,000 cfm

b. 48,000 cfm

c. 2,000 cfm

d. 4,000 cfm

68. A hazardous chemical is stored in a room at sea level where barometric pressure is 760 mm Hg. The vapor pressure of this chemical at 75° F is equal to 200 mm Hg. The saturation concentration of this chemical in the room at 75° F is:

a. 15,000 ppm

b. 57,000 ppm

c. 162,943 ppm

d. 263,158 ppm

69. It has been determined that the saturation concentration of a chemical at 80° F is 123,000 ppm. If the barometric pressure is 760 mm Hg, the vapor pressure of this chemical at 80° F is:

a. 62.51 mm Hg

b. 93.48 mm Hg

c. 12.30 mm Hg

d. 76.25 mm Hg

70. In a ventilation system, the static pressure on the outlet side of the fan is equal to 0.7 in. wg. If the static pressure on the inlet side of the fan is 3.5 in. wg below atmosphere and the velocity pressure is 1.5 in. wg, the fan static pressure is equal to:

a. 2.7 in. wg

b. 5.0 in. wg

c. 1.3 in. wg

d. 4.2 in. wg

71. A hood has a square opening with each side equal to 6 in. The hood has been designed to have a volumetric flow rate of 16,000 cfm. This hood is to be used to remove contaminant vapors 5 feet away from the opening. The capture velocity at 5 feet must be at least:

a. 30.23 fpm

b. 25.12 fpm

c. 63.93 fpm

d. 86.42 fpm

72. A hood has a circular opening with a diameter equal to 10 inches. The hood is to be used in a laboratory to remove contaminant vapors at a distance of 4 feet away from the hood opening with a capture velocity of 200 fpm. The volumetric flow rate of air through this system must at least be:

a. 2,000 cfm

b. 8,000 cfm

c. 6,123 cfm

d. 32,108 cfm

73. The hood entry loss for a hood with a duct velocity pressure equal to 0.90 inches of water gauge (in. wg) and a hood entry coefficient equal to 0.80 is equal to

a. 0.5 in. wg

b. 0.72 in. wg

c. 0.80 in. wg

d. 0.64 in. wg.

74. A hood with an entry coefficient of 0.72 and a static pressure equal to 2.5 in. wg has an average air velocity through the duct equal to:

a. 3,622 fpm

b. 4,559 fpm

c. 3,856 fpm

d. 5,268 fpm

75. The static pressure for a hood with average air velocity of 5,000 fpm and coeffiecient of entry equal to 0.8 is equal to:

a. 1.72 in. wg

b. 4.00 in. wg

c. 2.43 in. wg

d. 3.85 in. wg

76. All of the following statements are true in regard to the instrument called a "velometer" EXCEPT:

a. It measures air velocity

b. It measures highly sensitive electrical voltage

c. It can be useful in conducting energy audits

d. It can be useful in hood and spray booth monitoring

77. You are standing 2 feet from a radiation source. How far should you move away to reduce your exposure to 1/100 of the original value?

a. 10 feet

b. 5 feet

c. 20 feet

d. 40 feet

78. The amount of radiation produced by a source at an unknown location away from the source is 500 rems. The radioactivity measured at 10 meters from the source is 50 rems. At what distance from the source the activity of 500 rems was measured?

a. 10.50 meters

b. 3.16 meters

c. 6.32 meters

d. 8.75 meters

79. A radioisotope emitting gamma rays has a half-life of 500 years. How long would it take to reduce the activity of this material to less than 15 percent of its original value?

a. 1,000 years

b. 1,500 years

c. 2,000 years

d. 2,500 years

80. A centrifugal fan used in a ventilation system delivers a flow rate of 100 cfm. What is the flow rate if the speed of the fan is tripled?

a. 10,000 cfm

b. 10 cfm

c. 300 cfm

d. 600 cfm

81. If the impeller speed of a centrifugal speed fan is increased from 100 to 400 rpm; horse power will increase by a factor of:

a. 24

b. 16

c. 64

d. 8

82. An atmosphere is generally considered to be oxygen deficient when the concentration of oxygen falls below:

a. 21% by volume

b. 16.5% by volume

c. 19.5% volume

d. 15.5% by volume

83. A liquid contains 40 percent (by weight) heptane with a TLV = 1,600 mg/m^3 and 60 percent (by weight) methylchloroform with a TLV = 1,900 mg/m^3. The TLV for the mixture is:

a. 1,800 mg/m^3

b. 1,685 mg/m^3

c. 2,010 mg/m^3

d. 1,767 mg/m^3

84. Air contains 700 ppm of methane (CH_4). How many grams of methane is in a room that has a volume of 25 cubic meters? The molecular weight of methane is 16.

a. 16

b. 21

c. 11.5

d. 5

85. What is the moisture content of air on a day when the dry bulb temperature is 80 °F and the relative humidity is 70%?

a. 0.016 lb of water per pound of dry air

b. 0.08 lb of water per pound of dry air

c. 0.07 lb of water per pound of dry air

d. 0.56 lb of water per pound of dry air

86. A liquid mixture contains 40 percent (by weight) heptane, 20% methyl chloroform, and the balance perchloroethylene. Assuming that all of this liquid evaporates, and that the atmospheric composition is similar to that of the original liquid. The TLV for the gaseous mixture generated from this liquid is equal to which of the following? The TLV for individual components are:

heptane: TLV = 1,600 mg/m3

methyl chloroform: TLV = 1,900 mg/m3

perchloroethylene: TLV = 335 mg/m3

a. 723 mg/m^3

b. 1,232 mg/m^3

c. 645 mg/m^3

d. 957 mg/m^3

87. According to Raoult's Law, in a binary system, when liquid and vapor phases have reached equilibrium:

a. The vapor has a higher concentration of the more volatile component as compared to the liquid.

b. The liquid has a higher concentration of the more volatile component as compared to the liquid.

c. The concentration of the less volatile component is the same in the vapor and liquid phases.

d. Raoult's Law deals with electricity and magnetism and does not address vapor/liquid equilibria.

88. Fick's Law deals with:

a. Diffusion

b. Heat transfer

c. Fluid flow in pipes

d. Friction

89. The time-weighted exposure limit for worker exposure to a chemical is 100 ppm and the threshold limit value ceiling is 500 ppm. An employee is working in a laboratory where the concentration of the chemical is at a constant level of 400 ppm. How many hours can the employee work in this laboratory without being overexposed to the chemical?

a. 4

b. 3

c. 2

d. 1

90. A flammable liquid has been spilled in a laboratory (dimensions 10 m × 20 m × 14 m) and has completely evaporated into the lab space. The molecular weight of the liquid is 70 and it has a specific gravity of 0.6. The concentration of vapor in the room is 5,000 ppm. How many liters of this liquid were spilled? Assume that density of water is 1,000 g/L.

a. 66.8

b. 78.7

c. 54.6

d. 48.8

91. Which of the following tests is used to evaluate the mutagen-producing capability of a chemical?

a. Carcinogen test

b. Muta assay

c. Ames test

d. DNA test

92. A relatively new instrument has been given the name "Cutie Pie" and the user acceptance has been more enthusiastic than any previous instrument of this type. Which of the following is correct regarding Cutie Pie?

a. It is a portable beta and gamma radiation meter.

b. It measures the transmission or absorption of liquids or solids as a function of wavelength.

c. It is an instrument used for measuring air flow and velocity for hood design.

d. It is an instrument that is capable of analyzing a mixture and separating the mixture's components according to their molecular weights.

93. All of the following are forms of penetrating radiation EXCEPT:

a. X-rays

b. Gamma rays

c. Alpha rays

d. Beta rays

94. Which of the following instruments is used to measure noise that is variable over a time period?

a. Sound level meter

b. Spectrum analyzer

c. Frequency analyzer

d. Integrating meter

95. Ten gallons of a chemical with a molecular weight of 60 and a TLVC (threshold limit value ceiling) of 500 ppm is released into a 30 ft × 30 ft × 15 ft laboratory. Specific gravity is 0.6. Which of the following statements is true?

a. TLVC has been exceeded

b. TLVC for the 8-hour shift might not have been exceeded

c. TLVC has not been exceeded

d. TLVC has not been exceeded but PEL (permissible exposure limit) might have been exceeded

96. Which of the following personal protective equipment must be used in an atmosphere that is immediately dangerous to life or health (IDLH)?

a. Negative pressure SCBA

b. Positive pressure SCBA

c. SCBA with indirect ventilation ports

d. SCBA with direct ventilation ports

97. According to the Center for Disease Control (CDC), which of the following statements is true in regard to the chemical benzene (C_6H_6)?

a. Benzene works by causing cells to not work correctly

b. It can damage the immune system

c. It changes levels of antibodies in the blood

d. All of the above

98. One of the major health effects of polychlorinated biphenyls (PCBs), which were widely used in electrical transformers, is cancer. Which of the following is NOT an adverse non-cancer health effect of PCBs?

a. Effects on the immune system

b. Effects on the reproductive system

c. Effects on the nervous system

d. Effects on the digestive system

99. Which of the following statements is correct in regard to bloodborne pathogens described in the OSHA bloodborne pathogen standard (29 CFR 1910.1030)?

a. They are pathogenic microorganisms that are present in human blood and can cause disease in humans

b. Hepatitis B virus (HBV) is an example of these pathogens

c. Human immunodeficiency virus (HIV) is an example of these pathogens

d. All of the above

100. According to the Center for Disease Control (CDC), there are four biosafety levels (BSL-1 through -4). Which of the following statements is NOT true in regard to biosafety levels?

a. In BSL-1, the microbes are known to consistently cause disease in healthy adults.

b. In BSL-2, the microbes pose moderate hazards to humans and the environment.

c. In BSL-3, the microbes can cause serious or potentially lethal disease.

d. In BSL-4, the microbes pose a high risk of infections that are frequently fatal.

101. Sick Building Syndrome (SBS) is a situation in which occupants of a building experience acute health effects that seem to be linked to time spent in a building, but no specific cause can be identified. Which of the following is NOT part of what causes SBS?

a. Contaminants from outdoor sources

b. Contaminants from indoor sources

c. Too many glass windows

d. Biological contaminants

102. Which of the following statements is true in regard to dosimeters (film badges) for radiation monitoring?

a. They are not capable of measuring alpha or soft beta emitters with an average energy less than 100 keV.

b. Only the person who is assigned a film badge shall wear it.

c. Dosimeters should be worn whenever there is a possibility of being exposed to ionizing radiation.

d. All of the above.

103. Q fever is a worldwide disease with acute and chronic stages caused by the bacteria Coxiella burnetii. Which of the following animals are the primary reservoir(s) for this bacteria?

a. Cattle

b. Sheep

c. Goats

d. All of the above

104. Which of the following statements is NOT true in regard to the acute disease anthrax?

    a. It affects both humans and animals

    b. Most forms of the disease are lethal

    c. Some forms of the disease respond well to antibiotics

    d. There are no effective vaccines against anthrax

105. Which of the following statements is NOT true in regard to heat syncope?

    a. It is fainting as a result of overheating

    b. It is caused by mild overheating with inadequate water or salt

    c. It occurs when blood pressure is raised as a result of overexposure to heat

    d. It can be treated by positioning the patient in a seated position with legs raised, administering water slowly, and moving the patient to a cooler area

106. Which of the following statements is NOT true in regard to infrared radiation?

    a. It is absorbed by the skin

    b. It is absorbed as heat

    c. It is absorbed by the eyes

    d. It is a form of ionizing radiation

107. Lasers typically emit which of the following optical radiations?

    a. Ultraviolet (UV)

    b. Visible light

    c. Infrared radiation (IR)

    d. All of the above

108. Which of the following statements is true in regard to Draeger tube systems?

    a. They are glass vials filled with a chemical that reacts to a specific chemical or family of chemicals

    b. A known volume of air is drawn through a tube with a pump

    c. If the targeted chemicals are present, the chemical in the tube changes color

    d. All of the above

109. Which of the following statements is true in regard to the Ames test?

    a. It is an indirect assay for potential carcinogens

    b. It uses several strains of the bacterium *Salmonella typhimurium*

    c. It identifies mutagens that are also possible carcinogens

d. All of the above

110. Which of the following diseases is caused by inhalation of metal fumes or dust generated in most welding and grinding operations?

a. Siderosis

b. Byssinosis

c. Brucellosis

d. Presbycusis

111. Which of the following statements is true in regard to threshold limit values (TLVs)?

a. TLV–time weighted average (TWA) is based on the average exposure in an eight hours per day, 40 hours per week schedule.

b. TLV–short term exposure limit (STEL) is spot exposure for 15 minutes and cannot be repeated more than four times a day.

c. TLV–ceiling (TLVC) is the exposure limit that cannot be exceeded even momentarily.

d. All of the above

112. All of the following are areas used in the design of HVAC systems EXCEPT:

a. Heat transfer

b. Diffusion

c. Fluid mechanics

d. Thermodynamics

113. Which of the following statements is true regarding demand control ventilation to maintain acceptable indoor air quality?

a. Carbon monoxide sensors are used to control the rate of air flow.

b. Carbon dioxide sensors are used to control the rate of air flow.

c. Oxygen sensors are used to control the rate of air flow.

d. All of the above

114. When manually lifting a load, the load must be kept:

a. As far away from the body as possible.

b. As low as possible.

c. As close to the body as possible.

d. In such a way that the line through the center of gravity of the load makes an angle of 80 degrees with the hands.

115. The moment generated on the back muscles of a woman as a result of lifting a load compared to the moment generated on the back muscles of a man lifting the same load is generally:

    a. Smaller

    b. Larger

    c. Same

    d. Depends on the shape of the load

116. In lifting a load:

    a. The back should be kept naturally straight

    b. The load must be lifted using legs

    c. The back should make a 90° angle with the load

    d. Only (a) and (b) above

117. The science that applies the knowledge related to human capabilities and limitations to the design of work environments is called:

    a. Anthropometry

    b. Epidemiology

    c. Ergonomics

    d. Anthropology

118. In designing a piece of equipment, the controls and displays must conform to which of the following principles?

    a. Controls must be positioned opposite to the displays.

    b. The movement of controls should follow the principle of non-congruity.

    c. If the display moves to the right, the control should move counterclockwise.

    d. Displays should generally move in the same direction as movement of controls.

119. Some industrial tasks may cause tendonitis, bursitis, or carpal tunnel syndrome. Which one of the following is more likely to cause these diseases?

    a. One time lifting of a very heavy object

    b. Extensive use of visual display terminals

    c. A static load on hand and shoulder

    d. Frequent twisting in low back area

120. In occupational ergonomics, the abbreviation CTD stands for:

    a. Carpal tunnel disorders

b. Caption translation for deaf

c. Critical task design

d. Cumulative trauma disorders

121. To prevent overexertion from manual material handling tasks, a comprehensive and systematic approach is needed involving all elements of a work system. Which one of the following is more likely NOT to be included in such an analysis?

a. Object's material and toxicity

b. Object's weight

c. Worker characteristics

d. Available mechanical lifting aids

122. Approximately what percent of musculoskeletal injuries are caused by pushing or pulling objects?

a. 2%

b. 6%

c. 20%

d. 40%

123. What is the approximate pushing force (in pounds) that a healthy young male can exert on an object, if the floor coefficient of friction is 0.3?

a. 12

b. 18

c. 44

d. 81

124. The probability of tipping over an object by pushing it increases as the:

a. Grasping point moves above the object's center of gravity

b. Grasping point moves toward the worker's center of gravity

c. Grasping point moves below the object's center of gravity

d. Grasping point becomes more parallel to the object's center of gravity

125. In designing a task requiring pushing objects, it is advantageous to consider which of the following?

a. Use the body weight to lift and then push the object.

b. Use a mechanical aid as a leverage to lift the load.

c. Use the body weight to push without any lifting force applied.

d. Reduce the coefficient of friction to make it easy for the load to slide.

126. Based on anthropometric data, the design features of a work station should accommodate which of the following range of measurements?

a. 0 to 100 percent of population

b. 5th to 95th percentile

c. 10th to 90th percentile

d. 50th percentile

127. A piece of equipment is being designed which requires workers to stand and reach vertically to activate its emergency switch. Which one of the following do you recommend for the design of the height of the switch?

a. The 5th percentile of female population

b. The 95th percentile of male population

c. The 50th percentile of average person

d. The 90th percentile of male population

128. A worker lifts finished products from an assembly line that is 20 inches above the floor and places them in boxes that are located 35 inches above the floor. The weight of each product is 15 lbs. For each lift, the distance of hands away from midpoint between ankles is 12 inches. In order to properly place the load at its destination, the worker needs to turn 45 degrees. The worker places 5 finished products in boxes every minute. The coupling type is classified as "Good." The LI at the origin and destination for 3 hours of continuous work are respectively:

a. 1.150, 1.355

b. 0.934, 1.722

c. 1.349, 0.836

d. 2.739, 0.728

129. The term "heat stress" deals with which of the following?

a. Too much heat gained by the body

b. Too much heat loss from the body

c. Both heat loss from or heat gained by the body

d. When body temperature is above 110°F

130. Illumination is measured in which of the following units?

a. Foot-candle

b. Light index

c. Lux

d. Illuminance

131. Which of the following statements is the correct definition of "dose"?

a. Time-weighted TLV

b. Short term exposure limit

c. Concentration multiplied by exposure duration

d. Slope of the dose-response curve

132. Which of the following best describes the science of epidemiology?

a. It deals with prevention of disease in a population.

b. It deals with frequency of diseases in a population.

c. It deals with distribution of diseases in a population.

d. All of the above.

133. Which of the following is the correct description of "Presbycusis"?

a. A condition caused as a result of overexposure to metal fumes.

b. An irreversible hearing loss caused by damage to organ of "corti" and degeneration of neural elements of the auditory nerve.

c. Loss of sensitivity to high frequency noise as a result of aging

d. Lack of ability of a person to interpret what is heard.

134. The type of radiation which is capable of dislodging electrons from the atoms is called:

a. Laser radiation.

b. Ultraviolet radiation.

c. Ionizing radiation.

d. All of the above.

135. A radioactive material has a half-life of 200 days. If we start with 500 grams of this material, how many grams is left after 450 days?

a. 250 grams

b. 210 grams

c. 325 grams

d. 105 grams

136. Which of the following statements is correct regarding nanoparticles?

a. Are particles between 1 and 100 nanometers (nm) in size with a surrounding interfacial layer.

b. Through nanotechnology, nanoparticles can help make materials lighter, more durable, and more reactive.

c. Naturally occurring nanoparticles can be found in volcanic ash, ocean spray, fine sand and dust, and even biological matter (e.g. viruses).

d. All the above.

137. Employees who abuse alcohol and drugs can pose significant safety and other problems for their employers, managers, and co-workers. Some of the signs of drug and alcohol abuse are diminished job performance, lower productivity, absenteeism, tardiness, mood changes, and problems with relationships. You suspect that one of your employees is abusing drugs. Your company's drug and alcohol testing policy does not include drug testing for reasonable suspicion. All the following are among the actions you should take EXCEPT:

a. Document any complaints, concerns, behavior patterns or witnesses to the behavior.

b. Observe employee's behaviors with a second management person.

c. Meet with the employee.

d. Ask the employee to agree to a drug test to avoid disciplinary action.

138. According to the results of a National Institute for Drug Abuse (NIDA) sponsored survey, which of the following statements is true?

a. Drug-using employees are 3.6 times more likely to be involved in a workplace accident.

b. Drug-using employees are 2.5 times more likely to have absences of eight days or more.

c. Drug-using employees are three times more likely to be late for work.

d. All the above.

139. Which of the following are signs that an employee might be abusing drugs?

a. Frequent tardiness and several unexplained absences.

b. Inconsistency on job performance.

c. Causing several small incidents which resulted in minor injuries.

d. All the above.

140. Any organization that enters a federal contract for the procurement of property or services valued at $100,000 or more or receives any federal grant must comply with the regulations of which of the following acts?

a. Consumer Products Safety Act

b. Federal Water Pollution Control Act

c. Drug-Free Workplace Act

d. Clean Air Act

6.8 Example Answers

1. Select (c)

   Dermatitis, which is classified into primary irritation and sensitization of skin, is the most frequent occupational disease. It is caused by contact with acids, alkaline materials such as soaps and detergents, fabric softeners, solvents, or other chemicals. The reaction usually looks like a burn.

   Other irritants may include:

   - Cement
   - Hair dyes
   - Long-term exposure to wet diapers
   - Pesticides or weed killers
   - Rubber gloves
   - Shampoos

2. Select (a)

   Many workers simply use hands with no PPE to work with petroleum products, greases, and solvents. As a result, dermatitis is the most common occupational disease caused by these products.

   Glanders is an infectious disease that is caused by the bacterium Burkholderia mallei. While people can get the disease, glanders is primarily a disease affecting horses. It also affects donkeys and mules and can be naturally contracted by other mammals such as goats, dogs, and cats.

   Siderosis is a lung disease caused by inhaling metal fumes. Mortality studies among iron workers (welders, iron foundry workers, and steel workers) show that an association exists between working with iron and death from lung cancer and other respiratory causes.

   Carpal tunnel syndrome occurs when the median nerve, which runs from the forearm into the palm of the hand, becomes pressed or squeezed at the wrist. Symptoms include frequent burning, tingling, or itching numbness in the palm of the hand and other fingers. Occupationally speaking, carpal tunnel syndrome is caused by repeated use of vibrating hand tools.

3. Select (a)

   CTD is a term used to describe physical disorders that are caused as a result of repeated movement of body parts. CTDs result when repeated stress is placed on tendons, muscles, or nerves causing inflammation or damage. Some of the more common CTDs are tendonitis (inflammation of the tendons), tenosynovitis (inflammation of the synovial sheath), and carpal tunnel syndrome (compression of the me-

dian nerve). Some of the conditions that may lead to CTDs are repetition, posture, and lack of rest.

4. Select (a)

   $LI = \frac{22}{16} = 1.375$

   Note that a LI that exceeds 1.0 is too much weight for the worker, and the task must be changed to lower the LI.

5. Select (a)

   The correct answer is (a). Pocket dosimeters are used to measure exposure to gamma rays and X-rays. The two types most commonly used in industry are direct read pocket dosimeters (DRPD) and digital electronic dosimeters (DED).

6. Select (c)

   Volume of air in the container initially:

   $20 \times 20 \times 10 = 4{,}000\ ft^3$

   total $CO_2 = 18.9\ ft^3$

   total volume $= 4{,}000 + 18.9 = 4{,}018.9\ ft^3$

   Partial volume of $CO_2 : \frac{V_{CO_2}}{V_{total}} = \frac{18.9}{4{,}018.9}$

   CO_2 concentration $= 4.7 \times 10^{-3}$ volume fraction.

7. Select (a)

   Increase in air velocity increases heat transfer by convection as well as evaporative rate of heat transfer. Heat transfer by convention is directly proportional to the temperature difference and area of heat transfer

   $Q = HA\ (T_1 - T_2)$

   The constant of proportionality H is strongly dependent on the velocity. As velocity increases, so does H resulting in an increase in convective rate of heat transfer.

8. Select (c)

   Dilution ventilation should not be used as a primary control when air contaminants are highly flammable or toxic or when they are produced in high rates. The vapors or gases may collect locally and pose a sever fire or health hazard.

9. Select (b)

   Number of air changes per hour does not accurately reflect the actual dilution of air contaminants. For example, a room with a ceiling height of 8 feet will have twice the air changes per hour of a room with a 16 feet ceiling, assuming each has the same air volume flow rate.

10. Select (b)

    The formula for calculation of general ventilation air flow rate is

$Q = \frac{(403)(\text{S.G.})(P \times 10^6)(K)}{(\text{M.W.})(L)}$

Where:

Q is the required air flow in ft^3/min.

S.G. is the specific gravity of solvent

P is number of pints evaporated every hour

K is the factor of safety

M.W. is the molecular weight of solvent

L is maximum concentration allowed; for example LFL or TLV in parts per million.

Molecular Weight of acetone = $(15) \times 2 + 12 + 16 = 58$

$Q = \frac{(403)(0.79)(8 \times 10^6)(6)}{(58)(1.5 \times 10^4)}$

Q = 17,565 ft^3 / min.

11. Select (d)

$Q = \frac{(403)(\text{S.G.}) \times 10^6 \times P \times K}{(\text{M.W.})(L)}$

M.W. = $8(12) + 18 = 114$

$Q = \frac{(403)(0.7) \times 10^6 \times 8 \times 8}{(114)(1) \times 10^4} = 15{,}837 \frac{ft^3}{min}$

12. Select (b)

This problem can be solved by using the following equation

$C = \frac{G}{Q}(1 - e^{-Qt/V})$

$C = \frac{0.9}{1500}\left(1 - e^{-\frac{(1500)(120)}{3000}}\right)$

$C = 600$ ppm

Where:

G is the rate of generation of air contaminants in ft^3/min

Q is the ventilation rate in ft^3/min

C is the concentration of contaminants in after t minutes

V is the volume of room in ft^3.

Note: We have multiplied the value of C calculated from the above equation by 10^6 to convert it to parts per million (ppm).

13. Select (b)

The following equation can be used to solve this problem

$Ln\frac{C_2}{C_1} = \frac{-Q}{V}(t_2 - t_1)$

where:

C_2 is concentration after t_2 minutes form start of ventilation

C_1 is concentration at the start of ventilation

Q is rate of ventilation in ft^3/min

V is the volume of room in ft^3.

$Ln\frac{C_2}{3000} = \frac{-3000}{10{,}000}(20)$

$Ln\frac{C_2}{3000} = -6$

$\frac{C_2}{3000} = e^{-6}$

$C_2 = 7.4ppm.$

14. Select (c)

$Ln\frac{C_2}{C_1} = \frac{-Q}{V}(t_2 - t_1)$

$Ln\frac{50}{1000} = \frac{-2500}{15{,}000}(t_2 - t_1)$

$(t_2 - t_1) = 18$ minutes

15. Select (b)

$Ln\frac{C_2}{C_1} = \frac{-Q}{V}(t_2 - t_1)$

Solve the above equation for Q:

$Q = \frac{-VLn\frac{C_2}{C_1}}{t_2 - t_1}$

$Q = \frac{-7000Ln\frac{50}{5000}}{10}$

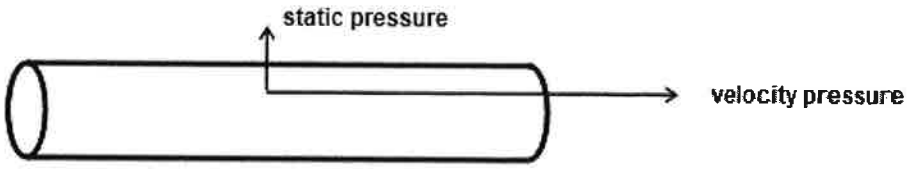
$Q = 3{,}223\ ft^3\ /\ min$

16. Select (b)

As opposed to dilution ventilation, local exhaust ventilation tries to capture, contain, and remove all emitted contaminants before dilution with workroom air. All local exhaust systems experience fugitive emissions. The air volume flow rate is based on physical conditions at the hood, not on contaminant generation rate.

17. Select (b)

In fluid flow, the total fluid pressure has two components, static pressure and velocity pressure. The static pressure is the pressure exerted to the walls of the piping system if the fluid was stationary. Static pressure is exerted in all directions. Velocity pressure is the pressure due to kinetic motion of the fluid and is exerted in the direction of fluid flow as shown in the diagram.



The relationship between total pressure (TP), static pressure (SP), and velocity pressure (VP) is:

TP = SP + VP.

The relationship between air velocity and velocity pressure is

V = 4,005 (VP) ^{½}

where V is air velocity in feet per minute, and VP is velocity pressure in inches of water.

For the problem at hand:

VP = $\frac{(1000)^2}{(4005)^2}$ = 0.06 *inches of water*

TP = - 2.0 + 0.06 = - 1.94

Note: Static pressure can have a positive or negative value. Velocity pressure, on the other hand, always has a positive value.

18. Select (d)

The total volumetric flow rate in the main duct is:

Q = Q_1 + Q_2 = 300 + 200 = 500 ft^3/min

Q = VA

Where Q is volumetric flow rate, V is velocity and A is the area of flow.

500 = $V \times \left(\frac{3.14(6)^2}{4\times144}\right)$

V = 2,548 ft/min.

To obtain velocity pressure we use V = 4,005 $(VP)^{½}$

2,548 = 4,005 $(VP)^{½}$, VP = 0.404 inches of water.

19. Select (d)

The following relationship can be used to calculate the decibel value of a sound wave from root mean square values.

(decibels) = 20 $log\frac{P}{20}$

where P is in micropascals and 20 micropascals is our reference point.

L(decibels) = 20 $log\frac{0.4\times10^6}{20}$ = 86 dB

20. Select (b)

The noise dose can be calculated from:

$D = 100 \sum_{i=1}^{n} \frac{C_i}{t_i}$

where C_i is the exposure time and t_i the allowable time. The allowable time can be calculated from:

$t = \frac{8}{2^{(L-90)/5}}$

where L is the exposure in decibels.

For the problem at hand:

$t = \frac{8}{2^{(95-90)/5}} = 4$ hours

$D = 100\left(\frac{5}{4}\right)$

D = 125% of 8 hr. TWA.

21. Select (d)

First, we calculate allowable times for noise levels of 110, 95, and 90 dB:

$t = \frac{8}{2^{(L-90)/5}}$

$t_{110} = \frac{8}{2^{(110-90)/5}} = 0.5$

$t_{95} = \frac{8}{2} = 4$

$t_{90} = \frac{8}{2^0} = 8$

noise dose $= 100 \sum_{i=1}^{n} \frac{C_i}{t_i}$

$D = \left(\frac{1}{0.5} + \frac{3}{4} + \frac{3}{8}\right) 100$

D = 312% of 8 hour TWA.

22. Select (b)

When in a free field and the difference between two sound levels is zero, we add 3 dB to obtain the combined effect.

23. Select (c)

First, calculate allowable times:

$t_{91} = \frac{8}{2^{(91-90)/5}} = 7$ hours

$t_{98} = \frac{8}{2^{8/5}} = 2.6$ hours

$t_{105} = \frac{8}{2^{15/5}} = 1$ hour

noise dose $= 100\left(\frac{3}{7} + \frac{1}{1} + \frac{2}{2.6}\right)$

noise dose = 219% of 8 hr TWA

24. Select (d)

We use the following equation:

$$\boxed{NR = \frac{12.6P\alpha^{1.4}}{A}}$$

Where NR is the noise reduction in decibels per foot, P is the perimeter of the duct in inches, and A is the cross section area of the duct in square inches.

For the problem at hand:

$0.2 = \frac{12.6\times8\times12\alpha^{1.4}}{24\times24}$

$\alpha = 0.186$

25. Select (a)

$NR = \frac{12.6P\alpha^{1.4}}{A}$

$NR = \frac{12.6\times3.14\times2\times12\times0.75^{1.4}}{3.14(1)^2\times144}$

$NR = 1.4$ decibel/foot

26. Select (d)

$NR = \frac{12.6P\alpha^{1.4}}{A}$

Perimeter $P = 3.14D$

Therefore:

$3 = \frac{12.6(3.14D)(0.8)^{1.4}}{3.14D^2/4}$

$9.42D^2 = 115.79D$

$D(9.42D - 115.79) = 0$

$D = 12.29$ inches

Note that the equation:

$D(9.42D - 115.79) = 0$

has two solutions for D. One is $D = 0$, and the other is obtained by solving:

$9.42D - 115.79 = 0$

or

$D = \frac{115.79}{9.42} = 12.29$ inches

Since the diameter of the duct cannot be zero, we accept the other solution for D, which is 12.29 inches.

27. Select (c)

SPL in decibels $= 20log\frac{\text{rms sound pressure}}{20 \text{ microPascal}}$

$95 = 20\ log\frac{P}{20}$

$log\frac{P}{20} = 4.75$

or we can say $\frac{P}{20}$ is equal to antilog of 4.75 (your calculator should have an antilog function).

$\frac{P}{20} = antilog 4.75 =$ 56,234

or

P = 20 (56,234) = 1,124,682 micropascals

1,124,682 $\times$ 10^{-6} = 1.12 Pascals

P = 1.12 Pascals

28. Select (a)

The cochlea is the main element of the inner ear. It is filled with a fluid and shaped like a coil. Sound waves travel through the cochlea before reaching the hair-like nerve cells for transmission to the brain.

29. Select (a)

Although there are some differences among individuals, exposure to high frequency noise is more damaging to the ears than a low frequency noise having the same sound intensity and for the same exposure time.

NIHL is caused by damage to the microscopic hair cells of the cochlea. A sound level of 85 dB or higher can cause permanent damage to hearing, especially if it has a relatively high frequency.

30. Select (c)

TTS is caused as a result of over-exposure to loud noise which damages the organ of Corti and its hair cells.

The organ of Corti is located in the inner ear and acts like a microphone for the body. It is situated in one of the three parts of the cochlea and contains four rows of hair cells on its surface. There are about 16,000–20,000 hair cells in the basilar membrane following the spiral of the cochlea. Small movements of the layers of membrane trigger the hair cells, which in turn send a very small voltage to the associated nerve fiber, called an axon. These impulses are transferred to the brain for processing.

31. Select (c)

First calculate OSHA allowable times from:

$t = \frac{8}{2^{(L-90)/5}}$ (time in hours)

$t_{90} = \frac{8}{2^{0/5}} = 8$

$t_{95} = \frac{8}{2^{1}} = 4$

$t_{110} = \frac{8}{2^4} = 0.5$

Calculate noise dose from:

$D = 100 \sum_{i=1}^{n} \left(\frac{\text{exposure time}}{\text{allowable time}}\right)_i$

$D = 100 \left(\frac{1}{8} + \frac{2}{4} + \frac{5/60}{0.5}\right)$

D = 79% of 8 hr. TWA.

Since the noise dose percentage does not exceed 100%. This shop is in compliance with OSHA requirements.

32. Select (b)

Raynaud's syndrome, also known as "Dead Fingers" or "White Fingers", results from over-exposure of hands to vibrating tools. The circulation in the fingers of the hand guiding the tool becomes impaired and when these fingers are exposed to cold temperatures, they become white and devoid of sensation.

33. Select (a)

Radioisotopes are unstable isotopes of a given element that can undergo radioactive decay and emit ionizing radiation. Isotopes of a given element have the same atomic number (number of electrons and protons), but different atomic mass (number neutrons plus number of protons)

34. Select (d)

222 is the atomic mass which is the number of protons (which is equal to number of electrons) plus the number of neutrons. 86 is the number of protons in the nucleus which is equal to number of electrons.

number of neutrons = atomic mass – number of protons

222 - 86 = 136

35. Select (c)

Times (day)	Weight (gram)
0.0	1
3.8	1/2
7.6	1/4
11.4	1/8
15.2	1/16

36. Select (a)

We use the equation

$I = I_0 e^{-\mu x}$

Where:

I is activity after time x

x is time

I_0 is initial activity (at time zero)

μ is decay constant

Half-life is the length of time which is needed to reduce the activity to one half the original value. In other words after one half-life we can write:

$I = \frac{1}{2} I_0$

Substitute for I:

$\frac{1}{2} I_0 = I_0 e^{-\mu(3.8)}$

$e^{-\mu(3.8)} = 0.5$

We take the natural logarithm (Ln) of both sides noting that

$\text{Ln}(e^{-\mu(3.8)}) = \text{Ln}\ (0.5)$

Therefore:

$-\mu(3.8) = \text{Ln}\ (0.5)$

or

$-\mu(3.8) = -0.693$

$\mu = 0.182\ \text{days}^{-1}$

To obtain μ in units of sec^{-1} we write:

$\mu = \frac{0.182}{\text{day}} \times \frac{1\text{day}}{24\text{hours}} \times \frac{1\text{hour}}{3{,}600\text{sec}}$

$\mu = 2.1 \times 10^{-6}\ \text{sec}^{-1}$.

37. Select (b)

$I = I_0 e^{-\mu x}$

$0.15 I_0 = I_0 e^{-2\times10\text{-}10} x$

$0.15 = e^{-2\times10\text{-}10} x$

$Ln0.15 = -\ 2 \times 10^{-10}\ x$

$-2 \times 10^{-10} x = -1.897$

$x = 300$ years

38. Select (d)

$I = I_0 e^{-\mu x}$

Half-life is the value of x when I becomes equal to ½ I_0. Substitute in the above equation:

$\frac{1}{2}I_0 = I_0 e^{-1.4\times10^{-8}x_{1/2}}$

$1.4 \times 10^{-8} x_{1/2} = 0.693$

$x_{1/2} = \frac{0.693}{1.4\times10^{-8}}$

$x_{1/2} = 49.5 \times 10^6$ seconds

$x_{1/2} = 1.57$ years

39. Select (b)

Radiation intensity follows the inverse square law

$I_1 \, d_1^2 = I_2 \, d_2^2$

Where:

I_1 is intensity at a distance of d_1 from the source, and I_2 is intensity at a distance of d_2 away from the source.

For the problem at hand:

$(0.06) \, (2)^2 = I_2 \, (6)^2$

$I_2 = 6.66 \times 10^{-3}$ rem.

40. Select (c)

$I_1 d_1^2 = I_2 d_2^2$

$A(4) = 0.1 A d_2^2$

$d^2{}_2 = \frac{4}{0.1} = 40$

$d_2 = 6.32$ft

41. Select (d)

Geiger-Mueller is suitable for measuring gamma, beta, and alpha rays. It is a tube which is filled by a gas capable of undergoing ionization. Interaction of ionizing radiation with the gas produces ions which in turn produce an electric current which is measured.

42. Select (b)

Luminescent detectors are effective measuring instruments for flow of neutrons. The collision of neutrons with the solid material in the detector generates excess energy which is emitted in the form of light which is proportional to the amount of energy received by the material.

43. Select (d)

All are examples of somatic effects of ionizing radiation.

44. Select (a)

Physical processes such as those mentioned do not usually affect the radioactive properties of a material. Chemical transformations, on the other hand, can drastically affect such properties. For example. one area for handling nuclear waste which is under research is to use nuclear reactions to convert radioisotopes of long half-life to radioisotopes having very short half-life.

45. Select (d)

Erythema, which is reddening of skin, sometimes accompanied by blisters is caused as a result of over-exposure to ultraviolet radiation in the sunlight.

46. Select (c)

Scotoma is caused as a result of over-exposure to infrared radiation. Extensive over-exposure can result in cataracts.

47. Select (d)

Toxicity data is obtained by conducting experiments on selected laboratory test animals. Lethal Dose (LD) is defined as the amount of chemical which can produce death in tested animals. Lethal Dose 50 indicates the amount of chemical which can produce death in 50 percent of tested animals in a given period of time. When the route of entry of the chemical is by ingestion or skin absorption, lethal doses are usually expressed as LD_{50}, and when the route of entry of the chemical into an animal's body is by inhalation, lethal doses are expressed as LC_{50}.

48. Select (b)

See description of lethal doses in the text.

49. Select (b)

Simple asphyxiants can cause suffocation as a result of reducing the available oxygen concentration. For example, if an inert non-toxic gas such as nitrogen is continuously pumped into a room that initially has normal oxygen concentration, eventually the oxygen concentration would diminish to a point that can no longer support life. Argon or methane also are good examples of simple asphyxiants.

50. Select (d)

Hepatotoxins attack the liver when they enter the blood stream. Examples are carbon tetrachloride, ethyl alcohol, and vinyl chloride.

51. Select (c)

$\frac{C_1}{T_1} + \frac{C_2}{T_2}$

$\frac{500}{750} + \frac{50}{200} < 1$

52. Select (c)

Molecular of weight of $CH_4 = 12 + 4 \text{ x } 1 = 16$

$ppm = \frac{\left(\frac{mg}{m^3}\right)(24.4)}{\text{M.W.}}$

$700 = \frac{(\frac{mg}{m^3})(24.4)}{16} = 459\frac{mg}{m^3}$

total = 459 × 25 = 11,475mg = 11.5 grams (approximately)

53. Select (d)

$c = \frac{\lambda}{T}$

Where:

Λ = wavelength

T = period

C = speed of light = 300,000 kilometers per second = 300,000,000 meters per second

$T = \frac{\lambda}{c}$

$T = \frac{10 \times 10^{-3} m}{3 \times 10^{8} m \cdot sec^{-1}}$

T = 3.3 × 10^{-11}sec

54. Select (c)

We use the following relationship:

I = β I_0 $e^{-\mu x}$

where:

I = intensity of attenuated radiation

β = buildup factor, dimensionless

I_0 = intensity of exposure

μ = attenuation coefficient, value depends on the shielding material. Expressed in cm^{-1}

x = thickness of shield, cm

For the problem at hand, we have:

I = (3.00) (4) $e^{(-0.6 \times 4 \times 2.54)}$ the 2.54 is for conversion from inches to centimeter

I = 0.027 mrem/hr

55. Select (b)

The relationship we use to solve this problem is:

$W = \frac{AP}{\lambda^2 r^2}$

where:

W = power density, units of power per distance squared e.g. W/m^2

A = antenna area

P = power

r = distance from antenna

λ = wavelength

For the problem at hand we have:

$W = \frac{1 \times 3000}{(0.05)^2(100)^2}$

$W = 120\ W\ /\ m^2$

56. Select (d)

We use the following relationship to solve this problem:

S = 6CE

where:

S = expected radiation level at 1 ft. in roentgens per hour (R/hr.)

C = strength of radiation source expressed in units of Curie (Ci)

E = energy of gamma radiation expressed in Mev, obtained from handbook.

For the problem at hand we have:

S = 6 (0.4)(3.5)

S = 8.4 R/hr.

57. Select (c)

The relationship between sound level and distance is expressed by the following relationship:

$dB_1 = dB_0 + 20log\frac{d_0}{d_1}$

Where:

dB_1 = sound level at distance d_1

dB_0 = sound level at distance d_0

For the problem at hand, we have:

$dB_1 = 96 + 20log\frac{4}{12}$

$dB_1 = 86.45$

58. Select (d)

We start with:

$dB_1 = dB_0 + 20log\frac{d_0}{d_1}$

In this case $\frac{d_0}{d_1} \equiv 0.5$ distance doubled. We have to calculate

$dB_1 - dB_0$:

$dB_1 - dB_0 = 20 \log 0.5$

$dB_1 - dB_0 = -6$

This means that if we double our distance from a sound source, the sound pressure level decreases by 6 decibels.

59. Select (a)

The relationship for calculation of noise reduction is:

$dB = 10log\left(\frac{A_2}{A_1}\right)$

where:

dB = amount of noise reduction in decibels

A_1 = amount of absorption before treatment expressed in units of sabins

A_2 = amount of absorption after treatment in sabins

Values of A_1 and A_2 can be obtained by multiplying the ceiling area by the coefficients of absorption. For the problem at hand:

$A_1 = (6{,}000\ ft^2) \times (0.04) = 240$ sabins

$A_2 = (6{,}000\ ft^2) \times (0.8) = 4{,}800$ sabins

$dB = 10log\frac{240}{4800} = -13$ decibels

60. Select (b)

The relationship between noise dose and TWA is:

$TWA = 16.61log\frac{D}{100} + 90$

where:

TWA = time weighted noise exposure in dB

D = noise dose in percent. For the problem at hand:

$95 = 16.61log\frac{D}{100} + 90$

$log\frac{D}{100} = \frac{5}{16.61}$

or

$\frac{D}{100} = 1.99$

$D = 199\%$

61. Select (d)

The relationship between hood entry coefficient, velocity pressure, and static pressure is:

$C_e = \sqrt{\frac{VP}{SP_h}}$

where:

C_e = hood entry coefficient (dimensionless)

VP = velocity pressure in inches of water

SP_h = absolute value of static pressure in inches of water

For the problem at hand we have:

$C_e = \sqrt{\frac{0.70}{1.30}} = 0.73$

62. Select (b)

$C_e = \sqrt{\frac{VP}{SP_h}}$

$0.85 = \sqrt{\frac{VP}{1.1}}$

$0.72 = \frac{VP}{1.1}$

VP = 0.79 inches of water

63. Select (a)

$C_e = \sqrt{\frac{VP}{SP_h}}$

$0.70 = \sqrt{\frac{0.9}{SP_h}}$

$0.49 = \frac{0.9}{SP_h}$

$SP_h = \frac{0.9}{0.49}$

$SP_h = 1.84$

64. Select (d)

We use the following relationship to solve this problem:

$Q = 10^6 \times \frac{G}{\text{TLV}}$

where:

Q = the dilution rate in cubic feet per minute

TLV = the threshold limit value in parts per million

G = the rate of generation of vapor or gas in cubic feet per minute

For the problem at hand, we have:

$Q = \frac{0.5}{200} \times 10^6$

Q = 2,500 cfm

65. Select (c)

$Q = 10^6 \times \frac{G}{\text{TLV}}$

$G = \frac{Q \times \text{TLV}}{10^6}$

$G = \frac{4000 \times 50}{10^6} = 0.2$ cfm

66. Select (b)

$Q = 10^6 \times \frac{G}{\text{TLV}}$

$\text{TLV} = 10^6 \times \frac{G}{Q}$

$\text{TLV} = 10^6 \times \frac{0.75}{3000}$

$\text{TLV} = 250$ ppm

67. Select (c)

We use the following relationship

$Q' = \frac{G}{C}$

where:

Q' = effective ventilation rate

G = actual ventilation rate

C = factor of safety

For the problem at hand, we have:

$Q' = \frac{16{,}000}{8} = 2{,}000$ cfm

68. Select (d)

We use the following relationship:

$C = \frac{10^6 \times P_v}{P_b}$

where:

C = saturation concentration (ppm)

P_v = vapor pressure at a given temperature (mm Hg)

P_b = barometric pressure (mm Hg)

For the problem at hand, we have:

$C = \frac{10^6 \times 200}{760} = 263{,}158$ ppm

69. Select (b)

$C = \frac{P_v \times 10^6}{P_b}$

$123{,}000 = \frac{P_v \times 10^6}{760}$

$P_v = 93.48$ mm Hg

70. Select (a)

We use the following relationship:

$SP_{fan} = SP_{out} - SP_{in} - VP_{in}$

where:

SP_{fan} = fan static pressure (inches of water gauge)

SP_{out} = static pressure on the outlet side of the fan (in. wg)

SP_{in} = static pressure on the inlet side of the fan (in. wg)

VP_{in} = velocity pressure on the inlet side of fan (in. wg)

For the problem at hand, we have:

$SP_{fan} = 0.7 - (-3.5) - 1.5 = 2.7$ in wg

71. Select (c)

We use the following relationship:

$V = \frac{Q}{10x^2+A}$

where:

V = capture velocity at distance x from the hood opening (feet per minute)

Q = volumetric flow rate of air through the system (cfm)

x = centerline distance from the hood opening (ft.)

A = hood opening area (ft^2)

For the problem at hand, we have:

$A = 6 \times 6 = 36in^2 = 0.25\ ft^2$

$V = \frac{16{,}000}{10(5)^2+0.25} = \frac{16{,}000}{250.25} = 63.93$

V = 63.93 fpm

72. Select (d)

$V = \frac{Q}{10x^2+A}$

$Q = V(10\ x^2 + A)$

V = 200 fpm

x = 4 ft

$A = \frac{\pi d^2}{4} = \frac{\pi(10)^2}{4} = 78.5\ in^2 = 0.54\ ft^2$

$Q = 200\ (10 \times 16 + 0.54)$

Q = 32,108 CFM

73. Select (a)

We use the following relationship:

$h_e = \frac{(1-C_e^2)VP}{C_e^2}$

where:

C_e = hood entry coefficient (dimensionless)

h_e = hood entry loss (in. wg)

VP = velocity pressure (in. wg)

For the problem at hand, we have:

$h_e = \frac{(1-0.80^2)0.9}{(0.80)^2} = 0.5$ in. wg

74. Select (b)

We use the following relationship:

$V = 4005 C_e \sqrt{SP_h}$

where:

V = average velocity of air through duct (fpm)

C_e = hood entry coefficient (dimensionless)

SP_h = hood static pressure (in. wg)

For the problem at hand, we have:

$V = 4005 \times 0.72\sqrt{2.5}$

V = 4,559 fpm

75. Select (c)

$V = 4005 C_e \sqrt{SP_h}$

$\sqrt{SP_h} = \frac{v}{4005 C_e}$

$SP_h = \left(\frac{v}{4005 C_e}\right)^2$

V = 5,000 fpm

$C_e = 0.80$

$SP_h = \left(\frac{5000}{4005 \times 0.08}\right)^2$

$SP_h = 2.43$ in. wg

76. Select (b)

Statement (b) is not true in regard to a velometer. This device can also be useful in OSHA compliance checks, in evaluation of drying systems, in evaluation of fan and blower performance, and in static pressure measurement.

77. Select (c)

Radiation intensity follows the inverse square law, which means that the intensity of radiation decreases with the square of the distance form the source.

$I_1 d_1^2 = I_2 d_2^2$

$\frac{I_2}{I_1} = 0.01 \frac{I_2}{I_1} = \frac{d_1^2}{d_2^2}$

$0.01 = \frac{4}{d_2^2}$

$d_2 = 20$ ft.

78. Select (b)

$I_1 {d_1}^2 = I_2 {d_2}^2$

$\frac{I_2}{I_1} = \frac{50}{500} = \frac{d_1^2}{100}$

$d_1 = 3.16$ meters

79. Select (b)

Time (Years)	Activity (% of Original)
0	100.0
500	50.0
1,000	25.0
1,500	12.5

80. Select (c)

The fan laws state that flow rate is directly proportional to fan speed.

$\frac{N_1}{N_2} = \frac{Q_1}{Q_2}$

$\frac{100}{300} = \frac{Q_1}{Q_2}$

$Q_2 = 3Q_1$

$Q_2 = 300$ cfm

81. Select (c)

The relationship between fan speed and horsepower is:

$\left(\frac{N_1}{N_2}\right)^3 = \frac{HP_1}{HP_2}$

$\left(\frac{100}{400}\right)^3 = \frac{1}{64} = \frac{HP_1}{HP_2}$

$HP_2 = 64HP_1$

82. Select (c)

An atmosphere is considered to be oxygen deficient when the concentration of oxygen falls below 19.5 per cent by volume.

83. Select (d)

$TLV_{\text{mixture}} = \frac{1}{\frac{0.4}{1600} + \frac{0.6}{1900}} = 1767 \frac{\text{mg}}{\text{m}^3}$

84. Select (c)

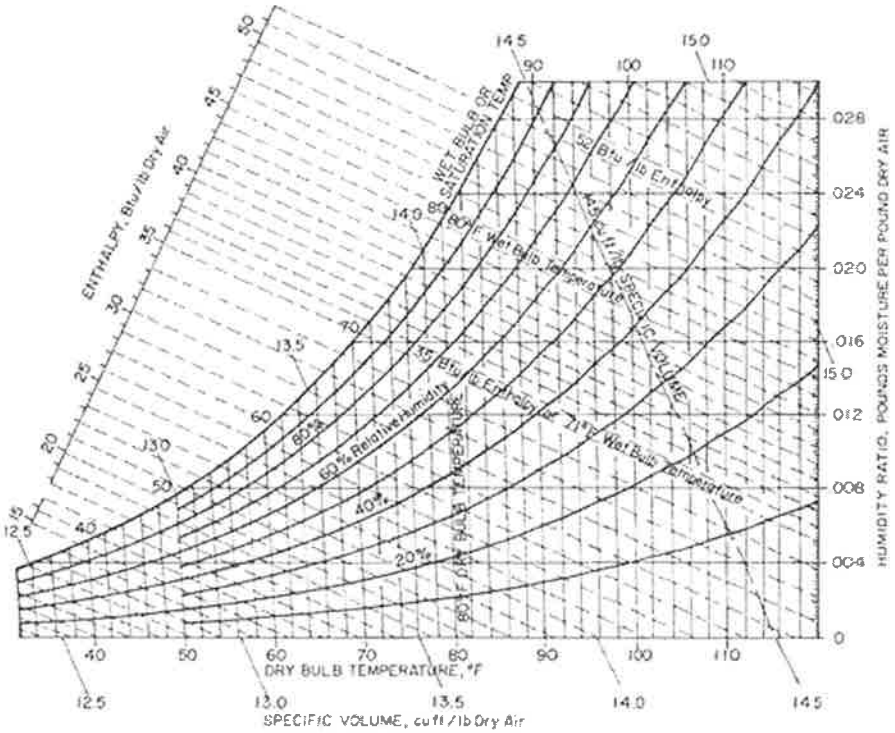
$$\text{ppm} = \frac{\left(\frac{\text{mg}}{\text{m}^3}\right)(24.4)}{\text{M.W.}}$$

$$700 = \frac{\left(\frac{\text{mg}}{\text{m}^3}\right)(24.4)}{16} = 459\frac{\text{mg}}{\text{m}^3}$$

$459 \times 25 = 11{,}475$ mg $= 11.475$ gr, rounded up to 11.5 gr

85. Select (a)

On the psychrometric chart below, first locate the point where the vertical line corresponding to 80 °F dry bulb temperature and the line of 70% relative humidity intersect. From this point on the chart, draw a horizontal line to the right to read the moisture content, which is 0.016 lb of water per pound of dry air.



86. Select (c)

$f_1 = 0.4$

$f_2 = 0.2$

$f_3 = 0.4$

$$TLV_{mixture} = \frac{1}{\frac{f_1}{(TLV)_1} + \frac{f_2}{(TLV)_2} + \frac{f_3}{(TLV)_3}}$$

$$TLV_{mixture} = \frac{1}{\frac{0.4}{1{,}600} + \frac{0.2}{1{,}900} + \frac{0.4}{335}}$$

$$TLV_{mixture} = 645\frac{mg}{m^3}$$

87. Select (a)

Raoult's Law deals with vapor/liquid equilibria. It states that, in a binary system, when the liquid and vapor phases have reached equilibrium, the vapor phase has a higher concentration of the more volatile (lower boiling point) component as compared to the liquid phase. This is the principle on which separation of components by distillation is based.

88. Select (a)

Fick's Law deals with diffusion. It expresses the rate of mass transfer per unit area by diffusion as a function of concentration difference. The constant of proportionality is called "diffusivity".

89. Select (c)

8-hour TWA $= (C_1t_1 + C_2t_2 + \ldots\ldots\ldots)/8$

$100 = (400t)/8$

$t = 2$ hours

90. Select (a)

$ppm = \frac{C\left(\frac{mg}{m^3}\right)(24.45)}{M.W.}$ and $\frac{mg}{m^3} = \frac{(C\ in\ ppm)(M.W.)}{24.45}$

Where:

C = concentration of contaminants

Ppm = parts per million

mg/m^3 = milligrams per cubic meter

M.W. = molecular weight

$Mg/m^3 = (5{,}000)\ (70)/24.45 = 14{,}315 = 14.315\ g/\ m^3$

Volume of lab $= 10 \times 20 \times 14 = 2{,}800\ m^3$

Mass $= 14.315 \times 2{,}800 = 40{,}082$ g

Density $= 0.6 \times 1{,}000$ g/L $= 600$ g/L

Volume $= 40{,}082/600 = 66.8$ L

91. Select (c)

The Ames test is used to evaluate a chemical's mutagen-producing capability.

92. Select (a)

Cutie Pie is a portable beta and gamma radiation meter of exceedingly small dimensions and weight. This instrument has been named Cutie Pie due to its diminutive size.

93. Select (c)

Alpha rays have a very weak penetrating power. Even a sheet of paper can stop their flow. They are most dangerous when inhaled or ingested.

94. Select (d)

Integrating meters are used to measure noise that is variable over a period of time. Spectrum analyzers measure the frequency of a sound wave.

95. Select (a)

V = room volume = $30 \times 30 \times 15 = 13{,}500\ \text{ft}^3$

$13{,}500\text{ft}^3 \left(\frac{1\text{m}^3}{3.2808^3\ \text{ft}^3}\right) = 382.3\ \text{m}^3$

Convert gallons to mg:

$10\ \text{gal} \times \left(\frac{35.3145\ \text{ft}^3}{264.17\ \text{gal}} \times \frac{0.6 \times 62.4\ \text{lb}}{\text{ft}^3}\right) \times \left(\frac{1000\ \text{g}}{2.20462\ \text{lb}} \times \frac{1000\ \text{mg}}{1\ \text{g}}\right) \text{ppm} = \frac{\frac{\text{mg}}{\text{m}^3} \times 24.45}{\text{MW}}$

$= 2.2702394 \times 10^7\ \text{mg}$

$\text{ppm} = \frac{(2.2702394 \times 10^7) \times 24.45}{382.3 \times 60}$

ppm = 24,198

NOTE: In the above calculation, in order to obtain the density of the chemical we multiply the specific gravity (0.6) by the density of water ($62.4\ \text{lbs/ft}^3$).

96. Select (b)

Positive pressure SCBA eliminates the possibility of any leakage from the contaminated atmosphere into the face mask.

97. Select (d)

Exposure to benzene can be detected by urine tests. Signs and symptoms of overexposure to benzene include drowsiness, dizziness, rapid or irregular heartbeat, headaches, and, at very high levels, death.

98. Select (d)

Even today, PCBs can be found in old electrical transformers. According to the EPA, statements (a), (b), and (c) are non-cancer adverse health effects of PCBs.

99. Select (d)

Statements (a), (b), and (c) are true in regard to bloodborne pathogens.

100. Select (a)

In BSL-1, the microbes pose minimal potential hazard to humans and the environment. The personal protective equipment for a BSL-1 laboratory are lab coats, gloves, and eye protection.

101. Select (c)

Another cause of SBS is inadequate ventilation.

102. Select (d)

Statements (a), (b), and (c) are all true in regard to dosimeters.

103. Select (d)

Organisms are excreted in milk, urine, and feces of infected animals. Infection of humans usually occurs by inhalation of these organisms from air that contains contaminated airborne barnyard dust. Humans are often very susceptible to the disease, and very few organisms may be required to cause infection. The symptoms include high fevers (up to 104–105° F), severe headache, general malaise, myalgia, chills and/or sweats, non-productive cough, nausea, vomiting, diarrhea, abdominal pain, and chest pain.

104. Select (d)

There are effective vaccines against anthrax. French scientist Louis Pasteur developed the first effective anthrax vaccine in 1881.

105. Select (c)

Heat syncope occurs when blood pressure is lowered as a result of overexposure to heat. Also, water is evaporated from the blood, reducing blood volume and causing an eventual further drop in blood pressure. The result is less blood to the brain, causing fainting.

106. Select (d)

Workers normally notice excessive exposure through heat sensation and pain. Sources of IR radiation include furnaces, heat lamps, and IR lasers.

IR is categorized as non-ionizing radiation. The most damage it causes is to the eyes.

Other forms of non-ionizing radiation include the spectrum of ultraviolet (UV), visible light, microwave (MW), and radio frequency (RF).

107. Select (d)

These non-ionizing radiations are primarily an eye and skin hazard.

108. Select (d)

Statements (a), (b), and (c) are all true in regard to Draeger tubes. For example, the reagent for very low concentrations of sulfur dioxide (0.1–3.0 ppm) changes color to orange.

109. Select (d)

The Ames test has been used to identify potential carcinogens used in commercial products. An example of one such substance is trisphosphate, which was used as a flame retardant in plastic and textiles used in children's sleepwear.

110. Select (a)

Byssinosis is an occupational disease that is caused by overexposure to cotton dust. Brucellosis, also called Malta fever, is caused by ingesting unsterilized milk or meat. Presbycusis is loss of hearing as a result of aging.

111. Select (d)

Statements (a), (b), and (c) are true in regard to TLVs. TLVs, along with biological exposure indices (BEIs), are published annually by the American Conference of Governmental Industrial Hygienists (ACGIH).

112. Select (b)

Heating, ventilation, and air conditioning (HVAC) design uses the principles of heat transfer, fluid mechanics, and thermodynamics. The design must initially have an estimate of the required heating or cooling, which depends on the outside climate as well as the inside desired conditions.

113. Select (b)

When the carbon dioxide exhaled by the occupants of a building reaches a certain concentration, the carbon dioxide sensors in the building activate the ventilation system.

114. Select (c)

The load must be kept as close to the body as possible. This would minimize the moment created by the load on the back muscles.

115. Select (b)

A woman's torso length relative to body weight is generally larger than that for a man. This would generally create a larger value of moment on the back muscle of a woman for the same load.

116. Select (d)

It is important to keep the back naturally straight and use the legs in lifting a load. This would not generate excessive pressure on the back muscles.

117. Select (c)

Ergonomics relates human capabilities and limitations to the design of work environment to achieve an optimum degree of efficiency and safety.

Ergonomics is the science of fitting workplace conditions and job demands to the capabilities of the working population. Effective and successful "fits" assure high productivity, avoidance of illness and injury risks, and increased satisfaction among the workforce.

Although the scope of ergonomics is much broader, the term here refers to assessing those work-related factors that may pose a risk of musculoskeletal disorders and recommendations to alleviate them. Common examples of ergonomic risk factors are

found in jobs requiring repetitive, forceful, or prolonged exertions of the hands; frequent or heavy lifting, pushing, pulling, or carrying of heavy objects; and prolonged awkward postures. Vibration and cold may add risk to these work conditions.

Jobs or working conditions presenting multiple risk factors will have a higher probability of causing a musculoskeletal problem. The level of risk depends on the intensity, frequency, and duration of the exposure to these conditions. Environmental work conditions that affect risk include the intensity, frequency, and duration of activities.

118. Select (d)

Control and display movement must be compatible. (Also see description in the text.)

119. Select (c)

The presence of "static loading" has been found to cause or aggravate disorders such as tendonitis, bursitis, or carpal tunnel syndrome.

120. Select (d)

In occupational ergonomics, CTD is an abbreviation for Cumulative Trauma Disorders. Cumulative trauma disorders (CTDs) are injuries of the musculoskeletal and nervous systems that may be caused by repetitive tasks, forceful exertions, vibrations, mechanical compression (pressing against hard surfaces), or sustained or awkward positions.

121. Select (a)

Although an object's toxicity is an important factor in safe handling of the object, it is not included as a factor for study of overexertion as a result of manual material handling.

122. Select (c)

Inappropriate pushing or pulling has been responsible for approximately 20 percent of muskuloskeletal injuries. Some injuries that are classified as slips or falls can also have contribution from pushing or pulling objects.

123. Select (c)

A healthy young male, on the average, can exert a pushing force of 44 lb when the coefficient of friction between shoes and the floor is 0.3. For coefficients of friction greater than 0.6, the mean push or pull strength increases to 66 lb for the same group.

124. Select (a)

Objects tip over as a result of the moment which is generated by the pushing force. The farther the grasping point from object's center of gravity, the higher the probability for the object to tip over.

125. Select (c)

The safest way to push an object is described in statement (c).

126. Select (b)

Based on anthropometric data, (which is the study of dimensions, weights, and strengths of various human body members for the design of equipment and work stations), the design features of a work station should accommodate from 5th percentile female to 95th percentile male.

127. Select (a)

See description in the text.

128. Select (a)

For a detailed discussion of NIOSH revised lifting equations, see the section, "Ergonomics and Human Factors Engineering."

The lift must be analyzed at both the origin and destination of the lift:

Mult	Origin	Destination
HM	$10/H = 10/12 = 0.833$	$10/H = 10/12 = 0.833$
VM	$1 - (0.0075\|20 - 30\|) = 0.925$	$1 - (0.0075\|20 - 30\|) = 0.925$
DM	$0.82 + (1.8/15) = 0.940$	$0.82 + (1.8/15) = 0.940$
AM	$1 - (0.0032 \times 0) = 1.000$	$1 - (0.0032 \times 45) = 0.856$
FM	0.35 (from Table)	0.35 (from Table)
CM	1.00 (from Table)	1.00 (from Table)

RWL (origin) $= 51 \times 0.833 \times 0.925 \times 0.940 \times 1.000 \times 0.35 \times 1.00$

RWL (origin) $= 13$ lbs.

LI $= 15/13 = 1.15$ RWL

RWL (destination) $= 51 \times 0.833 \times 0.925 \times 0.940 \times 0.856 \times 0.35 \times 1.00$

RWL (destination) $= 11.06$ lbs.

LI $= 15/11.06 = 1.355$

Discussion. Since LI exceeds unity (1.0) at both the origin and the destination of the lift, this lifting is considered to be hazardous. The lift at the destination, with a Lifting Index of 1.4, is more hazardous than the lift at its origin. The lift's destination is therefore the part on the lift that deserves greatest attention.

NIOSH recommends that ergonomic redesign be used to engineer the hazards out of the lifting situation. However, in this case, the lifting could be improved (in order of importance) by these administrative controls:

- Reducing the frequency of lifting.
- Reducing the work duration from 3 hours to less than two hours of continuous lifting by shift ration.

These changes can bring the LI down to 0.57.

Ergonomic redesign is also important, and much more desirable than depending upon administrative controls. By raising the line to 30 inches, and positioning the load closer, the LI is reduced to less than half of unity (0.49), significantly increasing the safety of the workers at this workstation.

Then, if the workers revert to the more hazardous lifting technique of twisting to place the load, the LI still remains at just above half of unify (0.57) and their safety has not been compromised.

129. Select (a)

Heat stress refers to too much heat gained by the body. In general, the human body is more capable of handling the heat loss from the body compared to heat gain. Heat stress is determined by calculating the Wet Bulb Globe Temperature (WBGT) and comparing it to the threshold values Published by the ACGIH.

130. Select (c)

The "Lux" is the SI unit of illuminance measuring luminous flux per unit area. it is equal to one lumen per square meter.

131. Select (c)

Statement (c) is the correct definition of dose.

132. Select (d)

Descriptive epidemiological studies focus on the number of cases of a disease in a given time period. This type of study provides information on the distribution of the disease as well as the risk factors for an individual to contract the disease.

133. Select (c)

Statement (b) is a description of "Sensorineural Impairment" and statement (d) is a description of "Central Impairment".

134. Select (c)

Ionizing radiation causes dislodging of electrons. When electrons are removed from an atom which is neutral in its normal state, ions are formed, and therefore, the term ionizing radiation.

135. Select (d)

$N(t) = N_0(1/2)^{\frac{t}{t_{1/2}}}$

Where:

N0 is the initial quantity of the substance that will decay (this quantity may be measured in grams, moles, number of atoms, etc.),

N(t) is the quantity that still remains and has not yet decayed after a time t,

$t_{1/2}$ is the half-life of the decaying quantity

$N(t) = 500 \times (1/2)^{2.25} = 105\ grams$

136. Select (d)

Nanoparticles are particles between 1 and 100 nanometers (nm) in size with a surrounding interfacial layer. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter.

Through nanotechnology, nanoparticles can help make materials lighter, more durable, and more reactive. Nanoparticles are applicable in a wide variety of industries and uses, including electronics to make computers faster, memory chips smaller, and screens clearer and brighter.

Naturally occurring nanoparticles can be found in volcanic ash, ocean spray, fine sand and dust, and even biological matter (e.g. viruses).

137. Select (d)

Many times, the coworkers and /or clients notice an employee being under influence before a supervisor notices the same. It is extremely important to document any complaints, concerns, behavior patterns or witnesses to the behavior. It is important that a second management person also observes the behavior. Both observers must document their observations in detail. Only after everything is documented, you should meet with the employee and discuss what has been observed. Always have a second party at the meeting as a witness. Once these steps have been taken, you have the option of enforcing whatever is stated in the company's drug and alcohol policy.

138. Select (d)

Also, drug-using employees are 2.2 times more likely to request early dismissal or time off, and five times more likely to file a workers' compensation claim.

139. Select (d)

Other signs of drug abuse include showing very little concern over personal appearance and practicing very poor hygiene, unusual physical symptoms or behaviors such as hyperactivity, paranoia or overreacting to constructive criticism, and lower levels of productivity in the mornings.

140. Select (c)

The 1988 Drug-Free Workplace Act requires certification to the federal agency issuing the contract that the organization will provide a drug-free workplace. It must be pointed out that although legal in several states, marijuana remains a schedule I drug under federal Controlled Substance Act, and therefore, employers must include marijuana prohibition in their workplace drug control policy. It must also be pointed out that many jurisdictions allow employee drug testing based on probable

cause or reasonable suspicion. It is extremely important that every organization include employee drug testing based on reasonable suspicion in their workplace drug policy.

Domain VII: Environmental Management Systems

7.1 Air Pollution

Air Pollution:

Air pollution is the presence of contaminants in the air that can harm human health and the environment. Air pollution can be caused by either natural or man-made sources. Wild fires are example of natural source of air pollution and emissions from vehicles is an example of man-made source of air pollution.

Air pollutants can be classified into two broad categories, primary air pollutants and secondary air pollutants. The primary air pollutants are those pollutants that are directly emitted into the atmosphere such as carbon monoxide from vehicle emissions. The secondary air pollutants are defined as those pollutants that are formed by a chemical reaction. For example, reaction between sulfur oxides and moisture in the atmosphere to form sulfuric acid is a good example of secondary air pollutant.

Harmful Effects of Air Pollutants:

Carbon monoxide: is a gas which is produced as a result of incomplete combustion of carbon containing materials. It is colorless and odorless and it is 210 times more reactive with the hemoglobin in the blood compared to oxygen.

Nitrogen Dioxide: It is a reddish-brown irritating gas. It reacts with moisture in the atmosphere to form nitric acid. Nitrogen oxides are formed as a result of combustion of nitrogen containing fuels. This gas can cause severe lung damage.

Sulphur Dioxide: It is a colorless but irritating gas. It is formed as a result of combustion of sulfur containing fuels such as coal. It can cause severe breathing problems, and in the atmosphere, it is converted to sulfuric acid.

Suspended Particulate Matter (SPM): the sources of SPM include coal-burning power plants, and heavier fuels combustion such as diesel. The health effects of SPM include lung damage, and irritation of nose and throat.

Ozone: it is a highly reactive gas. It occurs naturally in the atmosphere and it protects us from the harmful ultraviolet radiations from the sun. However, ozone is considered to be an air pollutant on earth. Ozone on earth is formed by the chemical reaction between nitrogen oxides and volatile organic compounds.

Lead: the compounds of lead are emitted into the atmosphere as particulate matter. The sources of lead pollution include paint, metal works, batteries, and leaded automobile fuels. Adverse health effects include central nervous system damage which could lead to mental retardation, digestive system problems, and cancer

Chromium: it is emitted into the atmosphere as particulate matter. Paint and chromium plating are examples of sources of this air pollutant. It is harmful to nasal septum and can cause chrome holes

EQUIPMENT USED TO CONTROL AIR POLLUTION:

Air pollution from industrial sources can be controlled by the following:

1. By supplying adequate amount of excess air and maintaining high enough temperatures and residence time in the combustion processes to ensure complete combustion of the fuel and conversion of carbon in the fuel to carbon dioxide rather than incomplete combustion which generates carbon monoxide.
2. By using mechanical devices such as cyclones, scrubbers, electrostatic precipitators, and bag houses

Scrubbers: Scrubbers are effective for removing air pollutants from industrial exhaust streams. Scrubbers fall into two broad categories, wet and dry. Wet scrubbers are essentially a column in which the dirty gas stream flows up the column and comes into contact with a suitable liquid which is capable of removing the hazardous components of the dirty gas stream. Dry scrubbers are the type most commonly used in plants today, and they utilize a collection of dry substances to remove harmful gases. The system sprays a collection of dry reagents into an exhaust stream.

a. **Cyclones:** Rotational effects and gravity are used to separate mixtures of solids and fluids. The method can also be used to separate fine droplets of liquid from a gaseous stream.

b. **Electrostatic Precipitators:** An electrostatic precipitator is a device that can remove fine particles from a gas stream by introducing an electrostatic charge.

c. **Bag Houses:** A baghouse, bag filter, or fabric filter removes contaminants from a gas stream by the process of filtration. Baghouses have a very high collection efficiency typically 99% or better.

7.2 Migration of Hazardous Materials through underground water

Migration of Hazardous Materials through underground water:

Many industrial operations have the potential for release or spills of hazardous chemicals into the environment and can cause underground water contamination. Underground water is formed by soaking of rain or melting snow and ice into the soil. The water is stored in small pores between rocks and other particles of soil. It is estimated that about half of our drinking water and the water used in agriculture comes from underground water.

Groundwater is found in two zones. The **unsaturated zone** also called **Vadose zone**, immediately below the land surface, contains water and air in the open spaces, or pores. The **saturated zone**, a zone in which all the pores and rock fractures are filled with water, underlies the unsaturated zone. The top of the saturated zone is called the **water table**. The water table may be just below or hundreds of feet below the land surface. The boundary between saturated and unsaturated zones is called ***potentiometric surface*** which is an area in which the pressure exerted by the water table equals atmospheric pressure.

The movement of underground water can be quantified by using Darcy's law. Darcy's Law is useful in quantifying the movement of pollutants through underground waters. It relates the discharge (volume per unit time) to the hydraulic conductivity of the aquifer, the area the water moves through horizontally, and a dimensionless friction or head pressure loss.

$Q = KA(H_1 - H_2)/L$

Where:

Q = discharge, volume per unit time

K = hydraulic conductivity

A = cross sectional area

$(H_1 - H_2)/L$ = a dimensionless head pressure loss term

$(H_1 - H_2)$ = difference in elevation which is usually expressed in feet

L = linear distance between the two locations studied for water flow.

Example:

What is the amount of underground water flow in cubic feet per day when underground water is flowing between two points with an elevation difference of 100 ft., a linear distance of 2,000 ft. through a cross sectional area of 100 ft2? The soil is made up of gravel with a hydraulic conductivity of 10,000 ft/day.

Q = 10,000 x 100 (100/2,000)

Q = 50,000 cubic feet per day

What is an aquifer?

Where groundwater can move rapidly, such as through gravel and sandy deposits, an **aquifer** can form. In an aquifer, there is enough groundwater that it can be pumped to the surface and used for drinking water, irrigation, industry, or other uses.

For water to move through underground rock, pores or fractures in the rock must be connected. If rocks have good connections between pores or fractures and water can move freely through them, we say that the rock is **permeable**. **Permeability** refers to how well a material transmits water.

Aquifers can be confined or unconfined. In confined aquifers, a confining bed overlies the water bearing formation. The water below the confining layer is under pressure and has a tendency to reach equilibrium with atmospheric pressure. In unconfined aquifers, also called "water table aquifers", the water table can rise or drop seasonally. The water table usually rises in the winter when there is more rainfall and drops in the summer. When a pumping well removes water from an unconfined aquifer, the water table is depressed. This depression is called ***cone of depression***. The instrument used for measuring water table elevations is called a ***Piezometer***.

How is groundwater contaminated?

Groundwater can become contaminated in many ways. If surface water that recharges an aquifer is polluted, the groundwater will also become contaminated.

Contaminants that can dissolve in groundwater will move along with the water, potentially to wells used for drinking water. If there is a continuous source of contamination entering moving groundwater, an area of contaminated groundwater, called a **plume**, can form.

7.3 Contamination of Soil by Hazardous Materials

Contamination of Soil by Hazardous Materials:

Soils Overview

Soils are formed by the decomposition of rock and organic matter over many years. Once contaminants are in soils, where they go and how quickly they travel depends on many factors. Some organic (carbon-based) contaminants can undergo chemical changes or degrade into products that may be more or less toxic than the original compound. The characteristics of the soil also affect the fate of contaminants and whether they can be readily taken up by plants or animals.

How are People Exposed to Soil Contaminants?

Generally, people can be exposed to contaminants in soil through ingestion (eating or drinking), dermal exposure (skin contact) or inhalation (breathing). The route of human exposure to a soil contaminant will vary with the contaminant and with the conditions and activities at a particular site.

7.4 Example Questions

1. Which of the following statements is the correct definition of the process of adsorption?
   a. Adsorption is the process of removing a component of a liquid mixture into a gas stream.
   b. Adsorption is the process of removing a component of a liquid mixture into another liquid.
   c. Adsorption is the process of removing a pure gas or one or more components of a gaseous mixture into a liquid stream.
   d. Adsorption is the process of removing a pure gas or one or more components of a gaseous mixture into a solid bed.
2. Chemical hazardous wastes must be segregated from incompatibles. Chemical wastes should be segregated by general groupings. Which of the following is NOT part of chemical groupings for segregation of hazardous waste?
   a. Mineral acids
   b. Alkenes
   c. Oxidizers
   d. Caustics
3. Hazardous wastes under RCRA are divided into two major categories: characteristic wastes and listed wastes. Which of the following is NOT the property of a characteristic waste?
   a. Ignitability
   b. Permeability
   c. Reactivity
   d. Toxicity
4. Air pollutants are classified into "primary" and "secondary pollutants." Which of the following is an example of a secondary air pollutant?
   a. Carbon monoxide in the air
   b. Sulfur oxides in the air
   c. Nitric acid in the air
   d. Nitrogen oxides in the air
5. Which of the following is NOT a means of control for air pollutants?
   a. Combustion

b. Distillation

c. Absorption

d. Adsorption

6. All of the following are examples of proper segregation of hazardous wastes EXCEPT:

a. Segregate oxidizers from organics and flammables

b. Segregate cyanides from acids

c. Segregate aldehydes from ketones

d. Segregate acids from bases

7. Which of the following steps help reduce storm water pollution from hazardous wastes?

a. Hazardous wastes must be stored in a sealed container which is made of suitable materials of construction and must be properly labeled.

b. Storage, transportation, and disposal must comply with provisions of federal, state, and local laws and regulations.

c. Waste containers must be stored in containment facilities

d. All of the above

8. Ground-level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions. Which of the following chemicals react to produce "bad" ozone?

a. Reaction between oxides of nitrogen (NOx) and volatile organic compounds in the presence of sunlight.

b. Reaction between oxygen molecule (O2) and oxygen atom (O) in presence of ultra violet light.

c. Reaction between oxygen and volatile organic compounds catalyzed by lighting

d. Reaction between sulfur oxide (SOx) and hydrocarbon gases in presence of sunlight

9. Which of the following processes is NOT a source of lead emissions into the air?

a. Ore and metal processing operations

b. Waste incinerations

c. Scrubbing operations

d. Battery manufacturing operations

10. The EPA has identified six air pollutants as "criteria" air pollutants. Which of the following is NOT a member of "criteria" air pollutants as identified by the EPA?

a. Carbon monoxide

b. Nitrogen oxides

c. Ground-level ozone

d. Carbon dioxide

11. The EPA has identified six air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria for setting permissible levels. These six air pollutants are known as:

a. NESHAP pollutants

b. Criteria Pollutants

c. Highly toxic Pollutants

d. All of the above

12. Unconfined aquifers are also called:

a. Water table aquifers.

b. Saturated aquifers.

c. Confining bed aquifers.

d. Unsaturated aquifers.

13. The instrument used to measure water table elevation is called a:

a. Hydrometer.

b. Piezometer.

c. Aquimeter.

d. Darcymeter.

14. The ratio of volume of voids to the total volume of rock or soil is called:

a. Void density.

b. Homogeneity.

c. Void specific gravity.

d. Total porosity.

15. One of the important characteristics of aquifers is "specific yield". Which of the following statements BEST describes this term?

a. It is a measure of how quickly water will pass through the aquifer.

b. It is the volume of water that is retained on soil or rock after gravity drainage.

c. It is the volume of water that will drain by gravity from a specific volume of soil or rock.

d. All of the above.

16. Which of the following is used to calculate the velocity and travel times of pollutants in groundwater?

    a. Raoult's Law

    b. Fick's Law

    c. Newton's second law of motion

    d. Darcy's Law

17. Which of the following is formed when ground water is pumped from an unconfined aquifer?

    a. Sinkholes

    b. Cone of depression

    c. Drawdown

    d. Confining bed

18. Which of the following is considered to be the primary source of ground water?

    a. Rainfall

    b. Snow

    c. Rivers

    d. Lakes

19. Rainfall has a pH of about 5.7. This means that:

    a. Rainfall is slightly acidic.

    b. Rainfall can dissolve carbonates in the soil or rock.

    c. The ground water has a PH greater than the rainfall.

    d. All of the above.

20. An underground storage tank containing diesel fuel has been leaking and might have caused groundwater contamination. The monitoring well for sampling must be designed in such a way to provide means for sampling from the _____ of the aquifer.

    a. Bottom

    b. Mid-point

    c. Top

    d. Top, mid-point, and bottom (mix to make a representative sample)

21. The *unsaturated zone* is an area directly below the soil surface where the soil particles are surrounded by both water and air. The unsaturated zone is also called the:

    a. Potentiometric zone.

b. Confining bed.

c. Vadose zone.

d. Lithification zone.

22. A measure of the ability of an aquifer to transmit water is:

a. Gravel.

b. Specific retention.

c. Specific velocity.

d. Hydraulic conductivity.

23. Which of the following statements is true in regard to soil permeability?

a. It is a measure of how easily water can move through an aquifer.

b. The permeability value depends on the properties of the aquifer materials only.

c. Permeability is a value usually obtained in a laboratory.

d. All of the above.

24. The boundary between the saturated and unsaturated zones of soil is called the:

a. Water table aquifer.

b. Potentiometric surface.

c. Lithified zone.

d. Vadose zone.

25. The process that reduces the solubility of hazardous constituents and reduces the exposed area that may allow the migration of the contaminants is called:

a. Screening.

b. Sedimentation.

c. Stabilization.

d. Flotation.

26. LDR is an acronym for which of the following?

a. Laboratory Disposal Report

b. Land Disposal Restrictions

c. Lowest Dose Reported

d. Lethal Dose Restrictions

27. Contaminated wastewater and groundwater can be treated biologically to remove hazardous substances. The microorganisms for biological treatment may be classified as *heterotrophic* and *autotrophic*. Which of the following statements is true in regard to these classes of microorganisms?

    a. Heterotrophs use inorganic matter.

    b. Heterotrophs use organic matter.

    c. Autotrophs use organic matter.

    d. Both heterotrophs and autotrophs use organic matter.

28. Microorganisms may be categorized as *aerobic* and *anaerobic* according to their utilization of oxygen. Which of the following statements is true in regard to these classes of microbes?

    a. Anaerobic microbes use oxygen that is combined with other elements.

    b. Anaerobic microbes use free oxygen.

    c. Aerobic microbes use oxygen that is combined with other elements.

    d. Anaerobic microbes can use both free and combined oxygen.

29. Undesirable heavy metals are usually removed from a liquid waste by precipitation. The solubility of heavy metals in a liquid waste can be reduced by varying the ___-

    ___

    a. PH.

    b. Specific gravity.

    c. Conductivity.

    d. Ion exchange.

30. Air stripping is commonly used to remove low concentration of hazardous materials from wastewater. Which of the following statements is true in regard to air stripping?

    a. Stripping towers may be induced-draft towers.

    b. In stripping towers, the air flows upward and the liquid waste flows downward.

    c. The gas-liquid system eventually reaches equilibrium based on Henry's Law.

    d. All of the above.

31. The removal of low concentrations of hazardous substances from aqueous waste using activated carbon is accomplished by which of the following mechanisms?

    a. Absorption

    b. Ion exchange

    c. Adsorption

d. Floatation

32. Which of the following statements is NOT true in regard to dust particles?

a. They are formed when particles migrate and condense from the surface of a molten solid into the air.

b. They consist of mechanically-produced solid particles whose size can range from microscopic to visible.

c. Dust particles can be inorganic or organic.

d. The proper evaluation of dust hazards requires information regarding particle size, chemical composition, concentration, and factors that affect dispersion.

33. Cyclones are extensively used as an air pollution control device. Which of the following statements is NOT true in regard to cyclones?

a. Cyclones operate to collect relatively large-size particulate matter from a gaseous stream through the use of centrifugal forces.

b. Dust-laden gas is made to rotate in a decreasing diameter pathway, forcing solids to the outer edge of the gas stream for deposition into the bottom of the cyclone.

c. Efficiencies of 90% in particle sizes of 10 microns or greater are possible.

d. One of the disadvantages of cyclones is that operation at elevated temperatures is not possible.

34. Absorption and wet-scrubbing equipment are used extensively for air pollution control. All of the following statements are true in regard to this type of equipment EXCEPT:

a. The goal is the removal of gases and particulate matter by causing the gaseous contamination to dissolve into the liquid stream and the solids to become entrained in the liquid.

b. The rate of gas transfer into the liquid is dependent upon the solubility, mass transfer mechanism, and equilibrium concentration of the gas in solution.

c. One of the advantages of this type of equipment is that high pressure drops are required.

d. The rate of particulate matter collection at constant pressure drops is inversely proportional to the aerodynamic mean diameter of the particulate matter and scrubber droplets.

35. Baghouses are used extensively for air pollution control. Which of the following statements is true in regard to this type of equipment?

a. Baghouses use sieving, impaction, agglomeration, and electrostatic filtration principles to remove solids from a gaseous exhaust stream.

b. Baghouses maximize the filtration area by configuring the fabric filter media into a series of long, small-diameter fabric tubes, referred to as bags.

c. They are tightly packed into a housing wherein the dust-laden air moves across the bag fabric, thereby removing it from the gas stream and building up a filter cake which further enhances air cleaning.

d. All of the above.

36. Electrostatic precipitators are used extensively as air pollution control devices. Which of the following statements is true in regard to electrostatic precipitators?

a. They use gaseous ions to charge particles, which are then moved through an electric field to be deposited onto charged collection plates.

b. Collected particulate material is removed by rapping or washing the plates.

c. To produce the free ions and electric field, high internal voltages are required.

d. All of the above.

37. An environmental Life-Cycle Assessment (LCA):

a. Is a tool that can be used to evaluate the potential environmental impacts of a product, material, process, or activity

b. Helps to promote the responsible design and redesign of products and processes

c. Allows businesses to make product improvements through environmentally sound process, material, and design choices

d. All of the above

38. Vapor-cloud dispersion models used for predictions of migration of hazardous materials into the atmosphere require input of data. All of the following are examples of data input into the dispersion models EXCEPT:

a. Meteorological conditions

b. Terrain evaluation at the source location

c. Ambient air temperature

d. Absorption coefficient

39. At the simplest level, treatment of sewage and most wastewaters is carried out through which of the following?

a. Distillation

b. Absorption

c. Crystallization

d. Separation of solids from liquids

40. Wastewater comes in three main types. Which of the following does not belong to the three main types of wastewater?

    a. Blackwater

    b. Graywater

    c. Bluewater

    d. Yellow water

41. REACH is an acronym for Registration, Evaluation, Authorization and Restriction of Chemicals. Which of the following statements is correct regarding REACH?

    a. It is enforced by OSHA under Hazards Communication standard (29CFR1910.1200).

    b. It is a European Union regulation.

    c. It is an EPA regulation enforced under Toxic Substances Control Act (TSCA).

    d. It is part of OSHA's voluntary standards.

42. Which of the following statements is correct regarding the Restriction of Hazardous Substances (RoHS)?

    a. It is a legislation controlling hazardous substances throughout their whole life cycle.

    b. It is a legislation which focuses on hazardous substances in electrical and electronic equipment.

    c. It is an EPA regulation enforced under Land Disposal Restrictions (LDR).

    d. It is part of the Globally Harmonized System (GHS) for hazardous substances.

7.5 Example Answers

1. Select (d)

   Air purifying respirators remove the contaminants in the air by adsorption. Activated charcoal is a good example of an adsorbent.

2. Select (b)

   The other groupings are: flammables, non-halogenated organic solvents, halogenated organic solvents, organic acids, carcinogens, mercury and mercury compounds, and general "dry" lab chemicals.

3. Select (b)

   The fourth trait for characteristic hazardous waste is corrosivity. Toxicity is determined by Toxicity Characteristic Leaching Procedure (TCLP). Under RCRA, ignitable wastes are defined by their flash points.

4. Select (c)

   Secondary pollutants are formed as a result of reaction between a primary pollutant and moisture and other elements in the atmosphere. For example, nitric acid is formed as a result of reaction between nitrogen oxides (primary pollutants) and moisture in the atmosphere. Also sulfuric acid which is formed as a result of reaction between sulfur oxides and moisture is considered a secondary air pollutant.

5. Select (b)

   Combustion is used when the air pollutants are organic gases and vapors. Combustion converts the pollutants to carbon dioxide and water.

   Absorption: The harmful gases are removed by a suitable liquid in scrubbers.

   Adsorption: The harmful gases are removed on the surface of a suitable porous solid.

6. Select (c)

   Oxidizers can release oxygen that can make an ongoing fire in flammables much worse. Acid-base reactions are heat generating and the reaction between acids and cyanides can release highly toxic gases.

7. Select (d)

   The steps outlined in (a), (b), and (c) are designed to minimize storm water pollution from hazardous wastes.

8. Select (a)

   Ground-level or "bad" ozone can be generated by the chemical reaction between oxides of nitrogen and volatile organic compounds. The reaction is catalyzed by sunlight.

9. Select (c)

   Other sources of lead emissions into the air include utilities plants and piston-engine air craft operating on leaded aviation fuel.

10. Select (d)

    The other three air pollutants identified as "criteria" pollutants are sulfur oxides, lead, and particulate matter.

11. Select (b)

    The six air pollutants are identified by the EPA as "criteria" pollutants. These are carbon monoxide, nitrogen oxides, ground-level ozone, sulfur oxides, lead, and particulate matter.

12. Select (a)

    Unconfined aquifers are usually in unconsolidated material and the water table depth varies seasonally. The water table tends to rise in the winter when there is more rainfall, and fall in the summer due to less rainfall infiltration.

13. Select (b)

    A piezometer is used to measure water table elevation.

14. Select (d)

    This ratio is called the total porosity of rock or soil. It is expressed as a percentage or fraction. Porosity is a measure of the maximum amount of water a rock or soil can hold when it is saturated with water. For example, gravel porosity has a range of 25 to 40 percent.

15. Select (c)

    Statement (b) is a description of specific retention. Statement (a) is a description of hydraulic conductivity. The porosity of a rock or soil is the sum of specific yield and specific retention.

16. Select (d)

    Darcy's Law is useful in quantifying the movement of pollutants through underground waters. It relates the discharge (volume per unit time) to the hydraulic conductivity of the aquifer, the area the water moves through horizontally, and a dimensionless friction or head pressure loss.

    $Q = KA(H_1 - H_2)/L$

    Where:

    Q = discharge, volume per unit time

    K = hydraulic conductivity

    A = cross sectional area

$(H_1 - H_2)/L$ = a dimensionless head pressure loss term

17. Select (b)

When water is pumped from a confined aquifer, a cone of depression is formed.

18. Select (a)

Rainfall is considered to be the primary source of groundwater.

19. Select (d)

Rainfall generally has a pH less than 7.0 due to dissolved gases from the atmosphere. This makes rainfall slightly acidic. Therefore, rainfall can easily dissolve and react with carbonates and other minerals that are bases. This process increases the pH of the rainfall as it migrates and joins the underground waters.

20. Select (c)

Diesel fuel has a specific gravity of less than 1.0 and is insoluble in water. It will float on top of water. The sample should be taken from the top of the aquifer.

21. Select (c)

The unsaturated zone is also called the Vadose zone. The saturated zone is the area beneath the unsaturated zone where the soil particles are completely surrounded by water.

22. Select (d)

Hydraulic conductivity is a measure of how fast water passes through an aquifer. The fluid properties and the properties of the aquifer materials are factored into the value of hydraulic conductivity.

23. Select (d)

Statements in (a), (b), (c) are true in regard to permeability. Permeability is very similar to hydraulic conductivity. Usually, permeability is a value obtained in a laboratory, while hydraulic conductivity is measured in field.

24. Select (b)

A potentiometric surface is an area where the hydrostatic pressure exerted by the water table is equal to atmospheric pressure

25. Select (c)

Most stabilization processes incorporate the waste into a solid matrix using a binding agent or polymers.

26. Select (b)

LDR is an acronym for Land Disposal Restrictions. LDR restricted wastes are those that fall under the land disposal restriction standard under RCRA.

27. Select (b)

Heterotrophs use organic matter and autotrophs use inorganic matter as the source of their nutrients in contaminated wastewater, groundwater, and soil.

28. Select (b)

Anaerobic microbes use oxygen that is combined with other elements. Examples are nitrates, carbonates, or sulfates.

29. Select (a)

The pH is an important factor in removing heavy metals from a liquid waste stream. For example, the neutralization of an acidic waste can also cause the precipitation of heavy metals. The hydroxides of heavy metals are usually insoluble, so lime is commonly used for precipitating them.

30. Select (d)

Statements (a), (b), and (c) are all true in regard to air stripping towers. The air-waste stream usually undergoes secondary treatment such as incineration. In steam stripping, live steam is injected into the liquid waste.

31. Select (c)

Adsorption is the process of removing a component of a liquid or gas on a solid. Absorption is the process of removing a component into a liquid. Ion exchange is a reversible exchange of ions between liquid and solid phases.

32. Select (a)

Statements (b), (c), and (d) are true in regard to dust. Statement (a) is a characteristic of fumes.

33. Select (d)

Cyclones can operate at elevated temperatures. This is considered to be one of the advantages of cyclones.

34. Select (c)

High pressure drops in absorption and wet-scrubbing equipment is a disadvantage.

35. Select (d)

Statements (a), (b), and (c) are true in regard to baghouses.

36. Select (d)

Statements (a), (b), and (c) are true in regard to electrostatic precipitators. Since the collection process does not rely on mechanical processes such as sieving or impaction, but rather electrostatic forces, the internal gas passages within a precipitator are relatively open with small pressure drops and lower energy costs to move the gas stream. Electrostatic precipitators are best suited for removing small particles (less than 1 micron) from the air stream. Electrostatic precipitators have very high removal efficiency (99%) for particulate matters.

37. Select (d)

    LCA also gives businesses governmental incentives with the goal of obtaining environmental benefits.

38. Select (d)

    Other data that may be required include but are not limited to atmospheric turbulence, cloud cover, and solar radiation. The two types of vapor-cloud dispersion models are plume and puff.

39. Select (d)

    At the simplest level, treatment of sewage and most wastewaters is carried out through separation of solids from liquids, usually by sedimentation. By progressively converting dissolved material into solids, usually a biological floc, which is then settled out, an effluent stream of increasing purity is produced.

40. Select (c)

    Wastewater comes in three main types namely Blackwater, Graywater and Yellow water. This is wastewater that originates from toilet fixtures, dishwashers, and food preparation sinks. It is made up of all the things that you can imagine going down the toilets, bath and sink drains.

41. Select (b)

    Registration, Evaluation, Authorization and Restriction of Chemicals (**REACH**) is a European Union regulation dating from 18 December 2006. REACH addresses the production and use of chemical substances and their potential impacts on both human health and the environment.

42. Select (b)

    REACH is a horizontal legislation controlling the risks associated with chemical substances throughout their whole life cycle, while **RoHS** is a product-specific vertical legislation focuses on hazardous substances in electrical and electronic equipment (EEE).

Domain VIII: Training/Education

8.1 Training & Education

Effective Training Techniques:

The safety training most widely used for adults is "competency-based training". In this technique, three questions must be answered:

1. what is expected of the trainees after the training. In other words, what do we want the trainees to be able to do after the training.
2. What is the best way to teach these competencies?
3. How can you measure if your goals have been accomplished?

Before developing any training program, a "need assessment" must be conducted. A need assessment is a series of activities conducted to identify problems or other issues in the workplace and to determine whether training is an appropriate response.

According to AIHA, there are five steps for identifying a training need. These steps are:

Step One: Identify needs and performance gaps.

Step Two: Clearly Define the Problem, Answer —**Who, What, Why, When** and **How**

Step Three: Determine the Type of Training Need

Step Four: Develop Priorities. Set Priorities for the Various Identified Needs (cost of meeting the need vs. The cost of ignoring it)

Step Five: Meet with management to present initial findings.

Learning Objectives:

Once training needs have been clearly identified, it is important that learning goals and objectives are set. Effective learning objectives must be clear and measurable, making it possible to evaluate the training at a later date. Training objectives should precisely spell out the desired skill or behavior using specific, action-oriented language. Detailed learning objectives allow employees and employers to understand the expected outcome of the training.

Training Techniques:

After learning objectives are clearly identified, learning activities that support those objectives must be developed. Employers should consider which methods, materials,

and resources will be needed to most effectively convey the message. The type of training chosen (group, one-to-one etc.) should be selected keeping the audience and specific skill set in mind.

ADULT LEARNERS:

Adult learners consent to volunteer their time and money to learn. This means that they approach the training program with a positive attitude and expectations to learn. Also, they set aside time from their busy schedule to attend the training sessions and learn. They expect the instructor to be well prepared and clearly state how the objectives of training will be met. In general, when attending the training sessions, adults expect to be treated as peers who want to learn and share their life experiences. On the negative side, many adults might lack self-confidence because they have been out of formal school for a long period of time. Adult learners, in general, appreciate a well-organized instructor who is enthusiastic and cares about students.

HELPING ADULTS LEARN:

Adults are accustomed to learning in their own way informally. They learn all the time by doing, by observing, by reading and watching, by asking questions, and by talking to each other.

The techniques used in education for adults must be chosen to keep students involved as much as possible. The subject matter, the teacher's style and the physical situation (is there audiovisual equipment? for example) influence the techniques used.

Review of Selected Concepts in Safety Training:

- In safety training programs "Validity" refers to identification of hazards of each task and the required knowledge and skills to perform each task safely. For example, in handling corrosive chemicals, one major hazard is contamination of skin with the corrosives. Training in appropriate use of the right personal protective equipment is needed to handle this task safely.
- "Learning curve" in training suggests that the amount of learning increases with the amount of time devoted to training. However, the amount of learning eventually reaches a limit regardless of any additional time devoted to training.
- One of the techniques used in safety training is "role-playing". In this technique, the trainees have an opportunity to observe the role play and make their comments afterwards. For example, salespersons within an organization can be trained by having two people acting in a sales scenario; one acting as the salesperson and the other as the customer.

- "meeting" or "conference" method of training takes a problem-solving approach. A group takes on a problem or issue and work together to come up with solutions to the problem.
- In "performance-based" method of training, attention is focused on solving a specific on-the-job problem. This method is very cost-effective as the training focuses on specific performance outcomes.
- In "case study" method of training, attention is focused on how people or organizations have dealt with a situation. One of the disadvantages of this method of training is that it may not relate to the actual work situation.
- There are three domains of learning, "cognitive", "affective", and "psychomotor". The cognitive domain deals with mental skills, the affective domain focuses on improving in the emotional areas such as attitude, and the psychomotor domain focuses on improving physical skills.

8.2 Example Questions

1. The first step in development of a safety training program must be to:
   a. Identify employees who may need training
   b. Prepare workbooks that are easy to understand
   c. Find instructors who are qualified in the subject of training
   d. Define objectives of the training program
2. In defining a safety training program, "validity" refers to:
   a. Ensuring that the elements of the training program cover all relevant legal requirements of the tasks.
   b. Ensuring that the program is feasible and covers the areas which reduce risk and liability.
   c. Identification of hazards of each task and the required knowledge and skills for safe performance.
   d. Identification and analysis of each component of the training program to ensure that all covered areas are technically and legally correct.
3. Which of the following statements is true regarding a learning curve?
   a. The level of proficiency gained is inversely proportional with the amount of time devoted to learning.
   b. The level of proficiency gained is directly proportional with the amount of time devoted to learning.
   c. The level of proficiency gained varies exponentially with the amount of time devoted to learning.
   d. The level of proficiency gained is directly proportional with the amount of time devoted to learning but eventually tends to reach a limit.
4. Which of the following is NOT one of the characteristics of role-playing training technique?
   a. It can be used effectively to find innovative approaches to solving problems.
   b. Members participate to identify problems.
   c. Brain storming is used to find solutions to specific problems.
   d. It is an effective tool for identifying, evaluating, and changing personnel issues.
5. Which of the following statements is NOT true regarding the meeting or conference method of training?
   a. This technique is effective because it allows each member to bring his/her knowledge to the meeting.

b. The number of people in each meeting must be limited in such a way to allow effective discussions and exchange of ideas.

c. The ideas and opinions of each member must be recorded and a summary report must be prepared and presented to each group member.

d. The main reason for success of the meeting method of training is the fact that the group leader can have control of the topics that are being discussed.

6. Certain personal motives can have a direct positive impact on people's behavior. This in turn can have a positive impact on the outcome of training. Which of the following is considered to be the highest motivation factor?

a. Promotion

b. Achievement

c. Work environment

d. Company policies

7. Which of the following statements is NOT true regarding a cost-benefit analysis for training programs?

a. The benefits of a training program must exceed its costs.

b. The cost of a training program can usually be estimated with considerable accuracy.

c. Improved operating conditions can be a benefit of a training program.

d. Lowering the indirect average cost of an accident is usually considered a benefit of a training program.

8. Which of the following statements is true regarding a performance-based training program?

a. The focus of the training program is to solve a specific on-the-job problem.

b. This type of training, in general, can not be measured by analysis of worker's performance.

c. Feedback from workers during the evaluation of program has minimal effect on the final training.

d. Feedback from supervisors, in general, does not affect the final training program.

9. In many training programs, case studies are used for training purposes. Which of the following is the BEST description of case study?

a. Case study is a method of training in which group participation is not addressed.

b. Case study is a description of how people or organizations have dealt with a certain situation.

c. Case studies usually are an ineffective way of dealing with the development of problem-solving techniques.

d. Case studies are usually about generalizations and do not address specific conclusions.

10. In computer-based safety training, LANs can be used to deliver training to many workstations. LAN is an acronym for:

a. Leave A Network

b. Language Advanced Network

c. Local Area Network

d. Logistics Area Navigation

11. Which the following is NOT one of the three domains of learning?

a. Cognitive

b. Affective

c. Interactive

d. Psychomotor

12. Which of the following statements is NOT true in regard to safety training?

a. Safety training can be effective when the trainees are motivated.

b. Effective safety training, in general, does not affect employee morale.

c. The cost of safety training may be easier to hide than the cost of new equipment or facilities.

d. Safety training has a critical role in an occupational safety program.

13. One of the elements of developing an effective safety training program is to develop learning activities. All of the following are steps involved in developing learning activities EXCEPT:

a. Identify the trainees' learning characteristics.

b. Write course evaluation materials.

c. Select or develop instructional materials.

d. Identify training needs.

14. All of the following are considered to be red flags for the need or consideration of a safety training program EXCEPT:

a. Lack of instructional materials

b. New employees

c. Rising insurance rates

d. New equipment

15. Effective safety training programs require clearly stated goals and objectives that are measurable. All of the following are considered to be components of objectives EXCEPT:

    a. Performance

    b. Condition of the work

    c. Developing learning activities

    d. Standard of quality for performance that is described

16. In developing safety training programs, "performance" is a statement of what the trainee will do. It must include an action verb that describes a behavior that is observable and measurable. Which of the following is considered to be an action verb that is measurable?

    a. Appreciate

    b. Understand

    c. Know

    d. Select

17. In developing a "performance" statement for safety training purposes, it is important to ensure that what the trainee is expected to do is observable and measurable. All of the following are examples of measurable performances EXCEPT:

    a. Understand how to respond to a hazardous chemical spill

    b. List the steps that need to be followed in an emergency evacuation

    c. Select the proper tools necessary for heat exchanger maintenance

    d. Fill out a Uniform Hazardous Waste Manifest for shipment of hazardous waste

18. Safety training objectives must be based on which of the following?

    a. Course content

    b. Job Hazard Analysis

    c. Trainer's qualifications

    d. Available training tools

19. There are three steps to ensuring that learning activities succeed in enabling the trainees to master the behaviors listed in the training objectives. Which of the following is the correct order of these steps?

    a. Identify the learning characteristics of the trainees, structure the materials and activities into the training program, and develop or select instructional materials and activities.

b. Structure the materials and activities into the training program, develop or select instructional materials and activities, and identify the learning characteristics of the trainees.

c. Identify the learning characteristics of the trainees, develop or select instructional materials and activities, and structure the materials and activities into the training program.

d. Develop or select instructional materials and activities, identify the learning characteristics of the trainees, and structure the materials and activities into the training program.

20. All of the following are considered to be characteristics of the trainee population that may affect learning EXCEPT:

a. Physical characteristics

b. Education

c. Motivation

d. Societal issues

21. Which of the following statements is NOT true in regard to conducting a safety training program?

a. It is important to keep the trainees mentally active.

b. The presentation must be tailored to the values and learning styles of the trainees.

c. Unreasonable fears of occupational hazards must be avoided.

d. If the content of the course were tailored to the trainees learning needs and learning styles, starting with a pilot program would be considered an inefficient way of conducting training.

22. All of the following are considered to be guidelines that an experienced instructor would follow when presenting a safety training program EXCEPT:

a. Do not stay physically close to your listeners.

b. Get rid of professional terminology.

c. Remember that trainees tend to remember narrative chunks more than sophisticated information.

d. Appear to have fun, even be theatrical, if necessary.

23. Which of the following statements is NOT true in regard to presenting safety training materials?

a. The trainees will be much more open to learning if the instructor is successful in giving them a sense of disequilibrium.

b. Many educational psychologists believe that disequilibrium (the state of being out of balance) is not essential to learning.

c. The effectiveness of a safety training presentation depends both on the trainees and the instructor.

d. It is essential for the instructor to provide motivation to learn.

24. The first step in developing a safety training program is to conduct a needs assessment. "Needs assessment" refers to the process of determining if a safety training program is needed. Several techniques can be used to conduct a needs assessment. These include observation of employees performing the job, use of questionnaires, studying technical records and manuals, and interviewing subject matter experts. There are both advantages and disadvantages associated with different methods of needs assessment. All of the following are considered to be advantages of the "use of questionnaires" method of needs assessment EXCEPT:

a. Cost

b. Can collect data from a large number of persons

c. Possible low return rates

d. The data collected can be easily summarized

25. One of the methods used in conducting a needs assessment for safety training programs is to interview experts in the subject matter. All of the following are considered to be disadvantages of using this method to conduct a needs assessment EXCEPT:

a. It is time-consuming

b. It can uncover details of training needs

c. It is difficult to analyze

d. It needs skilled interviewer

26. One of the methods used in conducting a needs assessment for a safety training program is to read technical records and manuals. All of the following are considered to be advantages of using this method of needs assessment EXCEPT:

a. Good source of information on procedure

b. Objectivity

c. Good source of task information for new jobs

d. Materials may be obsolete

27. The needs assessment process for determining whether a safety training program is needed is comprised of three factors; organizational analysis, person analysis, and task analysis. All of the following are factors that needs to be considered in organizational analysis EXCEPT:

a. Reasoning ability of the trainer

b. The company's strategic direction

c. Managers' and peers' support for training activities

d. The training resources available

28. Research has shown that cognitive ability has a considerable amount of influence on learning and on job performance. Cognitive ability includes three dimensions. All of the following are considered to be a dimension of cognitive ability EXCEPT:

a. Verbal comprehension

b. Quantitative ability

c. Attitudes and motivation

d. Reasoning ability

29. Learning can be viewed as a relatively permanent change in an individual's capabilities that is not related to the growth process. These capabilities can be related to specific learning outcomes. All of the following are examples of types of learning outcomes EXCEPT:

a. Verbal information

b. Objectives

c. Motor skills

d. Attitudes

30. Learning is a relatively permanent change in an individual's capabilities that is not related to the growth process. These capabilities are related to specific learning outcomes. Examples of learning outcomes are verbal information, intellectual skills, motor skills, attitude, and cognitive strategies. Which of the following capabilities is related to the cognitive strategies learning outcome?

a. Manage one's own thinking and learning process

b. Choose a personal course of action

c. State, tell, or describe previously stored information

d. Execute a physical action with precision and timing

31. Several learning theories have been proposed that relate to how we learn. All of the following are examples of learning theories EXCEPT:

a. Reinforcement theory

b. Social learning theory

c. Goal setting theory

d. Participative management theory

32. Reinforcement theory is one of the several proposed learning theories. Which of the following statements BEST describes the "reinforcement theory"?

    a. Emphasizes that people learn by observing other individuals who, in their opinion, are knowledgeable and credible.

    b. Assumes that an individual's behavior is the outcome of the person's conscious goals and intentions.

    c. Emphasizes that the past outcomes of certain behaviors can motivate people to perform or avoid certain behaviors.

    d. Explains the amount of value that a person places on certain outcomes.

33. Which of the following statements BEST describes the information processing theory of learning?

    a. Suggests that an individual's behavior is based on expectancy, instrumentality, and valence

    b. Suggests that the orientation to learning must be problem-centered instead of subject-centered

    c. Suggests that the instruction must be based on the learner's interests and competencies

    d. Emphasizes the internal processes that occur when training content is learned and retained

34. According to the social learning theory, a person's learning is influenced by his or her self-efficacy. Which of the following statements BEST describes the concept of self-efficacy?

    a. Learners must remember the behavior or skills that they observe.

    b. Behavior modification is a training method that is based on reinforcement.

    c. An individual's judgment about whether he/she can successfully learn knowledge and skills.

    d. A need that motivates a person to behave in a manner to satisfy a deficiency.

35. The expectancy theory of learning suggests that three factors are the basis for an individual's behavior. These factors are expectancy, instrumentality and valence. Which of the following statements best describes valence?

    a. The value an individual places on an outcome

    b. Adults have a need to know why they are learning something

    c. Even the best designed training program cannot be successful if employees feel that their job security is threatened

    d. Changes in the intensity or frequency of the stimulus that affect attention

36. The learning processes can be divided into eight different categories. These are:

- Expectancy
- Perception
- Working storage
- Semantic encoding
- Long-term storage
- Retrieval
- Generalizing
- Gratifying

Which of the following BEST describes semantic encoding?

a. Refers to the mental state that the learner brings to the instructional process

b. Refers to the ability to organize the message from the environment so that it can be processed and acted upon

c. Refers to identifying learned material in long-term memory and using it to influence performance

d. Relates to short-term memory

37. Knowing the objectives of a training program greatly helps employees to learn best. A training objective has three components. Which of the following is NOT considered to be a component of a training objective?

a. A statement to elaborate the amount to be learned

b. A statement of what the employee's performance is expected to be

c. A statement of the quality of performance that is acceptable

d. A statement of the conditions under which the employee is expected to perform the outcome of the learning

38. Seating arrangement at the training site must be based on the type of trainee interaction desired and the desired trainee-trainer interaction. All of the following are types of seating arrangements EXCEPT:

a. Horseshoe

b. Fan-type

c. Conference-type

d. Instructor-student

39. All of the following are considered to be advantages of fan-type seating arrangement at a training site EXCEPT:

a. Allow the trainees to see from any point in the room.

b. Trainees can easily switch from listening to a presentation to working in teams.

c. Allows for maximum interaction of trainees with the trainer.

d. Trainees can communicate easily with everyone in the room.

40. Which of the following should be the first step in the development of a safety training program?

a. Ensure that qualified instructors are available.

b. Determine if there is a need for the training.

c. Set realistic and measurable goals and objectives for the training program.

d. Ensure that course material meets the objectives of the training program.

41. Which of the following is the BEST example of a hazardous waste handling training program?

a. Regulatory compliance

b. Storage

c. Transportation

d. Students understand and are able to practice the regulatory framework to handle hazardous waste from its point of generation to its ultimate disposal.

42. Which of the following IS NOT true in regard to the multiple choice method of knowledge assessment?

a. Objectivity

b. Statistical reliability

c. Subjectivity

d. Easy grading

43. Which of the following must be considered first, before a decision on computer-based safety training is made?

a. The type of software to be used

b. Availability of computers

c. Internet connection for training at multiple sites

d. Need analysis

44. Which of the following is the most important thing to do at the completion of a safety-training program?

a. Measure the class performance by conducting a statistical analysis of student grades.

b. Review the regulatory portion of the course to ensure that students understand regulatory compliance.

c. Give a hands-on test to ensure that students can put their knowledge into practice.

d. Obtain student feedback for continuous improvement.

45. Malcolm Knowles suggests six assumptions about adult learning. The need to know, the learner's self- concept, and the role of learners' experiences are three of these assumptions. All of the following are among assumptions about adult learning EXCEPT:

a. Readiness to learn

b. Orientation to learning

c. Role playing in learning

d. Motivation

46. Which of the following is NOT considered to be a distance learning advantage?

a. Flexibility

b. Cost

c. No commuting

d. Requires adaptability to new technologies

47. Bandwidth is an important factor to consider when setting up Internet-based safety training that involves several workstations. Which of the following bandwidths provides the highest signaling speed for Internet-based safety training?

a. DSL

b. ADSL

c. T-1

d. POTS

48. Which of the following provides real-time conferencing and visual exchange?

a. WebEx

b. Visio 2006

c. PowerPoint

d. All of the above

49. Which of the following is (are) among what participants should learn in an effective safety training program:

a. How to identify the safety and health problems at their workplace

b. How to analyze the causes of these safety and health problems

c. How to bring about safer, healthier workplaces

d. All of the above

50. A general review of training "best practices" reveals four characteristics that sound training programs have in common. Which of the following is NOT one of these four characteristics?

a. Accurate

b. Credible

c. Clear

d. Principles of adult learning

51. Three kinds of "learning exchanges" should be used during training. Which of the following is NOT one of the three learning exchanges?

a. Participant-to-Participant

b. Participant-to-Facilitator

c. Facilitator-to-Participant

d. Facilitator-to-Facilitator

52. In regards to the characteristics of adult learners, which of the following statements is incorrect?

a. Adults are self-motivated.

b. Adults do not expect to gain information that has immediate application to their lives.

c. Adults learn best when they are actively engaged.

d. Adult learning activities are most effective when they are designed to allow students to develop both technical knowledge and general skills.

53. An effective safety education environment must have sufficient space for all attendees to sit comfortably during instruction and sufficient room set-up for participants to interact with one another. Which of the following is not one of the most widely used seating arrangement for safety training?

a. U-Shape

b. Round tables

c. Diagonal

d. Hollow square

54. Which of the following is (are) component(s) of an effective safety training program?

a. Be performance based.

b. Progress be measurable.

c. Have an implementation plan.

d. All of the above.

55. Threshold Limit Values (TLVs) are published by which of the following organizations?

a. OSHA

b. EPA

c. ACGIH

d. ANSI

56. Adults can best learn when they _____ something.

a. Observe

b. Do

c. Read

d. Listen to

57. All of the followings are considered to be adult learning theories EXCEPT:

a. Cognitive

b. Psychometric

c. Behavioral

d. Motivational

58. All the following are advantages of online training EXCEPT:

a. Flexibility

b. Cost

c. Internet

d. Networking opportunities

8.3 Example Answers

1. Select (d)

   The most important step in development of a safety and health program is to clearly define the goals and objectives of the program.

2. Select (c)

   In defining an effective safety training program, validity refers to identification of the hazards associated with each task and the required knowledge and skills to perform those tasks in a safe manner.

3. Select (d)

   The learning curve suggests that the level of proficiency gained increases with the time devoted to learning but eventually tends to reach a limit.

4. Select (a)

   Statements (b), (c), and (d) are all true in regard to role-playing training technique. This approach is not necessarily used to find innovative" approaches to problem solving.

   This is an excellent technique for management as well as other employees within an organization to achieve a number of benefits. For example, salespersons within an organization can be trained by having two people act in a sales scenario—one acts as the salesperson and the other as the customer. The trainer and/or trainees have the opportunity to observe the role play and make their comments afterwards.

5. Select (d)

   Statements (a), (b), and (c) are true in regard to the conference method of training. Statement (d) is not considered to be one of the reasons for the success of this type of training technique.

   This method of training takes a problem-solving approach. A group takes on a problem or issue and work together to come up with solutions. Among the disadvantages of this method of training are the difficulties in controlling a group or the group coming up with solutions that might be different from management's, resulting in conflict.

6. Select (b)

   Achievement is considered to be the largest driving force behind motivating individuals to change behavior to enhance training.

7. Select (d)

   Training programs are usually designed to reduce or eliminate the number of preventable accidents, improve housekeeping and operating conditions, etc. Lowering the average indirect cost of accidents is not considered to be a goal of a successful training program.

8. Select (a)

   Performance-based training focuses on solving a specific on-the-job problem.

   Safety training programs in general are more cost-effective when the training focuses on specific performance outcomes, rather than training on a wide range of knowledge and skills that trainees may not be sure how to apply to their jobs.

9. Select (b)

   A case study is a description of how people or organizations have dealt with a certain situation. One of the disadvantages of the case study method of training is that it may not relate to the actual work situation.

   The case study method of training encourages trainees not only to apply known concepts to workplace situations but also to develop new concepts and ideologies. The main objective of this method of training is problem identification; the solution to the problem is secondary.

10. Select (c)

    In computer terminology LAN is an acronym for Local Area Network.

11. Select (c)

    "Interactive" is not considered to be one of the three domains of learning.

    The cognitive domain deals with mental skills (knowledge). The affective domain provides enhancement in emotional areas that can affect, for example, attitude. The psychomotor domain of learning deals with the enhancement of physical skills. Therefore, any training program should focus on improving the learners' knowledge, skills, and/or attitudes.

12. Select (b)

    Effective safety training can have a very positive effect on employee morale.

    Studies by the National Institute of Health have concluded that worker participation in the training program has a marked impact on the outcome of the program. These studies concluded that training involving behavioral modeling, a substantial amount of practice, and dialog is generally more effective than other methods of safety and health training. The present findings challenge the current emphasis on more passive computer-based and distance training methods within the public health workforce.

13. Select (d)

    Identifying training needs is not one the steps involved in developing learning activities.

14. Select (a)

    Lack of instructional materials does not indicate that there is a need for a safety training program.

The first step in the training process is a basic one; to determine whether a problem can be solved by training. Problems that can be addressed effectively by training include those that arise from lack of knowledge of a work process, unfamiliarity with equipment, or incorrect execution of a task. Training is less effective (but still can be used) for problems arising from an employee's lack of motivation or lack of attention to the job. Whatever its purpose, training is most effective when designed in relation to the goals of the employer's total safety and health program.

If the problem is one that can be solved, in whole or in part by training, then the next step is to determine what training is needed. For this, it is necessary to identify what the employee is expected to do and in what ways, if any, the employee's performance is deficient. This information can be obtained by conducting a job analysis that pinpoints what an employee needs to know in order to perform a job.

Once the kind of training that is needed has been determined, it is equally important to determine what kind of training is not needed. Employees should be made aware of all the steps involved in a task or procedure, but training should focus on those steps on which improved performance is needed. This avoids unnecessary training and tailors the training to meet the needs of the employees.

15. Select (c)

The "performance" is a statement of what the trainee will do. In order to have an effective safety training program, the condition of the work must be taken into account. Each objective must have a standard of quality for the performance that is described. Developing learning activities is not considered to be one of the components in identifying goals and objectives.

16. Select (d)

Verbs such as "appreciate", "understand", and "know" are examples of action verbs that are not measurable and should not be used for describing performance in safety training. On the other hand, verbs such as "select", "manipulate", "discriminate", and "identify" are action verbs that clearly denote specific actions.

17. Select (a)

The verb "understand" does not describe a behavior that is measurable. Examples in statements (b), (c), and (d) all describe behaviors that are clearly measurable and/or observable.

18. Select (b)

Job Hazard Analysis will identify the safety hazards that workers may encounter on the job. Appropriate engineering and administrative controls as well training can be provided to either eliminate or reduce the risk of exposure to hazardous conditions.

Supervisors can use the findings of a job hazard analysis to eliminate and prevent hazards in their workplaces. This is likely to result in fewer worker injuries and illnesses; safer, more effective work methods; reduced workers' compensation costs;

and increased worker productivity. The analysis also can be a valuable tool for training new employees in the steps required to perform their jobs safely.

A job hazard analysis can be conducted on many jobs in the workplace. Priority should go to the following types of jobs:

- Jobs with the highest injury or illness rates
- Jobs with the potential to cause severe or disabling injuries or illness, even if there is no history of previous accidents
- Jobs in which one simple human error could lead to a severe accident or injury
- Jobs that are new to your operation or have undergone changes in processes and procedures
- Jobs complex enough to require written instructions

19. Select (c)

The correct order of the steps to be followed is statement (c).

Once you have stated precisely what the objectives for the training program are, then learning activities can be identified and described. Learning activities enable employees to demonstrate that they have acquired the desired skills and knowledge.

To ensure that employees transfer the skills or knowledge from the learning activity to the job, the learning situation should simulate the actual job as closely as possible. Thus, employers may want to arrange the objectives and activities in a sequence that corresponds to the order in which the tasks are to be performed on the job, if a specific process is to be learned.

For instance, if an employee must learn the beginning processes of using a machine, the sequence might be : (1) to check that the power source is connected; (2) to ensure that the safety devices are in place and are operative; (3) to know when and how to throw the switch; and so on.

20. Select (d)

According to Mager and Beach, the characteristics of the target population that may affect learning are physical characteristics, education, motivation, and interests.

21. Select (d)

Actually, in this situation, the pilot program will hold the trainees' interests. Once a training program has been developed, it is always a good idea to conduct the training in a pilot program.

22. Select (a)

It is a good idea to stay physically close to the trainees while making a presentation. Also, it is helpful to place the information being presented in a larger, and interesting context. It is important to deliver only the quantity of material that the trainees need to know.

23. Select (b)

    Statements (a), (c), and (d) are all true in regard to safety training presentation. Many educational psychologists believe that bringing a state of "out of balance" to trainees is essential to learning.

    It is also important for the instructor to rehearse the presentation. Being positive and showing enthusiasm, speaking loud enough so everyone can hear, and making eye contact with trainees are among other factors that contribute to effective presentations.

24. Select (c)

    Select(c)

    Possible low return rates or inappropriate responses is one of the disadvantages of using questionnaires to conduct a needs assessment for safety training. This method is also time consuming and , in general, lacks detail.

25. Select (b)

    One of the advantages of the interview method of conducting needs assessment for a safety training program is that it is good at uncovering the detailed of training needs, as well as causes and solutions of problems.

26. Select (d)

    Another disadvantage of using this method of conducting needs assessment for a safety training program is that one may be unable to understand the technical language.

27. Select (a)

    Observation, use of questionnaires, studying technical manuals and records, and interviewing subject matter experts are different techniques used for the needs assessment process. Statements (b), (c), and (d) are factors that need to be considered in organizational analysis.

28. Select (c)

    Attitudes and motivations are not considered to be one of the three dimensions of cognitive ability.

    Cognitive ability can be measured by certain tests. Cognitive ability tests assess abilities involved in thinking (for example, reasoning, perception, memory, verbal and mathematical ability, and problem solving). Such tests pose questions designed to estimate applicants' potential to use mental processes to solve work-related problems or to acquire new job knowledge.

29. Select (b)

    Other examples of learning outcomes are intellectual skills and cognitive strategies. Trainee learning outcomes must be measurable, specific, practical, meaningful, and consistent.

30. Select (a)

    Statement (b) is related to the attitudes learning outcome, statement (c) is related to the verbal information learning outcome, and statement (d) is related to the motor skills learning outcome.

31. Select (d)

    Other proposed learning theories are the need theory, the expectancy theory, the adult learning theory, and the information processing theory.

    The goal setting theory emphasizes setting goals that are specific, measurable, achievable, realistic, and time-targeted (SMART). This theory states that individuals in a group that has a common goal must clearly understand what is expected from them.

    The adult learning theory focuses on the following:

    - Adults in general want to have a reason why they should learn.
    - Adults use their own experiences to assist in their learning process.
    - New social rules determine the readiness of adults to learn.
    - Adults generally have a desire to apply what they have learned to problem solving.

    The expectancy theory states that individuals can be motivated to learn if they have certain expectations.

    The information processing theory is a cognitive processing theory. It focuses on how the mind functions. Learning elements such as rehearsal are associated with this theory, but emphasis is placed on how information is processed.

    The need theory explains the amount of value that a person places on certain outcomes.

    Reinforcement theory states that learners choose or avoid certain actions or behavior based on the consequences that are expected. Choices that led to positive consequences in the past have a tendency to be repeated, while those actions that resulted in a negative consequence in the past are avoided.

    The social learning theory, developed by Albert Bandura, focuses on observing the attitudes, behaviors, and emotional reactions of others. This learning theory emphasizes learning by observation, and considers that "we learn from each other."

32. Select (c)

    Statement (a) is a description of social learning theory, statement (b) is a description of the goal setting theory, and statement (d) is a description of need theories.

33. Select (d)

    The statement (a) is a description of the expectancy theory of learning. Statements (b) and (c) are both descriptions of the adult learning theory.

34. Select (c)

    Self-efficacy is best described by statement (c).

    Another way to describe self-efficacy is that it is an individual's belief in his or her ability to succeed in a particular situation.

35. Select (a)

    Valence that is one of the factors that can influence an individual's behavior according to the expectancy theory of learning is best described by statement (a).

36. Select (d)

    Statement (a) is a description of expectancy, statement (b) is a description of perception, and statement (c) is a description of retrieval.

37. Select (a)

    Statements in (b), (c), and (d) are components of a training objective. Other examples of training program objectives include, but are not limited to, increasing productivity, better product quality, a better work environment, and improving health and safety.

38. Select (d)

    (a), (b), and (c) are all types of different seating arrangements. Classroom-type is also a type of seating arrangement.

    A horseshoe arrangement allows eye contact between the instructor and the trainees. It is ideal when the presentation includes a demonstration and also allows the trainees to have large group discussions.

    In fan-type seating, the trainees can see from any point in the room and can easily listen to a presentation as well as engage in group practices.

    The conference-type seating arrangement accommodates the most number of trainees per area and is appropriate for lectures and keynoters.

39. Select (c)

    One of the advantages of classroom-type seating arrangement is that it allows good interaction of the trainer with the trainees.

40. Select (b)

    The fundamental question that must be answered is whether the training program resolves the needs of the organization.

41. Select (d)

    A training objective must specifically identify what the students can do at the conclusion of the training program.

42. Select (c)

Multiple-choice questions can be graded on a pass/fail basis, and therefore, are very objective (and not subjective).

Multiple choice questions have both advantages and disadvantages. Advantages include easy grading and the minimization of guessing. One of the major disadvantages is that they limit creativity.

43. Select (d)

Before a decision on computer-based safety training is made, one must conduct a need analysis to find out if there is a need for such training.

44. Select (d)

Obtaining student feedback for continuous improvement of the training program is the most important thing to consider at the completion of the training program.

45. Select (c)

Role playing is a teaching strategy to assist participants in experiencing feelings and participating skills.

46. Select (d)

If a student does not enjoy working with technology, that student will probably get a lot less out of an online course. The student must feel comfortable working with computers and online programs before signing up for a class. In general, online courses offer more flexibility, lower cost, and the advantage of no commuting compared to conventional classroom courses.

47. Select (c)

T-1, which is a digital transmission link, provides the highest signaling speed for transferring information across the Internet. Basically, T1 lines are business connections, while cable/DSL services are usually residential.

48. Select (a)

Cisco WebEx provides real-time conferencing and also provides the capability for real-time visual exchange.

WebEx also provides on-demand applications that can enhance different aspects of business processes such as training and sales. Applications are delivered over a global network with a very high level of security.

49. Select (d)

According to OSHA, the other component is how to involve their co-workers in accomplishing all of the above.

50. Select (d)

The fourth characteristic according to OSHA is:

Practical. Training programs should present information, ideas, and skills that participants see as directly useful in their working lives. Successful transfer of learning occurs when the participant can see how information presented in a training session can be applied in the workplace.

51. Select (d)

Participant-to-Participant: "Participant-to-participant" learning exchange recognizes that participants can learn from one another's experiences. Participant-to-participant exchanges should be a key feature of the training.

Participant-to-Facilitator: Facilitators can learn as much from training sessions as participants do. On many subjects, a group of participants may have more extensive knowledge and experience in certain areas than a facilitator.

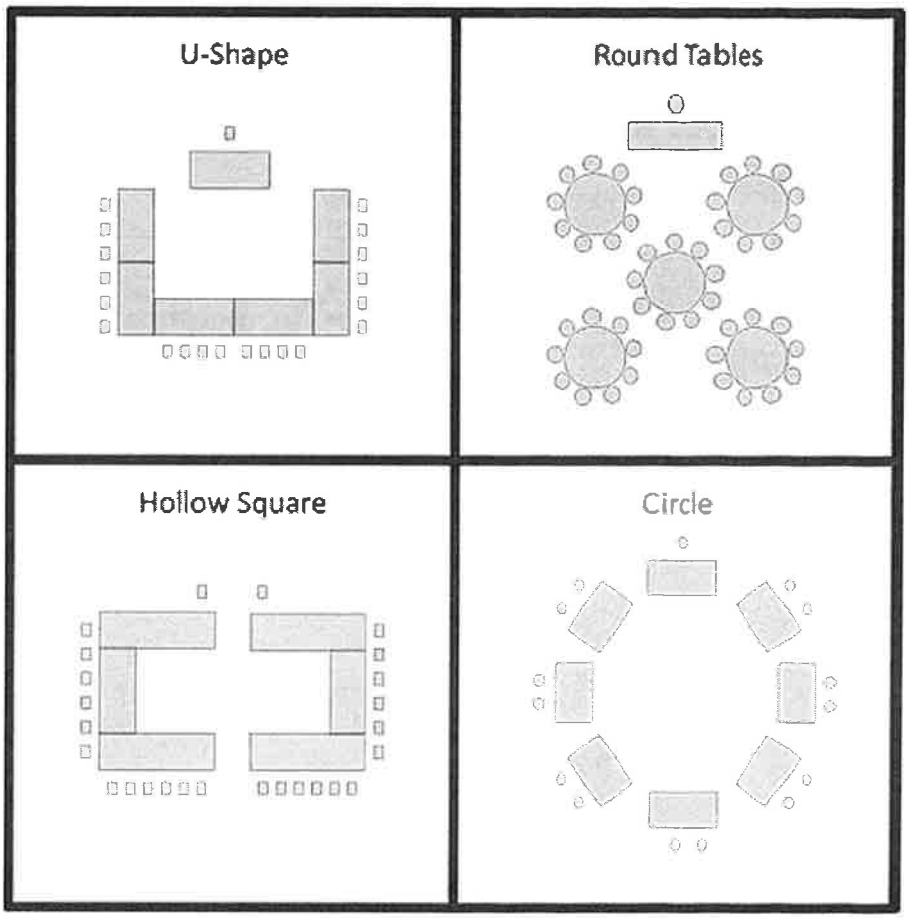
Facilitator-to-Participant: Classroom learning needs structure. A facilitator's role is to guide discussions, encourage participation, draw out and/or add information as needed, and highlight key issues and points.

52. Select (b)

Adults learn best when they have time to interact, not only with the instructor but also with each other. Adults learn best when asked to share each other's personal experiences at work and elsewhere.

53. Select (c)

Room Layouts That Encourage Participation and Improve Learning:



54. Select (d)

    A sound safety training program must accomplish transfer of knowledge gained to actual work situations, its progress be measurable, and have an implementation plan.

55. Select (c)

    The American Conference of Governmental Industrial Hygienist (ACGIH) publishes the TLVs. TLVs are airborne concentration of chemicals that a worker may be exposed to eight hours a day over a working lifetime without any adverse health effects. OSHA publishes the Permissible Exposure Limits (PELs).

56. Select (b)

57. Select (b)

    The cognitive theory addresses how information is processed and remembered. Behavioral theory deals with the fact that knowledge is a repertoire of behavioral responses to environmental stimuli. Motivational theory deals with how people learn when there is a motivation for learning.

58. Select (c)

    Benefits of Online training:

- Flexibility. Students have the freedom to juggle their careers and school because they aren't tied down to a fixed schedule.
- Reduced Costs. Online education can cost less due to a variety of reasons.
- Networking Opportunities.
- Documentation.
- Increased Instructor - Student Time.
- Access to Expertise.

Domain IX:
Law and Ethics

9.1 Codes of Ethics/Conduct

BCSP Code of Ethics:

Certificants shall, in their professional safety activities, sustain and advance the integrity, honor, and prestige of the safety profession by adherence to these standards.

Standards:

1. Hold paramount the safety and health of people, the protection of the environment and protection of property in the performance of professional duties and exercise their obligation to advise employers, clients, employees, the public, and appropriate authorities of danger and unacceptable risks to people, the environment, or property.
2. Be honest, fair, and impartial; act with responsibility and integrity. Adhere to high standards of ethical conduct with balanced care for the interests of the public, employers, clients, employees, colleagues, and the profession. Avoid all conduct or practice which is likely to discredit the profession or deceive the public.
3. Issue public statements only in an objective and truthful manner and only when founded upon knowledge of the facts and competence in the subject matter.
4. Undertake assignments only when qualified by education or experience in the specific technical fields involved. Accept responsibility for their continued professional development by acquiring and maintaining competence through continuing education, experience and professional training.
5. Avoid deceptive acts which falsify or misrepresent their academic or professional qualifications. Not misrepresent or exaggerate their degree of responsibility in or for the subject matter of prior assignments. Presentations incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, or past accomplishments with the intent and purpose of enhancing their qualifications and their work.
6. Conduct their professional relations by the highest standards of integrity and avoid compromise of their professional judgment by conflicts of interest.
7. Act in a manner free of bias with regard to religion, ethnicity, gender, age, national origin, disability, marital status, or sexual orientation.
8. Seek opportunities to be of constructive service in civic affairs and work for the advancement of the safety, health and wellbeing of their community and their profession by sharing their knowledge and skills.

AMERICAN SOCIETY OF SAFETY ENGINEERS CODE OF PROFESSIONAL CONDUCT

Membership in the American Society of Safety Engineers evokes a duty to serve and protect people, property and the environment. This duty is to be exercised with integrity, honor and dignity. Members are accountable for following the Code of Professional Conduct.

Fundamental Principles

1. Protect people, property and the environment through the application of state-of-the-art knowledge.
2. Serve the public, employees, employers, clients and the Society with fidelity, honesty and impartiality.
3. Achieve and maintain competency in the practice of the profession.
4. Avoid conflicts of interest and compromise of professional conduct.
5. Maintain confidentiality of privileged information.

Fundamental Canons

In the fulfillment of my duties as a safety professional and as a member of the Society, I shall:

1. Inform the public, employers, employees, clients and appropriate authorities when professional judgment indicates that there is an unacceptable level of risk.
2. Improve knowledge and skills through training, education and networking.
3. Perform professional services only in the area of competence.
4. Issue public statements in a truthful manner, and only within the parameters of authority granted.
5. Serve as an agent and trustee, avoiding any appearance of conflict of interest.
6. Assure equal opportunity to all.

9.2 Example Questions

1. Emergency response instruments must be calibrated:
   a. Annually
   b. Once a week
   c. Once a month
   d. Before and after each use
2. In regard to tort, all of the following statements are correct EXCEPT:
   a. The word *tort* denotes a common law civil wrong for which a court will provide a remedy.
   b. Tort arises from the existence of a generalized legal duty to avoid causing harm to others.
   c. Tort can arise through acts of omission, as well as, commission.
   d. Tort arises from an explicit promissory agreement between the parties to the action.
3. Tort law in product liability includes the concept of "duty to warn." Which of the following is not a criterion for determining whether a duty to warn exists?
   a. Potential for an accident when the product is used without warning
   b. Probable seriousness of injuries
   c. Effectiveness and feasibility of a warning
   d. Laws or regulations applicable to the warning
4. Which of the following regulates the safety of automobile fuels?
   a. EPA
   b. OSHA
   c. DOT
   d. CPSC
5. Company A sells a product to company B which in turn sells the product to a consumer C. "Privity" exists between:
   a. Company A and consumer C
   b. Consumer C and company A
   c. Company A and company B
   d. All of the above

6. The Consumer Products Safety Act requires that manufacturers, distributors and private labelers of consumer products that are subject to this act certify that their products are in compliance with the provisions of this act. Which of the following is NOT part of the certification label?

   a. CPSC identification number

   b. Statement of compliance

   c. Identification of manufacturer or distributor

   d. Identification of private labeler

7. Which of the following situation eliminates the need for a consumer product-warning label?

   a. The danger is foreseeable

   b. The danger can only result lack of exercise of due care

   c. The danger is obvious

   d. The danger can only result from user's negligence

8. All of the following are true in regard to a consumer product warning label EXCEPT:

   a. The potential for causing harm must be indicated.

   b. The warning must be well communicated.

   c. The manufacturer, distributor, or private labeler is responsible to provide warning.

   d. The applicable PEL or TLV must be indicated.

9. Decisions regarding the ability of workers to perform the tasks required for the job must be made in accordance with which of the following?

   a. Occupational Safety and Health Act

   b. Occupational Disability Act

   c. Americans with Disabilities Act

   d. Workers with Disabilities Act

10. Which of the following statements BEST describes the expression "*res ipsa loquitur*" that is sometimes used in product safety litigation cases?

    a. Strict liability exists on the part of the product manufacturer.

    b. A direct relationship or privity exists between the product manufacturer and the product distributor.

    c. Express warranty does not have to be in writing. Verbal expressions of the product manufacturers also constitute express warranty.

d. Situations when it is assumed that a person's injury was caused by the negligent action of another party because the accident was the sort that would not occur unless someone was negligent.

11. Which of the following statements best describes the most recent ruling on the product liability statute of limitations?

    a. All product liability tailgates are covered by the statute of limitations

    b. The statute covers only products with uncertain life expectancy

    c. The product liability tail must be limited by contractual agreement

    d. The statute does not begin to run until an injury has occurred

12. All of the following statements are true in regard to the OSHA Hazard Communication Standard (29 CFR 1910.1200) EXCEPT:

    a. The standard deals with hazardous chemicals only.

    b. The standard requires that hazardous chemical manufacturers, importers, or distributors prepare container labels.

    c. The standard requires that hazardous chemical manufacturers, importers, or distributors prepare Safety Data Sheets (SDS).

    d. The standard requires that employers provide 40 hours of training to those employees who have potential for exposure to hazardous chemicals either during normal operations or in an emergency.

13. Under the tort law "punitive damages" maybe awarded to plaintiff for the purpose of punishing the defendant in a civil law suit. Punitive damages under the tort law are also known as:

    a. Exemplary damages

    b. Compensatory damages

    c. Hidden damages

    d. Contributory damages

14. "Anticipatory Breach of Contract" occurs when one party to the contract stops performing according to the terms of the contract leaving the other parties believing that he has no intention of fulfilling his part of the contract. Anticipatory breach is also known as:

    a. Anticipatory repudiation

    b. Frustration of purpose

    c. Rescission

    d. Force majeure

15. Which of the following terms is used in contracts and insurance policies for protection of parties involved in the event the terms of the contract cannot be fulfilled due to natural and unavoidable catastrophes?
    a. Partial breach
    b. Material breach
    c. Force majeure
    d. Frustration of purpose
16. The type of contract between a consumer and a car dealership for leasing a car is called:
    a. Compulsory contract
    b. Executory contract
    c. Caveat emptor
    d. Non-disclosure contract
17. In disability terminology, "quadriplegic" refers to a person with:
    a. Birth anomaly
    b. A learning disability
    c. Spinal cord injury
    d. Dementia
18. In disability terminology, the term "demented" refers to a person with:
    a. Congenital disability
    b. Alzheimer's disease
    c. Learning disability
    d. Polio
19. In disability terminology, the term "epileptic" refers to a person with:
    a. Emotional disorders
    b. Psychiatric disorders
    c. Seizure disorders
    d. Developmental disability
20. Which of the following legal frames is designed to protect a company's trade secrets in the United States?
    a. Uniform Trade Secrets Act (UTSA)
    b. Trade Secrets Protection Act (TSPA)

c. Misappropriation of Trade Secrets Act (MTSA)

d. Federal Trade Secrets Protection Act (FTSPA)

21. Jim owns two television sets. One is a new HD model and the other an older set which is not HD. Jim is selling the older model to Mike. However, Mike is under the impression that he is buying the new HD set. What element of a valid contract has been violated?

a. Offer and acceptance

b. Free consent of parties

c. Mutual consent of parties

d. Possibility of performance

22. All of the following are essential elements of a valid contract EXCEPT:

a. Mutual consent of parties

b. Monetary considerations

c. Free consent of parties

d. Offer and acceptance

23. "Free consent of parties" is one of the elements of a valid contract. "Consent" means the parties must agree upon the same thing in the same sense. Which of the following causes a consent not to be free?

a. Fraud

b. Misrepresentation

c. Coercion

d. All of the above

24. Which of the following IS NOT one of the canons of professional conduct set forth by the Board of Certified Safety Professionals?

a. Hold paramount the safety, health, and welfare of the public.

b. Issue public statements only in an objective and truthful manner.

c. Perform safety, health, and environmental services in all related areas.

d. Act for each employer or client as faithful agents or trustees.

25. A safety professional has discovered an imminent danger hazard in an operation in the workplace. Which of the following is the MOST appropriate action by the safety professional?

a. Notify anyone who is familiar with the operation and report to nearest OSHA area office.

b. Notify anyone who is familiar with the operation and ensure that the corrective action is taken.

c. Shut down the operation and notify the responsible operation supervisor.

d. Notify the operation supervisor and recommend immediate corrective action.

26. All of the following can affect the ethical/unethical decision making EXCEPT:

a. Language background.

b. Stage of moral development.

c. Organizational environment.

d. Locus of control.

27. Certified Safety Professionals can earn points for "Continuance of Certification" (COC) by attending professional conferences. According to the BCSP the percentage of safety related materials in the conference must be at least;

a. 50%

b. 40%

c. 60%

d. 75%

28. How many COC points can be earned by attending a 2-day professional conference which is at least 50% safety related?

a. 2.5

b. 2.0

c. 1.5

d. 1.0

29. Which of the following statements is true regarding a safety professional who adheres to the profession's code of ethics?

a. Provides a safe work environment regardless of the means used to achieve this goal.

b. Reports to OSHA any imminent danger in the workplace that is not corrected.

c. Provides advice and consultation only in the areas of his/her expertise.

d. Requests for disciplinary action for workers who repeatedly commit unsafe acts.

30. Any charges of unethical conduct against a Certified Safety Professional must:

a. Be submitted to the BCSP in writing with a copy sent to the individual affected by the charges

b. Be in writing, notarized and submitted to BCSP

c. Be in writing submitted to the individual affected, BCSP and ASSE president

d. Be in writing and be submitted to the BCSP and local municipal court

31. As a CSP, you have been asked by a company that manufactures pressure vessels to review their design and approve it. You should:

a. Review the design for a flat fee

b. Request a percentage of total sales

c. Review that design and make necessary adjustment prior to approval

d. Tell the company that the job is beyond your areas of expertise

32. During a safety inspection, you have discovered that a pipe carrying a highly toxic chemical under high pressure is badly corroded and poses a serious threat to the safety and health of the personnel, the public, and the environment. As a CSP, your first step should be to:

a. Shut down the process immediately and inform the responsible supervisor.

b. Inform the responsible supervisor for immediate corrective action.

c. Inform the responsible supervisor and the plant manager for immediate corrective action.

d. Inform the responsible supervisor for immediate corrective action and report the hazardous condition to the OSHA area office.

33. All of the following statements describe the concept of "ethics" except:

a. Philosophical study of moral values.

b. Distinguishing good from bad and right from wrong

c. Developing and justifying sets of moral principles, duties, and obligations.

d. A science that cannot guide human thought and actions and is based only on description of moral and ethical facts.

34. Your company has decided to conduct a HAZOP on a hazardous process. The company has hired an outside contractor to conduct the HAZOP and you have been assigned to serve on the HAZOP team. The contractor has asked you to help out with the project and has offered a flat fee for your services. As a CSP, which of the following is the most appropriate action to take?

a. Reject the monetary offer and provide the services free of charge.

b. Reject the monetary offer and do not provide any services to the contractor.

c. Accept the flat fee and provide the services to the contractor.

d. Reject the flat fee offer and ask for a reasonable hourly rate for your services.

35. Which of the following has the potential of coming into conflict with what is the morally the right thing to do?

a. Legal requirements.

b. Religion requirements.

c. What family and friends believe one should do.

d. All of the above.

36. All of the following forms of immoral actions must be regulated by law EXCEPT:

a. Actions involving one's speech.

b. Having immoral thoughts.

c. Actions involving one's body.

d. Actions involving one's private property.

37. Which of the following statements is correct?

a. Morality deals with the way the laws in a society are made.

b. The main goal of ethics is to train people to develop a virtuous character.

c. Ethical behavior is concerned with making sure that everyone follows the rules.

d. Ethical theories are often impossible to apply to actual situations.

38. Decontamination is required for which of the following operations?

a. Fire fighting

b. Laboratory work

c. Demolition

d. Spill response

39. Which of the following best describes the General Data Protection Regulation (GDPR)?

a. It is an OSHA standard aimed at protection of medical information.

b. It is a new set of rules designed to give EU citizens more control over their personal data.

c. It is part of the Uniform Trade Secret Act (UTSA).

d. It regulates software developers to include data security in development of software.

40. A trade secret can be defined as almost anything which gives a company an economic advantage over its competitors. However, the owner of a trade secret is required to take reasonable steps to protect and safeguard the confidentiality of a trade secret. Labeling the secret materials is one way of achieving this goal. All the following are legends that can be used on a label EXCEPT:

a. Trade secret

b. Confidential

c. Secret

d. Stockholders' business property

41. In workers' compensation terminology, the no-fault system means:

a. Regardless of who is at fault, the worker will be paid for workplace illnesses and injuries.

b. The employer is protected against lawsuits.

c. The worker can only be paid upon proof of negligence on the part of the employer.

d. Both (a) and (b) above.

42. In workers' compensation, which of the following is **not** used in determining a facility's Experience Modification Rate?

a. Number of accidents in a given time period.

b. Severity of accidents.

c. Industry rate.

d. Hazard ratings of the facility's operations.

43. A facility has an Experience Modification Rate of 0.4. This means that the safety performance is:

a. Better than the industry.

b. Below the industry.

c. Same as the industry.

d. Slightly below the industry.

44. Which of the following is not used to determine workers' compensation insurance rates?

a. Manual rating

b. Compound-loss rating

c. Retrospective rating

d. Experience rating

45. Organizations which pay workers' compensation premiums recognize such expense as:

a. Indirect cost of accidents.

b. Uninsured cost of accidents.

c. Hidden cost of accidents.

d. Insured cost of accidents.

9.3 Example Answers

1. Select (d)
2. Select (d)

   The duty to exercise care to avoid causing harm to others is non-contractual. No explicit promissory agreement between the parties to the action is needed
3. Select (d)

   Applicable laws or regulations are not criteria for "duty to warn."
4. Select (d)

   The CPSC regulates the safety of automobile fuels.
5. Select (c)

   "Privity" refers to a direct contractual relationship between two parties. In this case privity exists between company A and B, and also, between company B and consumer C. No privity exists between company A and consumer C.
6. Select (a)

   The Consumer Products Safety Act does not require the manufacturer, distributor, or private labeler to include an identification number as part of their compliance statement.
7. Select (c)

   The use of warning labels on certain consumer products such as knives is not mandatory because of the obvious nature of the danger involved.
8. Select (d)

   The PEL for hazardous chemicals (not consumer products) is established by OSHA.
9. Select (c)

   Decisions regarding the ability of workers to perform certain tasks must be made in accordance with Americans with Disabilities Act.

   Employees with disabilities must meet qualification standards that are job-related and consistent with business necessity and must be able to perform the essential functions of the position, with or without reasonable accommodation.

   Although, an employee's disability typically has no bearing on performance or conduct, sometimes an individual's disability may contribute to performance or conduct problems. When this is the case, a simple reasonable accommodation often may be all that is needed to eliminate the problem.
10. Select (d)

Statement (d) is the correct definition of *res ipsa loquitur*, or "the thing speaks for itself".

11. Select (d)

    In product liability cases, the statute of limitations begins when an injury or damage occurs. However, once an injury has occurred, the injured person has a set time period in which to file a lawsuit.

12. Select (d)

    This standard does not require any minimum number of hours of training. It does require that at the conclusion of training, employees are able to understand and interpret container labels and SDSs.

13. Select (a)

    Punitive damages are also known as exemplary damages. Examples of "compensatory damages" also known as "tortious conduct" include reimbursement for property loss or damage, medical expenses, pain and suffering, and loss of earnings.

14. Select (a)

    Anticipatory breach is also known as anticipatory repudiation.

15. Select (c)

    Force majeure is a French term that refers to certain events that cannot be reasonably anticipated or controlled.

16. Select (b)

    Executory contract stipulates that there are certain duties that the parties have to perform on a certain date as identified in the contract. In the example of leasing a car, the dealership provides the car and the consumer makes the lease payments.

17. Select (c)

    The terms "quadriplegic" and "paraplegic" refer to persons with spinal cord injury.

18. Select (b)

    The terms 'demented" and "senile" refer to a person with Alzheimer's disease or dementia.

19. Select (c)

    Epileptic refers to a person with epilepsy and with seizure disorders.

20. Select (a)

    The UTSA published by the Uniform Law Commission in 1979 and amended in 1985 was a uniform act of the United States promulgated in an effort to provide legal framework to better protect trade secrets for the U.S. companies operating in multiple states.

21. Select (c)

    In order to constitute a valid contract, the parties must agree upon the same thing and in the same sense and at the same time.

22. Select (b)

    Other elements of a valid contract are "intention to create obligation", parties must be competent to the contract, and lawful consideration

23. Select (d)

    "Undue influence" and "mistakes" also render a contract to be invalid by not having free consent of the parties.

24. Select (c)

    Performing safety, health, and environmental services in all related areas is not one of the canons of professional conduct set forth by the BCSP. The code of professional conduct requires that a safety professional provide services only in his/her areas of expertise.

25. Select (d)

    The most appropriate action is to notify the operation supervisor and recommend immediate corrective action.

26. Select (a)

    Cultural background is not considered to be a factor in ethical/unethical decision making. "Locus of control" refers to a personal characteristic found in certain people who believe that they have control and are responsible for the events in their lives.

27. Select (a)

    At least 50% of the conference must be safety related.

28. Select (d)

    A 2-day professional conference, that is at least 50% safety related, will earn the attendee 1.0 COC point.

29. Select (c)

    According to the code of professional conduct set forth by the BCSP for the safety profession, a safety professional must provide services only in his/her areas of expertise.

30. Select (b)

    Any charges of unethical conduct against a CSP must be in writing, be notarized, and be submitted to the BCSP (according to BCSP code of professional conduct.)

31. Select (d)

The code of professional conduct of the BCSP requires that "certificants shall perform professional services and assignments only in the areas of their competence." (see BCSP Code of Professional Conduct)

32. Select (b)

    The CSP must notify the responsible supervisor for immediate corrective action. Safety professionals must keep the responsibility for safety, health, and environmental issues at the management level and have an advisory role for the management and personnel.

33. Select (d)

    This is not a good description of the concept of "ethics".

34. Select (a)

    It is against the engineering code of ethics for engineers to accept financial or other valuable consideration, directly or indirectly, from contractors, their agents, or other parties in connection with work for employers or clients for which they are responsible.

35. Select (d)

    The morally right thing to do may come into conflict with what the law or religion requires one to do. Also, the morally right thing to do may come into conflict with what friends or family believe one should do.

36. Select (b)

    There is no justification that law regulates one's immoral thoughts.

37. Select (b)

    The main goal of ethics is best described by statement (b).

38. Select (d)

    At the conclusion of a spill response operation, the personnel involved must be properly decontaminated. OSHA requires (29 CFR 1910.120) that monitoring instruments to detect presence of hazardous substances as well as proper PPE be provided to the spill response personnel.

39. Select (b)

    The **General Data Protection Regulation (GDPR)** is a new EU regulation and its aim is to improve privacy and give greater control to customers and citizens over their personal information and how it is used.

40. Select (d)

    Other legends include "proprietary information," "confidential information," etc.

41. Select (d)

The no-fault system ensures the worker is paid and protects the employer against lawsuits.

42. Select (d)

Frequency of accidents as well as their severity is used to determine a facility's Experience Modification Rate. The industry rate is used to compare the facility's performance to that of the industry as a whole.

43. Select (a)

The Experience Modification Rate compares the frequency and severity of accidents in a facility to that of the industry. An Experience Modification Rate of less than 1.0 indicates the facility's safety performance is better than the industry's safety performance. An Experience Modification Rate of greater than 1.0 indicates that the facility's safety performance is below the industry's safety performance.

44. Select (b)

Compound-loss rating is not a method to determine workers' compensation insurance rates. The Experience Modification Rate compares the frequency and severity of accidents in a facility to that of the industry. Manual rating is an insurance rate based on the experience of a probable class of risks and published in a manual. A retrospective rating plan can be defined as a rating plan "in which the final premium is based on the insured's actual loss experience during the policy term, subject to a minimum and maximum premium, with the final premium determined by a formula which is guaranteed in the insurance contract."

45. Select (d)

The costs are definite and known to the organization, and therefore they comprise the insured cost of the total cost associated with an accident.

Sample Test

10.1 Sample Test Questions

1. Which of the following is used to demonstrate the difference between actual expenditure at a given time and the projected budget for a project?

   a. Gantt chart

   b. Budget variance report

   c. Budget slack report

   d. Budget bar chart

2. A game of chance consists of tossing a coin and rolling a die. What is the probability of getting the event (tail, 3)? i.e. a 3 on the die and a tail on the coin?

   a. $\frac{3}{6}$

   b. $\frac{1}{12}$

   c. $\frac{2}{36}$

   d. $\frac{3}{24}$

3. Which of the following statements is correct in regard to OHSAS 18001?

   a. Calls for continuous improvement in safety and health management systems

   b. Sets standards to predict the financial health of an organization

   c. Sets standards for proper environmental management and in particular proper disposal of hazardous wastes

   d. Sets standards for pollution prevention

4. The following data is available for vapor pressure of acetone as a function of temperature.

   Temperature, ºF: 130º 120º 110º 100º 90º

   Vapor Pressure, mm Hg: 760 740 720 700 695

   When atmospheric pressure is 740mm Hg, the vapor pressure of acetone is also 740mm Hg at 120ºF. This means that the boiling point of acetone at 740mm Hg is:

   a. Equal to 120ºF

   b. Higher than 120ºF but less than 130ºF

   c. Lower than 120ºF but more than 110ºF

   d. Vapor pressure is a measure of the volatility of a liquid and has nothing to do with boiling point.

5. The root mean square sound pressure for a sound wave is 0.4 pascals. The sound pressure level in decibels relative to 20 micropascals is:

a. 80

b. 90

c. 75

d. 86

6. A container has dimensions of 20 × 20 × 10 feet and contains nitrogen. Assume that 18.9 ft^3 of carbon dioxide (CO_2) is released into this container. The concentration of CO_2 expressed in volume fraction is:

   a. 2.3

   b. 0.006

   c. 0.0047

   d. 0.65

7. A fire water supply system delivers 8,000 gallons per minute (gpm) when the pressure drops from 85 psig to 40 psig. What is the flow rate if the pressure drops from 85 psig to 25 psig?

   a. 8,700 gpm

   b. 5,200 gpm

   c. 9,344 gpm

   d. 16,000 gpm

8. During a safety inspection of your facility, you have discovered an unsafe act being committed by an employee. Your best course of action is:

   a. To stop the unsafe act and instruct how the job can be done safely.

   b. To report an unsafe act to employee's supervisor.

   c. Provide adequate training.

   d. All of the above.

9. Which of the following should be the first step in the development of a safety training program?

   a. Ensure that qualified instructors are available.

   b. Determine if there is a need for the training.

   c. Set realistic and measurable goals and objectives for the training program.

   d. Ensure that course material meets the objectives of the training program.

10. An electrical circuit protective device such as a fuse or circuit breaker protects the circuit from overload by:

    a. Closing the circuit

b. Dissipating excess heat

c. Opening the circuit

d. Electrical bonding

11. How much money should you be willing to pay now for a note that will yield $1,000 per year for 10 years starting next year at an interest rate of 10 percent?

a. $6,144

b. $5,293

c. $7,895

d. $4,238

12. Which of the following is NOT true in regard to Halon fire extinguishing agents?

a. Halons are made by halogenating a hydrocarbon.

b. Halons stop the spread of fire by chemically disrupting combustion.

c. The only disadvantage of Halons is that they leave a residue on the equipment after putting out the fire.

d. Halon is rated for Class B and Class C fires, but is also effective on Class A fires.

13. A system has two components in series, which means the failure of either component will cause the system to fail. The probability of failure for the first component is 10^{-3} and the probability of failure for the second component is 10^{-4}. What is the reliability of this system?

a. 0.9272

b. 0.9486

c. 0.9989

d. 0.9167

14. All of the following are examples of spreadsheet software EXCEPT:

a. Excel

b. VisiCalc

c. PowerPoint

d. Lotus

15. A flammable liquid storage area made of 1 foot-thick brick walls having a thermal conductivity of 0.4 Btu/hr/foot/^{o}F is on fire. Assuming that heat is transferred from one of the walls having a temperature of 800^{o}F and an area of 100 ft^2 to the other side of the wall, which has a temperature of 200°F, the rate of heat transfer in Btu/hr is:

a. 80,000

b. 24,000

c. 36,000

d. 8,000

16. When an employer establishes a fire brigade to respond to workplace fires, it must meet organizational, training, and personal protective equipment requirements. All of the following are procedural, program, and/or equipment requirements that the employer must meet except:

a. Prepare and maintain a fire brigade written organizational statement and document fire brigade member training information in the organizational statement.

b. Ensure employees expected to fight fires are physically capable to perform assigned duties.

c. Inspect and maintain fire- fighting equipment monthly. Inspect respirators and fire extinguishers annually. Remove and replace damaged equipment.

d. Supply protective clothing with components to protect the head, body, and extremities at no cost to the employees.

17. What is the noise reduction in decibels per foot of a 2 ft. diameter circular duct lined with a material having a sound absorption coefficient of 0.75?

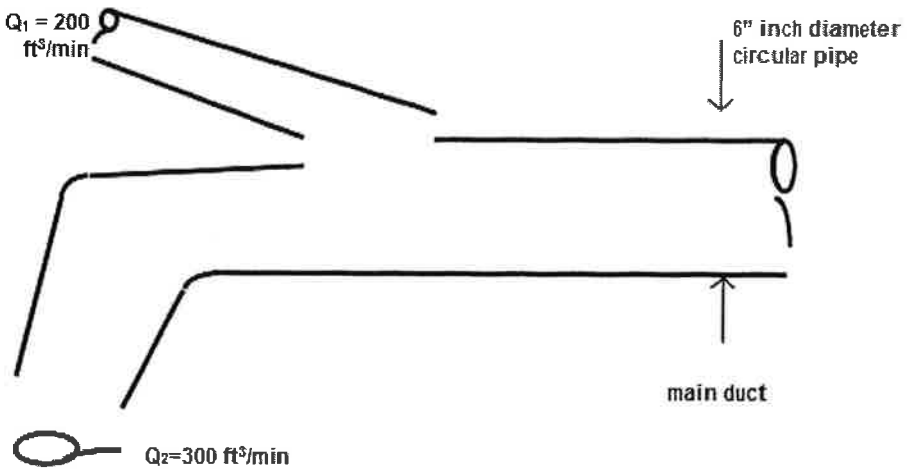
a. 1.4

b. 2.3

c. 3.8

d. 2.9

18. In the diagram shown below, the velocity pressure in the 6 inch duct is (assume STP):



a. -0.302 inches of water

b. +0.762 inches of water

c. -0.108 inches of water

d. +0.404 inches of water

19. A cab company conducted a study of their accident frequency for 200 days. At the conclusion of the study, it was found that the probability of NOT having an accident is 0.99. This means that, on the average, the cab company experiences an accident every_____ days.

a. 20

b. 100

c. 200

d. 50

20. Waterborne pathogens can be divided into three main categories. Which of the following does not belong to these categories?

a. Viruses

b. Bacteria

c. Parasite

d. Mold

21. Staff and line members within an organization perform different functions. Line managers are involved with producing a product or delivering a service to clients while staff members assist in special matters such as finance, legal, and security. Safety must be part of:

a. Line element of an organization only

b. Line supervisors only

c. Both line and staff functions

d. Staff element only

22. OSHA requires (29CFR1910.138) that whenever an employee uses his/her own PPE:

a. The employer is responsible to ensure that it is of the approved type.

b. The employee assumes full responsibility.

c. The employee assumes responsibility for PPE being of the approved type but employer is responsible for its maintenance and disinfection.

d. OSHA requires that no employee owned PPE be used in the workplace.

23. Which of the following IS NOT addressed in the "process safety information" element of the process safety management standard?

a. Incident investigation.

b. Process Technology.

c. Process equipment.

d. Process Chemicals.

24. The safety office of Company XYZ reports an average of four lost time injuries in the past three months. What is the probability that there will be three or less lost time injuries in the next three months?

a. 0.2754

b. 0.3265

c. 0.4332

d. 0.14618

25. Which of the following is NOT considered to be a distance learning advantage?

a. Flexibility

b. Cost

c. No commuting

d. Requires adaptability to new technologies

26. The cochlea is the main element of the:

a. Inner ear

b. Middle ear

c. Outer ear

d. Tympanic membrane

27. Assuming that the number of miles per gallon of gasoline for all midsize cars sold in the United States is normally distributed with a mean of 18 and a standard deviation of 3 miles per gallon, what percentage of midsize cars obtain less than 16 miles per gallon?

a. 32%

b. 7%

c. 18%

d. 25%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

28. OSHA requires that the employer designates an emergency response coordinator and a backup coordinator. Duties of the coordinator and employer include all of the following EXCEPT:

    a. Determining what emergencies may occur and seeing that emergency procedures are developed to address each situation.

    b. Directing all emergency activities including evacuation of personnel.

    c. Ensuring that outside emergency services are notified when necessary.

    d. Ensuring that a member of the local fire department and police serve on the emergency committee.

29. The amount of radiation emitted by a source at 2 feet away from the source is 0.06 rem. What level of radiation we expect to measure at 6 feet away from the source?

    a. 0.02 rem

    b. 6.66×10^{-3} rem

    c. 0.12 rem

    d. 0.18 rem

30. The time weighted average noise exposure for a worker is 95 decibels in a shift. The noise dose is:

    a. 120%

    b. 199%

    c. 50%

    d. 190%

31. LDR is an acronym for which of the following?

    a. Laboratory Disposal Report

    b. Land Disposal Restrictions

    c. Lowest Dose Reported

    d. Lethal Dose Restrictions

32. Which of the following best describes the basic strategy of a safe system approach for road traffic safety?

    a. To ensure that in the event of a crash, the impact energies remain below the threshold likely to produce either death or serious injury.

    b. To apply fault tree analysis to identify and eliminate the events that can lead to an accident.

    c. To ensure that the airbags are properly designed and can absorb the force generated as a result of a crash.

    d. All the above.

33. Which of the following are examples of class D fire extinguishing agents?

    a. Graphite powder

    b. Talc

    c. Sand

    d. All of the above.

34. Drums containing Polychlorinated Biphenyls (PCB) must be made of:

    a. Metal

b. Polyethylene

c. Ceramic

d. PVC

35. In designing outdoor plant layout, all equipment that may spill flammable materials should be located:

a. In an isolated area on the upwind side

b. On the downwind side

c. Near fire stations and on the upwind side

d. Close to the receiving area

36. A company must sell $1,000,000 worth of its product to recover $100,000 cost of loss from a recent accident in its manufacturing facility. The company's margin of profit is:

a. 10%

b. 20%

c. 5%

d. 15%

37. Which of the following statements is NOT true in regard to infrared radiation?

a. It is absorbed by the skin

b. It is absorbed as heat

c. It is absorbed by the eyes

d. It is a form of ionizing radiation

38. Which of the following colors are used on the coverings of grounded conductors?

a. Red

b. White or natural gray

c. Green

d. Yellow

39. Which of the following has the potential of coming into conflict with what is the morally the right thing to do?

a. Legal requirements.

b. Religion requirements.

c. What family and friends believe one should do.

d. All of the above.

40. A power plant delivers electricity to a transformer station through 10,000 feet of a 10 gauge copper wire having a cross sectional area of 1.44 in^2 and a resistivity of 0.9989×10^{-5} ft-ohms. If the circuit potential difference is 500 volts, the amount of power consumed by the copper wiring is:

    a. 10 kilowatts

    b. 15 kilowatts

    c. 5 kilowatts

    d. 25 kilowatts

41. A box accelerates from rest with an acceleration equal to 0.56 m/sec^2. In 10 seconds the box will travel a distance which is equal to:

    a. 50 meters

    b. 100 meters

    c. 10 meters

    d. 28 meters

42. In designing a task requiring pushing objects, it is advantageous to consider which of the following?

    a. Use the body weight to lift and then push the object.

    b. Use a mechanical aid as a leverage to lift the load.

    c. Use the body weight to push without any lifting force applied.

    d. Reduce the coefficient of friction to make it easy for the load to slide.

43. The system safety technique that evaluates the success or failure of safety functions is called:

    a. System Safety Analysis

    b. Failure Mode Effect Analysis

    c. Event Tree Analysis

    d. Fault Tree Analysis

44. *Pure risk* is defined as risk that can only produce negative outcomes. *Speculative risk* is defined as risk that can produce both positive and negative outcomes. Which of the following is not an example of pure risk?

    a. Fire

    b. Unrecoverable disability

    c. Gambling

    d. Accident

45. According to Raoult's Law, in a binary system, when liquid and vapor phases have reached equilibrium:

    a. The vapor has a higher concentration of the more volatile component as compared to the liquid.

    b. The liquid has a higher concentration of the more volatile component as compared to the liquid.

    c. The concentration of the less volatile component is the same in the vapor and liquid phases.

    d. Raoult's Law deals with electricity and magnetism and does not address vapor/liquid equilibria.

46. A gas mixture contains 32 lbs. of methane (molecular weight = 16), 6 lbs. of hydrogen (molecular weight = 2), and 44 lbs. of carbon dioxide (molecular weight = 44). The mole fraction of hydrogen in the gas mixture is:

    a. 3.0

    b. 0.5.

    c. 2.0

    d. 0.8

47. Which of the following statements is true regarding Radon $_{222}Rn^{86}$?

    a. It has 86 protons and 222 neutrons

    b. It has 86 electrons and 222 neutrons

    c. has 86 protons and 222 electrons

    d. has 86 protons and 136 neutrons

48. All the following statements are correct about Job Safety Analysis (JSA) EXCEPT:

    a. JSA breakdowns a job into several steps.

    b. JSA identifies the hazards associated with each step.

    c. JSA can be used to educate employees on safe practices.

    d. JSA can quantify the accident probabilities.

49. Placing a shield between an ionizing radiation source and an employee is an example of:

    a. Engineering control

    b. Administrative or management control

    c. Management control

    d. Only (a) and (b) above

50. The following initiating event probabilities were identified as a result of an FTA analysis on a system:

Event	Probability
A	10^{-8}
B	10^{-9}
C	10^{-8}
D	10^{-8}

The minimal cut sets are:

A, B

C, D

The probability of the top event is:

a. 1×10^{-24}

b. 11×10^{-17}

c. 1×10^{-17}

d. 11×10^{-24}

51. All of the following are considered to be guidelines that an experienced instructor would follow when presenting a safety training program EXCEPT:

a. Do not stay physically close to your listeners.

b. Get rid of professional terminology.

c. Remember that trainees tend to remember narrative chunks more than sophisticated information.

d. Appear to have fun, even be theatrical, if necessary.

52. Knowing the objectives of a training program greatly helps employees to learn best. A training objective has three components. Which of the following is NOT considered to be a component of a training objective?

a. A statement to elaborate the amount to be learned

b. A statement of what the employee's performance is expected to be

c. A statement of the quality of performance that is acceptable

d. A statement of the conditions under which the employee is expected to perform the outcome of the learning

53. OSHA requires [1910.212(a)(1)] that the employer must provide one or more methods of machine guarding to protect the operator and other employees from hazardous mechanical motion or action. Which of the following IS NOT an example of hazardous mechanical motion or action requiring machine guarding?

a. Point of operation

b. Ingoing nip points

c. Rotating parts

d. Vibrating parts

54. A cylindrical tank 30 ft high and 10ft in diameter is filled to 50% of its height with a liquid of unknown density. The pressure gauge at the bottom of the tank reads 3 psi. The density of the liquid in the tank is:

a. 62.4 lbm/ft^3

b. 52.7 lbm/ft^3

c. 28.8 lbm/ft^3

d. 68.3 lbm/ft^3

55. A conductor 10 ft long with a circular cross section having a diameter of 1/8 of an inch, and a resistivity of 5×10^{-3} ohm- inch has an electrical resistance equal to:

a. 83.2 ohms

b. 48.9 ohms

c. 72.6 ohms

d. 28.7 ohms

56. The OSHA Incidence Rate (IR) for a company with 300 employees and 9 recordable work related injuries and illnesses and 600,000 work hours is:

a. 5

b. 3

c. 4

d. 2

57. When setting safety and environmental goals, the goals must have all of the following qualities EXCEPT:

a. Be measurable

b. Be reportable

c. Be achievable

d. Have a time frame

58. CAD is an acronym for:

a. Construction and design

b. Cumulative anxiety disorders

c. Computer aided design

d. Construction and development

59. Decisions regarding the ability of workers to perform the tasks required for the job must be made in accordance with which of the following?

a. Occupational Safety and Health Act

b. Occupational Disability Act

c. Americans with Disabilities Act

d. Workers with Disabilities Act

60. A backward system safety analysis technique that visually demonstrates the interrelationships among equipment failure, human error, and environmental factors that can result in occurrence of an accident is called:

a. Event Tree Analysis

b. Fault Tree Analysis

c. THERP

d. EHE analysis

61. Under provisions of the process safety management standard, it is the responsibility of the employer to certify that they have evaluated compliance with the provisions of this OSHA standard. This certification must be done at least every:

a. 2 years.

b. 4 years.

c. 3 years.

d. 5 years.

62. Capacitors C_3 and C_4 with capacitances equal to 4 and 2 microfarad respectively are arranged in parallel. Capacitors C_1 and C_2 with capacitances equal to 5 and 2 microfarad respectively are arranged in series and connected to the above parallel arrangement. The equivalent capacitance for this circuit is: (Note: μF = microfarad)

a. 11.25 μF

b. 1.15 μF

c. 13.72 μF

d. 26.72 μF

63. Which of the following describes management leadership and effective employee participation as crucial factors contributing to the success of safety and health programs within organizations?

a. ANSI Z10

b. EPA Form R

c. Institute of Safety and Systems Management

d. Center for Occupational Safety and Health

64. _____ machine guards shut off or disengage power and prevent the machine from starting when the guard is opened.

a. Fixed

b. Adjustable

c. Interlocked

d. Self-adjusting

65. Simple asphyxiants are those chemicals which:

a. Can interfere with normal hemoglobin function and deprive the body of oxygen.

b. Cause suffocation by reducing oxygen concentration.

c. Are inert gases but once in the body are more reactive with blood than oxygen.

d. Only (a) and (c) above.

66. The cost of an injury or illness is divided into insured costs and uninsured costs. The total cost of an injury or illness is determined by:

a. Only considering the uninsured costs.

b. Subtracting the insured costs from the uninsured costs.

c. Adding the insured costs to the uninsured costs.

d. Subtracting the insured cost from the uninsured costs and dividing the result by the insured costs.

67. Maslow's hierarchy of needs states that we must satisfy each of our needs in turn, starting with the most obvious need for survival itself. Maslow's hierarchy of needs has five levels. Which of the following is NOT one of these five levels?

a. Esteem

b. Money

c. Belonging and love

d. Safety

68. Which of the following statements is true in regard to ionization smoke detectors?

a. They have a small amount of radioactive material between two electrically charged plates.

b. They ionize the air and cause current to flow between the plates.

c. Smoke disrupts the flow of ions, thus reducing the flow of current, which in turn activates the alarm.

d. All of the above.

69. Which of the following statements is correct?

a. Morality deals with the way the laws in a society are made.

b. The main goal of ethics is to train people to develop a virtuous character.

c. Ethical behavior is concerned with making sure that everyone follows the rules.

d. Ethical theories are often impossible to apply to actual situations.

70. 10,000 light bulbs were tested for 1,000 hours and 5 bulbs failed. What is the probability that a bulb from this batch would not fail in 1,000 hours of operation?

a. 90%

b. 99.95%

c. 99.99%

d. 99.55%

71. Which of the following organizations mandates lockout/tagout programs for service or maintenance of certain types of equipment?

a. NIOSH

b. OSHA

c. FEMA

d. CPSC

72. Which of the following best describes the General Data Protection Regulation (GDPR)?

a. It is an OSHA standard aimed at protection of medical information.

b. It is a new set of rules designed to give EU citizens more control over their personal data.

c. It is part of the Uniform Trade Secret Act (UTSA).

d. It regulates software developers to include data security in development of software.

73. In regard to the process of risk assessment, which of the following statements is the most correct?

a. Risk must first be managed and then assessed.

b. Risk can only be assessed after hazard identification.

c. Risk must be assessed before hazard identification.

d. Only (a) and (b) above.

74. Which of the following organizations has the most number of standards for unfired pressure vessels?

a. ANSI

b. NFPA

c. ASME

d. OSHA

75. In liability insurance coverage, the term "OCP" is an acronym for:

a. Operation and Chemical Protection

b. Owners and Contractors Protection

c. Operators and Contractors Protection

d. Operators and Constructors Protection

76. Strict liability is the absolute legal responsibility for an injury that can be imposed on the wrongdoer without proof of carelessness or fault. Which of the following IS NOT part of what the plaintiff must prove in product liability cases?

a. That the item was defective

b. That the defect proximately caused the injury

c. That the product did not work as expected

d. That the defect rendered the product unreasonably dangerous

77. Your company is planning to build a dike around a tank containing a hazardous chemical. The dike must be capable of containing 300,000 gallons and cannot exceed 3 ft in depth and 150 ft in length. The width of this dike is:

a. 109 ft

b. 160 ft

c. 59 ft

d. 89 ft

78. A ladder that is 20 feet from the base to the top support must be placed in such a way that the base distance from the vertical plane of the top support is:

a. 10 ft.

b. 5 ft.

c. 2 ft.

d. 1 ft.

79. Hazardous locations are classified by the National Electric Code (NEC) as Class I, Class II, and Class III locations. Class III locations are those in which there may be:

    a. Flammable vapors

    b. Flammable gases

    c. Flammable liquids

    d. Ignitable fibers

80. You have just completed a HAZCOM training for 300 employees at your workplace and have tabulated the results of their tests. The mean is 75 and the standard deviation is 4. What percentage of your students scored 81 or better? (Assume normal distribution.)

    a. 8.9%

    b. 6.8%

    c. 11.3%

    d. 14.6%

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

81. If the air contains 500 ppm of acetone (TLV, 750 ppm), and 50 ppm of MEK (TLV, 200 ppm):

    a. A Self Contained Breathing Apparatus (SCBA) must be used.

    b. The mixture TLV is above the recommended values.

    c. The concentration of the mixture is below recommended values of TLV.

    d. Only the TLV of the most hazardous component must be taken into account.

82. MORT is used extensively in Total Quality Management (TQM). MORT is an acronym for:

    a. Management Oversight Risk Tree

b. Minimum Operational Readiness Test

c. Management Objectives and Reorganization Technique

d. Management Organization and Restructure Technique

83. The ratio of volume of voids to the total volume of rock or soil is called:

a. Void density.

b. Homogeneity.

c. Void specific gravity.

d. Total porosity.

84. The term *boiling liquid expanding vapor explosion* (BLEVE) refers to which of the following?

a. An explosion caused by a flammable liquid at its boiling point

b. The failure of a container holding a liquid above its boiling point, which may result in an explosion

c. The volume of vapor expanding over the surface of a flammable liquid, which may result in an explosion

d. All of the above

85. Being independent of line management is a requirement for which of the following?

a. Safety training personnel

b. Safety audit teams

c. Contractors

d. All of the above

86. Effective safety training programs require clearly stated goals and objectives that are measurable. All of the following are considered to be components of objectives EXCEPT:

a. Performance

b. Condition of the work

c. Developing learning activities

d. Standard of quality for performance that is described

87. Which of the following statements is true regarding demand control ventilation to maintain acceptable indoor air quality?

a. Carbon monoxide sensors are used to control the rate of air flow.

b. Carbon dioxide sensors are used to control the rate of air flow.

c. Oxygen sensors are used to control the rate of air flow.

d. All of the above

88. A hood has a square opening with each side equal to 6 in. The hood has been designed to have a volumetric flow rate of 16,000 cfm. This hood is to be used to remove contaminant vapors 5 feet away from the opening. The capture velocity at 5 feet must be at least:

    a. 30.23 fpm

    b. 25.12 fpm

    c. 63.93 fpm

    d. 86.42 fpm

89. The first step in development of a safety training program must be to:

    a. Identify employees who may need training

    b. Prepare workbooks that are easy to understand

    c. Find instructors who are qualified in the subject of training

    d. Define objectives of the training program

90. A box weighing 100 lbs. is acted upon by a force of 1,000 lbf. Assuming a coefficient of friction 0.3, the acceleration of the box is:

    a. 300 ft./sec^2

    b. 10 ft./sec^2

    c. 312 ft/sec^2

    d. 30 ft/sec^2

91. The management technique that graphically demonstrates management styles by assigning values to the manager's concern for people and production is known as:

    a. MORT

    b. Theory Y

    c. The Blake Moulton Management Grid

    d. The Likert Scale

92. The leading cause of civilian fires is:

    a. Electrical

    b. Smoking

    c. Candles

    d. Cooking equipment

93. Which of the following IS NOT true in regard to the multiple choice method of knowledge assessment?

a. Objectivity

b. Statistical reliability

c. Subjectivity

d. Easy grading

94. In chemistry, the term *sorption* is used to cover which of the following processes?

a. Adsorption

b. Absorption

c. Ion exchange

d. All of the above

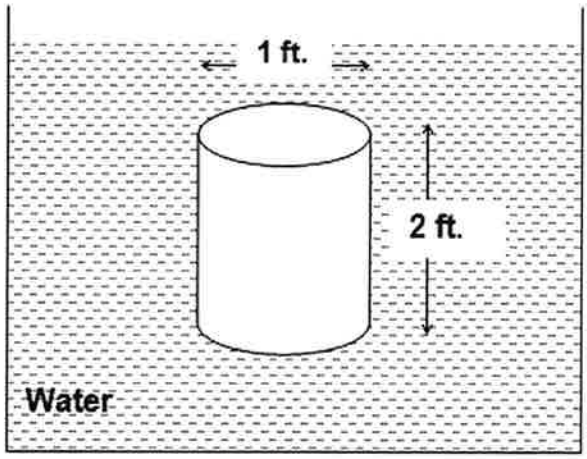
95. A cylindrical object having a diameter of 1 foot and a length of 2 feet is completely submerged in water, which has a density of 62.4 lbm/ft^3. The buoyant force exerted on this object is:

a. 154.2 lb

b. 97.97 lb

c. 45.63 lb

d. 62.4 lb



96. Which of the following best describes the most important step in an incident investigation program?

a. Collect meaningful data for subsequent analysis.

b. Preserve evidence and interview witnesses.

c. Ensure that appropriate regulatory agencies are notified.

d. Determine the casual factors and root causes that led to the incident.

97. Which of the following statements is true in regard to Class C hard hats?

    a. They offer limited head protection.

    b. They protect against falling objects and high-voltage shock and burns.

    c. They provide good impact protection.

    d. Both (b) and (c).

98. A drum of solvent is on fire in a storage room. Assume that heat is transferred from the outer surface of the drum having a temperature of 1,500°F to the wall having a temperature of 1,000°F by convection. If the heat transfer coefficient is 80 Btu/hr/ft^2/°F, the rate of heat transfer is: (Assume a heat transfer area of 50 ft^2.)

    a. 2×10^6 Btu/hr

    b. 96,000 Btu/hr

    c. 8.9×10^6 Btu/hr

    d. 12.7×10^6 Btu/hr

99. Which of the following is true in regards to workplace violence?

    a. Workplace violence is any act or threat of physical violence, harassment, intimidation, or other threatening disruptive behavior.

    b. It ranges from threats and verbal abuse to physical assaults and even homicide.

    c. In most workplaces where risk factors can be identified, the risk of assault can be prevented or minimized.

    d. All of the above.

100. A source is emitting electromagnetic radiation with a wavelength of 5 cm and an average power of 3,000 W. If the antenna has an area equal to 1 m^2, the power density at 100 meters from the antenna is:

    a. 300 W/m^2

    b. 120 W/m^2

    c. 30 W/m^2

    d. 600 W/m^2

101. Use of Ground-Fault Circuit Interrupters (GFCI) is an example of which of the following?

    a. Loss reduction

    b. Loss prevention

    c. Risk reduction

    d. All of the above

102. As compared to a normal fire, dust explosion needs two additional elements known as the dust pentagon. Which of the following is one of these two additional elements?

    a. Fuel to burn

    b. Ignition Source

    c. Suspension of Particles in air

    d. Oxygen

103. The maximum load which can be supported by a two-leg sling having an operating tension rating in each leg equal to 3,000 lbs. and each leg making a 45 degrees angle with the vertical is:

    a. 4,765 lb

    b. 5,000 lb

    c. 3,800 lb

    d. 4,242 lb

104. Gantt charts used in project scheduling are also called:

    a. Pie charts

    b. Matrix charts

    c. Bar charts

    d. Time charts

105. Which of the following techniques is most helpful to top management in placing priorities on corrective actions to eliminate or reduce risks?

    a. Fault tree analysis

    b. Risk analysis

    c. Failure analysis

    d. Cost/benefit analysis

106. Which of the following statements BEST describes Cumulative Trauma Disorders (CTD)?

    a. Disorders caused as a result of repeated movement of body parts.

    b. Disorders caused as a results of exposure to chemicals over a relative long period of time.

    c. Mental and psychological disorders developed over a period of time as a result of work related stress.

    d. Any disorder, physical or psychological, which is work related and has a cumulative effect over a given period of time.

107. Factors that affect safety effectiveness include behavioral influence as well as motivational factors. Which of the following is an example of behavioral influence?

    a. Achievement

    b. Advancement

    c. Church

    d. Responsibility

108. One of the problems associated with safety inspections is:

    a. Regulations may not be updated

    b. Control methods may not be economical

    c. Hazards are allowed to accumulate between inspections

    d. Lost time cases cannot be detected

109. Based on anthropometric data, the design features of a work station should accommodate which of the following range of measurements?

    a. 0 to 100 percent of population

    b. 5th to 95th percentile

    c. 10th to 90th percentile

    d. 50th percentile

110. A trench is:

    a. A narrow excavation

    b. Deeper than it is wide

    c. Never wider than 15 feet

    d. All of the above

111. Which of the following statements is NOT true in regard to dust particles?

    a. They are formed when particles migrate and condense from the surface of a molten solid into the air.

    b. They consist of mechanically-produced solid particles whose size can range from microscopic to visible.

    c. Dust particles can be inorganic or organic.

    d. The proper evaluation of dust hazards requires information regarding particle size, chemical composition, concentration, and factors that affect dispersion.

112. Which of the following provides the most efficient way to make Material Safety Data Sheets available to employees within an organization?

    a. Internet

b. Microsoft Internet Explorer

c. HTTP

d. LAN

113. The evaluation of hazards posed by a spilled substance must be conducted from a safe distance located:

a. Upwind of the spill

b. Down wind of the spill

c. Cross wind of the spill

d. Only (a) and (c) above

114. In regards to the characteristics of adult learners, which of the following statements is incorrect?

a. Adults are self-motivated.

b. Adults do not expect to gain information that has immediate application to their lives.

c. Adults learn best when they are actively engaged.

d. Adult learning activities are most effective when they are designed to allow students to develop both technical knowledge and general skills.

115. A set of data has a Pearson correlation coefficient of 0.5 between the dependent and independent variables. This indicates that:

a. As the independent variable increases, the value of the dependent variable decreases.

b. There is no relationship between the dependent and independent variables.

c. As the value of the independent variable increases, the value of the dependent variable increases.

d. As the value of the dependent variable increases, the value of the independent variable decreases.

10.2 Sample Test Answers

1. Select (b)

   The budget variance report is usually presented in the form of a table. The table lists the actual year-to-date expenditure, the actual year-to-date budget, and the difference between them.

   Gantt charts are bar charts commonly used in project scheduling. A Gantt chart demonstrates the start and finish times for different tasks in a project.

2. Select (b)

   Probability of getting a tail $= \frac{1}{2}$

   Probability of getting a 3 $= \frac{1}{6}$

   Probability of getting a tail and a 3 is equal to $\frac{1}{2} \times \frac{1}{6} = \frac{1}{12}$

3. Select (a)

   OHSAS calls for continuous improvement in safety and health performance in an organization.

4. Select (a)

   Boiling takes place at the temperature where liquid vapor pressures equals the ambient (atmospheric) pressure. Vapor pressure of a liquid always increases with an increase in temperature.

5. Select (d)

   The following relationship can be used to calculate the decibel value of a sound wave from root mean square values.

   (decibels) $= 20\, log\frac{P}{20}$

   where P is in micropascals and 20 micropascals is our reference point.

   L(decibels) $= 20\, log\frac{0.4\times10^6}{20} = 86$ dB

6. Select (c)

   Volume of air in the container initially:

   $20 \times 20 \times 10 = 4{,}000$ ft^3

   total $CO_2 = 18.9$ ft^3

   total volume $= 4{,}000 + 18.9 = 4{,}018.9$ ft^3

   Partial volume of CO_2 : $\frac{V_{CO_2}}{V_{\text{total}}} = \frac{18.9}{4{,}018.9}$

   CO_2 concentration $= 4.7 \times 10^{-3}$ volume fraction.

7. Select (c)

   The formula to solve this problem is:

   $Q_2 = Q_1 \left[\frac{(S-R_2)^{0.54}}{(S-R_1)^{0.54}}\right]$

   Where:

   Q_2 is the final flow rate

   Q_1 is the initial flow rate

   S is the initial pressure

   R_1 is the initial residual pressure

   R_2 is the final residual pressure

   For the problem at hand:

   $Q_2 = 8000 \left[\frac{(85-25)^{0.54}}{(85-40)^{0.54}}\right]$

   $Q_2 = 9{,}344.52$ gpm

8. Select (d)

   A sound safety management program sets forth provisions to stop unsafe acts as soon as they are discovered and to provide adequate training.

9. Select (b)

   The fundamental question that must be answered is whether the training program resolves the needs of the organization.

10. Select (c)

    Fuses and other circuit protective devices automatically open the circuit in the event of overflow of current. This action stops the flow of current.

11. Select (a)

    We use the formula:

    $P = A \left[\frac{(1+i)^n-1}{i(1+i)^n}\right]$

    where:

    P is present worth

    A is uniform series amount

    i is interest rate

    n is number of years

    For the problem at hand:

    $P = 1000 \left[\frac{(1+0.1)^{10}-1}{0.1(1+0.1)^{10}}\right]$

P = $6,144

12. Select (c)

Halons are made by halogenating hydrocarbons. Although hydrocarbons are flammable, the halogenated hydrocarbons lose their flammability characteristic as they become more halogenated.

Halons are especially effective for electrical fires in sensitive electronic equipment, because they leave no residue and therefore do not damage the equipment.

13. Select (c)

Let's solve this problem using two approaches. Since we have series components, we can write:

$R_{\text{system}} = R_1 \times R_2$

Reliability = 1 - probability of failure

$R_{\text{system}} = (1 - 1 \times 10^{-3}) \bullet (1 - 1 \times 10^{-4}) = 0.9989$

Now let's use the probability approach. Since the components are in series, the probabilities are added:

$P_f(\text{system}) = (1 \times 10^{-3}) + (1 \times 10^{-4}) = 0.0011$

$R_{\text{system}} = 1 - 0.0011 = 0.9989$

Both approaches result in the same answer.

14. Select (c)

Microsoft PowerPoint is not a spreadsheet program. An electronic spreadsheet organizes information into user-defined rows and columns. The data can then be manipulated by a formula to give a result. This type of software can be very useful in occupational safety management. For example, it can be used to manage accidents, unsafe conditions or acts, and lost work days data.

Lotus is a spreadsheet application developed by Lotus Development Corporation. IBM purchased the company in 1995 for $3.5 billion.

VisiCalc was the first spreadsheet application released in 1979 for Apple II computers.

15. Select (b)

The equation for heat transfer by conduction is:

$Q = K\frac{A}{L}(T_1 - T_2)$

where

Q is the rate of heat transfer

K is thermal conductivity

A is area through which heat is being transferred

T_1, T_2 are temperatures.

For the problem at hand:

$Q = \frac{0.4(100)}{1}(800 - 200)$

Q = 24,000 Btu / hr

16. Select (c)

The employer must do the following:

- Prepare and maintain a fire brigade written organizational statement. Document fire brigade member training information in the organizational statement.
- Ensure employees expected to fight fires are physically capable to perform assigned duties.
- Inspect and maintain fire- fighting equipment annually. Inspect respirators and fire extinguishers monthly. Remove and replace damaged equipment.
- Supply protective clothing with components to protect the head, body, and extremities at no cost to the employee.
- Ensure fire brigade members are provided with and use compliant respirators.

17. Select (a)

$NR = \frac{12.6P\alpha^{1.4}}{A}$

$NR = \frac{12.6\times3.14\times2\times12\times0.75^{1.4}}{3.14(1)^2\times144}$

NR = 1.4 decibel/foot

18. Select (d)

The total volumetric flow rate in the main duct is:

$Q = Q_1 + Q_2 = 300 + 200 = 500$ ft^3/min

Q = VA

Where Q is volumetric flow rate, V is velocity and A is the area of flow.

$500 = V \times \left(\frac{3.14(6)^2}{4\times144}\right)$

V = 2,548 ft/min.

To obtain velocity pressure we use $V = 4{,}005\ (VP)^{½}$

$2{,}548 = 4{,}005\ (VP)^{½}$, VP = 0.404 inches of water.

19. Select (b)

The probability of having an accident is 0.01 or 1/100 or one accident every 100 days.

20. Select (d)

The parasites are comprised of protozoa and helminths. Such pathogens reach water sources when infected people or animals shed microbes in feces.

21. Select (c)

The organization safety policy statement must clearly express that safety is part of everyone's job.

22. Select (a)

When employee-owned PPE is used in the workplace, the employer is responsible for ensuring that it is safe and of the approved type. It is also the responsibility of the employer to establish adequate measures for maintenance and disinfection of PPE.

23. Select (a)

Incident investigation is a separate element of the process safety management standard and is not part of the "process safety information" package.

24. Select (c)

We use the Poisson distribution. The formula for this distribution is:

$P_r = \frac{(\lambda t)^r e^{-\lambda t}}{r!}$

Since we are looking at probability in a time interval, the value of t is equal to 1.0 and λ is equal to 4. In order to calculate the probability of three lost time injuries, we have to calculate the probabilities of 0, 1, 2, and 3 incidents and add them up:

$P_0 + P_1 + P_2 + P_3$

Thus:

$P_0 = \frac{(4)^0 e^{-4}}{0!} = 1.83 \times 10^{-2}$

$P_1 = \frac{(4)^1 e^{-4}}{1!} = 7.33 \times 10^{-2}$

$P_2 = \frac{(4)^2 e^{-4}}{2!} = 0.1464$

$P_3 = \frac{(4)^3 e^{-4}}{3!} = 0.1952$

Therefore, the probability of having 3 lost time injuries in the next 3 months is:

$(1.83 \times 10^{-2}) + (7.33 \times 10^{-2}) + 0.1464 + 0.1952 = 0.4332$

25. Select (d)

If a student does not enjoy working with technology, that student will probably get a lot less out of an online course. The student must feel comfortable working with computers and online programs before signing up for a class. In general, online courses offer more flexibility, lower cost, and the advantage of no commuting compared to conventional classroom courses.

26. Select (a)

The cochlea is the main element of the inner ear. It is filled with a fluid and shaped like a coil. Sound waves travel through the cochlea before reaching the hair-like nerve cells for transmission to the brain.

27. Select (d)

$Z_{16} = \frac{16-18}{3} = -0.666$

Area for Z = – 0.66 is equal to 0.2454 which means approximately 25% of midsize cars obtain less than 16 miles per gallon of gasoline (0.5 – 0.2454). Areas are obtained from the table below.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

28. Select (d)

The emergency response coordinator must also be able to direct the shutdown of plant operations when necessary.

29. Select (b)

Radiation intensity follows the inverse square law

$I_1\ d_1^2 = I_2\ d_2^2$

Where:

I_1 is intensity at a distance of d_1 from the source, and I_2 is intensity at a distance of d_2 away from the source.

For the problem at hand:

$(0.06)\ (2)^2 = I_2\ (6)^2$

$I_2 = 6.66 \times 10^{-3}$ rem.

30. Select (b)

The relationship between noise dose and TWA is:

$TWA = 16.61 log \frac{D}{100} + 90$

where:

TWA = time weighted noise exposure in dB

D = noise dose in percent. For the problem at hand:

$95 = 16.61 log \frac{D}{100} + 90$

$log \frac{D}{100} = \frac{5}{16.61}$

or

$\frac{D}{100} = 1.99$

$D = 199\%$

31. Select (b)

LDR is an acronym for Land Disposal Restrictions. LDR restricted wastes are those that fall under the land disposal restriction standard under RCRA.

32. Select (a)

The basic strategy of a Safe System approach is to ensure that in the event of a crash, the impact energies remain below the threshold likely to produce either death or serious injury. This threshold will vary from crash scenario to crash scenario, depending upon the level of protection offered to the road users involved. For example, the chances of survival for an unprotected pedestrian hit by a vehicle diminish

rapidly at speeds greater than 30 km/h, whereas for a properly restrained motor vehicle occupant the critical impact speed is 50 km/h (for side impact crashes) and 70 km/h (for head-on crashes).

33. Select (d)

All have been used to smother metal fires.

34. Select (a)

PCB drums must be made of metal and must meet DOT specifications (49CFR).

35. Select (b)

Flammables should be placed on the downwind side otherwise, it is possible that the wind would carry the vapors from a spill over the plant where they could be ignited.

36. Select (a)

$$\text{margin of profit} = \frac{\text{cost of loss}}{\text{dollar volume to recover the loss}}$$

$$\text{margin of profit} = \frac{100{,}000}{1{,}000{,}000} = 0.1 \text{ or } 10\%$$

37. Select (d)

Workers normally notice excessive exposure through heat sensation and pain. Sources of IR radiation include furnaces, heat lamps, and IR lasers.

IR is categorized as non-ionizing radiation. The most damage it causes is to the eyes.

Other forms of non-ionizing radiation include the spectrum of ultraviolet (UV), visible light, microwave (MW), and radio frequency (RF).

38. Select (b)

Conductors that are grounded have a white or natural gray covering.

39. Select (d)

The morally right thing to do may come into conflict with what the law or religion requires one to do. Also, the morally right thing to do may come into conflict with what friends or family believe one should do.

40. Select (d)

First we calculate the resistance of the copper wire

$$R = \rho \frac{L}{A}$$

$$R = 0.9989 \times 10^{-5} \frac{10{,}000 \text{ ft}}{1.44 \text{ in}^2} \times \frac{144 \text{ in}^2}{1 \text{ ft}^2}$$

$$\text{R} = 9.989 \text{ ohms}$$

Next, we calculate the amount of current flow using Ohm's law:

$$\text{V} = \text{R I}$$

$500 = (9.989)I$

$I = 50.05$ amperes

Power can be calculated from $P = VI$ or $P = RI^2$

$P = (500)\ (50.05) = 25{,}027$ watts $= 25$ kilowatts

or

$P = (9.989)\ (50.05)^2 = 25$ kilowatts.

41. Select (d)

$s = 1/2\ \alpha t^2$

$s = 1/2\ (0.56)(100)$

$s = 28$ meters

42. Select (c)

The safest way to push an object is described in statement (c).

43. Select (c)

ETA begins with an initiating event and analyzes both the success and failure of safety functions that are designed to control the initiating event.

44. Select (c)

Gambling can offer winnings as well as losses.

45. Select (a)

Raoult's Law deals with vapor/liquid equilibria. It states that, in a binary system, when the liquid and vapor phases have reached equilibrium, the vapor phase has a higher concentration of the more volatile (lower boiling point) component as compared to the liquid phase. This is the principle on which separation of components by distillation is based.

46. Select (b)

Pound moles of methane $= \frac{32}{16} = 2$

Pound moles of hydrogen $= \frac{6}{2} = 3$

Pound moles of carbon dioxide $= \frac{44}{44} = 1$

Total number of moles $= 2 + 3 + 1 = 6$

Mole fraction of hydrogen $= \frac{3}{6} = 0.5$

47. Select (d)

222 is the atomic mass which is the number of protons (which is equal to number of electrons) plus the number of neutrons. 86 is the number of protons in the nucleus which is equal to number of electrons.

number of neutrons = atomic mass – number of protons

222 - 86 = 136

48. Select (d)

JSA breaks down a job into many steps and identifies the hazards associated with each step and their means of control. This technique can be used to educate employees on safe work practices.It must be pointed out that the priority for JSA should be assigned to those jobs that have a relatively high probability of leading to an accident which has severe consequences.

49. Select (a)

Hazard control is accomplished by either engineering or administrative (management) control. Generally, any type of control that requires design, construction, or design modifications is categorized as engineering control.

The best way to eliminate hazards is by means of engineering controls. However, if engineering controls cannot be implemented, then hazards must be controlled by means of administrative controls. Examples of administrative controls include training and reducing the time a worker is exposed to hazards.

50. Select (b)

First we multiply the probabilities within each set.

Set A,B: $10^{-8} \times 10^{-9} = 10^{-17}$

Set C,D: $10^{-8} \times 10^{-8} = 10^{-16} = 10 \times 10^{-17}$

Then we add the probability of all sets to get the probability of top event:

$10^{-17} + 10 \times 10^{-17} = 11 \times 10^{-17}$

51. Select (a)

It is a good idea to stay physically close to the trainees while making a presentation. Also, it is helpful to place the information being presented in a larger, and interesting context. It is important to deliver only the quantity of material that the trainees need to know.

52. Select (a)

Statements in (b), (c), and (d) are components of a training objective. Other examples of training program objectives include, but are not limited to, increasing productivity, better product quality, a better work environment, and improving health and safety.

53. Select (d)

The problem of vibrating parts usually does not require guarding and is solved using vibration dampers.

54. Select (c)

$h_p = \frac{P}{W}$

$W = \frac{P}{h_p}$

$\mathrm{P} = 3 \times 144 = 432$ psf

$W = \frac{432}{15} = 28.8$ lbm/ft^3

55. Select (b)

We use the formula:

$R = \rho \frac{L}{A}$

Note: As in other problems, we have to be careful to be consistent with units. Since resistivity is given in ohm-inch, we use inch for length and inch squared for area:

$A = \frac{\pi D^2}{4}$ (D is the diameter)

$A = \frac{\pi\left(\frac{1}{8}\right)^2}{4} = 0.0122$ in^2

$L = 10\text{ft}\frac{12\text{in}}{1\text{ft.}} = 120$ inches

$R = 5 \times 10^{-3}\frac{120}{0.0122} = 48.9$ ohms

56. Select (b)

The incidence Rate is calculated by multiplying the recordable injuries and illnesses by 200,000 and dividing by actual number of hours worked.

$IR = \left[\frac{\text{(injuries or illnesses) } 200{,}000}{\text{actual number of hours worked}}\right]$

$IR = \left[\frac{9 \times 200{,}000}{600{,}000}\right] = 3$

57. Select (b)

The goals and objectives must also be realistic and specific for the program at hand.

58. Select (c)

CAD is an acronym for Computer Aided Design. CAD systems are generally comprised of both software and hardware. This combination allows the design of everything from a bridge to a ship. Generally, CAD systems also require a high quality monitor to display graphics. Nowadays, CAD software is readily available for purchase.

59. Select (c)

Decisions regarding the ability of workers to perform certain tasks must be made in accordance with Americans with Disabilities Act.

Employees with disabilities must meet qualification standards that are job-related and consistent with business necessity and must be able to perform the essential functions of the position, with or without reasonable accommodation.

Although, an employee's disability typically has no bearing on performance or conduct, sometimes an individual's disability may contribute to performance or conduct problems. When this is the case, a simple reasonable accommodation often may be all that is needed to eliminate the problem.

60. Select (b)

This is a good description of Fault Tree Analysis.

61. Select (c)

It is the responsibility of the employers to certify that they have evaluated compliance with the provisions of this OSHA standard at least every three years to verify that the procedures and practices developed under the standard are adequate and are being followed.

62. Select (b)

First we find the equivalent capacitance for the parallel connection. This capacitor will then be in series with capacitors C_1 and C_2. Let's call the equivalent capacitance for the parallel connection C_5. We can write:

$C_5 = C_3 + C_4$

$C_5 = 4 + 2 = 6\mu F.$

Let's call the equivalent capacitance for the circuit C:

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_5}$

$\frac{1}{C} = \frac{1}{5} + \frac{1}{2} + \frac{1}{6}$

$C = 1.15\ \mu F.$

63. Select (a)

American National Standard Institute (ANSI) Z10 and the American Industrial Hygiene Association (AIHA) describe both management leadership and employee participation to be crucial factors in the success of safety and health programs.

64. Select (c)

Self-adjusting guards provide barriers that move according to the size of the stock entering the danger area. Fixed guards can be constructed to suit many applications and can provide a high level of protection. Adjustable guards provide an adjustable barrier.

65. Select (b)

Simple asphyxiants can cause suffocation as a result of reducing the available oxygen concentration. For example, if an inert non-toxic gas such as nitrogen is continuously pumped into a room that initially has normal oxygen concentration, eventually the oxygen concentration would diminish to a point that can no longer support life. Argon or methane also are good examples of simple asphyxiants.

66. Select (c)

The total cost of an injury or illness is obtained by adding the insured cost associated with the injury or illness to its uninsured costs.

Direct costs of accidents are those covered by insurance. Indirect costs of accidents are those that are not covered by insurance, and the company has to pay those costs. The uninsured costs of accidents are much greater than the insured costs. Examples of uninsured costs are loss of production, property damage, the cleanup and startup of operations, and the time to hire and train replacement workers.

67. Select (b)

The five levels of Maslow's hierarchy of needs are as follows:

- The first level is biological/physiological needs (air, food, and water).
- The second level is safety needs (protection and security)
- The third level is belonging/love needs (family, affection, and relationships)
- The fourth level is esteem needs (achievement and status)
- The fifth level is self-actualization needs (personal growth and fulfillment)

68. Select (d)

Another type of smoke detector is photoelectric. This type aims a light source into a sensing chamber at an angle away from the sensor. Smoke enters the chamber, reflecting light onto the light sensor, triggering the alarm.

69. Select (b)

The main goal of ethics is best described by statement (b).

70. Select (b)

$$\text{Reliability} = 1 - \frac{\text{number of failures}}{\text{total number of items exposed}}$$

$$R = 1 - \frac{5}{10{,}000}$$

$$R = 99.95\%$$

71. Select (b)

The correct answer is OSHA.

72. Select (b)

The **General Data Protection Regulation (GDPR)** is a new EU regulation and its aim is to improve privacy and give greater control to customers and citizens over their personal information and how it is used.

73. Select (b)

Risk assessment is conducted after hazard evaluation. The next step is to determine the probability and severity of the events which create the risk.

74. Select (c)

    Unfired pressure vessels such as compressed air tanks, steam-jacketed kettles, etc. must follow the ASME code, section VIII, division 1 and 2.

75. Select (b)

    "OCP" is an acronym for Owners and Contractors Protection. This type of insurance protects a business owner, property owner, or general contractor against liability due to the negligent act of an independent contractor or subcontractor who performs work on their behalf. The independent contractor or subcontractor purchases the policy. This type of policy covers a specific project at a specific location.

76. Select (c)

    This statement is related to implied warranty. Implied warranty is the assurance that a product will work if it is used for a reasonably expected purpose.

77. Select (d)

    First we convert gallons to cubic feet:

    $300{,}000 \div 7.48 = 40{,}106.95$

    Dike volume $= 150 \times 3 \times$ width

    $40{,}106.95 = 150 \times 3 \times$ width

    Width $= 89$ ft

78. Select (b)

    The safe procedure is that the distance of the ladder base from the vertical plane of the top support should be 1/4 of the distance between ladder base and top support.

    $\frac{20}{4} = 5ft.$

79. Select (d)

    Hazardous locations are classified by the NEC as Class I, Class II, and Class III, depending on the type of hazardous substance that may be present. In general, Class I locations are those in which flammable vapors and gases may be present; Class II locations are those in which combustible dusts may be found; and Class III locations are those in which there may be ignitable fibers.

    Each of these classes is divided into two hazard categories, Division 1 and Division 2, depending on the likelihood of the presence of a flammable or ignitable concentration of a substance. In general, the electrical installation requirements for Division 1 locations are more stringent than for Division 2 locations. Division 1 locations are designated as such because a flammable gas, vapor, or dust is normally present in hazardous concentrations. In Division 2 locations, hazardous quantities of these materials are not usually present, but may occasionally exist either accidentally or when material in storage is handled.

Additionally, Class I and Class II locations are subdivided into groups of gases, vapors, and dusts having similar properties.

80. Select (b)

$Z_{81} = \frac{81-75}{4} = \frac{6}{4} = 1.5$

Area for Z = 1.50 is equal to 0.4332, percentage of people with a score of 81 or better is 0.5 – 0.4332 = 0.068 or 6.8 %. Areas are obtained from the table below.

z	0	1	2	3	4	5	6	7	8	9
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.00359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0754
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2258	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2518	.2549
0.7	.2580	.2612	.2652	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2996	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

81. Select (c)

$\frac{C_1}{T_1} + \frac{C_2}{T_2}$

$\frac{500}{750} + \frac{50}{200} < 1$

82. Select (a)

MORT which has William G. Johnson as its principle author is an acronym for Management Oversight Risk Tree.

83. Select (d)

This ratio is called the total porosity of rock or soil. It is expressed as a percentage or fraction. Porosity is a measure of the maximum amount of water a rock or soil can hold when it is saturated with water. For example, gravel porosity has a range of 25 to 40 percent.

84. Select (b)

BLEVE is best described by statement (b). The consequences of BLEVE include overpressure blast wave, fireball, and vessel fragment hazards.

85. Select (b)

Safety audit teams must be independent of line management and be familiar with the systems or processes that they audit.

86. Select (c)

The "performance" is a statement of what the trainee will do. In order to have an effective safety training program, the condition of the work must be taken into account. Each objective must have a standard of quality for the performance that is described. Developing learning activities is not considered to be one of the components in identifying goals and objectives.

87. Select (b)

When the carbon dioxide exhaled by the occupants of a building reaches a certain concentration, the carbon dioxide sensors in the building activate the ventilation system.

88. Select (c)

We use the following relationship:

$V = \frac{Q}{10x^2+A}$

where:

V = capture velocity at distance x from the hood opening (feet per minute)

Q = volumetric flow rate of air through the system (cfm)

x = centerline distance from the hood opening (ft.)

A = hood opening area (ft^2)

For the problem at hand, we have:

$A = 6 \times 6 = 36in^2 = 0.25\ ft^2$

$V = \frac{16{,}000}{10(5)^2+0.25} = \frac{16{,}000}{250.25} = 63.93$

V = 63.93 fpm

89. Select (d)

The most important step in development of a safety and health program is to clearly define the goals and objectives of the program.

90. Select (c)

Newton's Second Law of Motion states that the resultant force in a given direction is equal to the mass of the object multiplied by its acceleration. In this case, the resultant force is:

1,000 lbf – frictional forces

F = 1,000 – (0.3)(100) = 970 lbf

$F = \frac{ma}{g_c}$

$970 = \frac{(100)\alpha}{32.2}$

$\alpha = 312$ ft./sec.^{2}

Note: Since we are working in the American Engineering System, the numerical value of force and mass are equal. In other words, an object having weight of 100 lbf has a mass of 100 lbm.

Also, we have to use

$g_c = 32.2$ because we work in the American Engineering System.

91. Select (c)

The Blake Moulton Management Grid assigns values based on the respondent's answers to questions about how he or she regards his or her employees versus the value of production. Each concern (people and production) is assigned a value between 1 and 9 on the management grid. The assigned values are plotted on 2-axis grid.

- Respondents who score a 9,1 are said to be Authoritarian, with a high concern for production and little concern for people.
- Respondents who score a 1, 9 are said to have a Country Club style of management. This means that people always get what they want and the manager avoids conflict.
- Respondents who score a 1,1 are considered Impoverished management. Conflict is avoided and the minimum amount of work is done to get by.
- Respondents who score a 9,9 are said to have a Team Management style where managers motivate people to work at the highest level of productivity.
- Respondents who score a 5,5 are considered Middle of the Road managers, or the Dampened Pendulum.

92. Select (b)

An estimated 35% of civilian fires are caused with cigarettes as their ignition source.

93. Select (c)

Multiple-choice questions can be graded on a pass/fail basis, and therefore, are very objective (and not subjective).

Multiple choice questions have both advantages and disadvantages. Advantages include easy grading and the minimization of guessing. One of the major disadvantages is that they limit creativity.

94. Select (d)

Absorption is the incorporation of a substance in one state into another of a different state (for example, a liquid being absorbed by a solid). Adsorption is the physical adherence or bonding of ions onto the surface of another phase (for example, reagents adsorbed to a solid catalyst surface). Ion exchange is an exchange of ions between two electrolytes or between an electrolyte solution and a complex.

95. Select (b)

Solution

According to the Archimedes' Principle, the buoyant force is equal to the weight of the water that is displaced by the cylinder.

Step 1: Calculate the volume of the cylinder.

$V = \frac{\pi D^2}{4} \times H$

Where V is the volume, D is the diameter, and H is the height of the cylinder.

$V = \frac{(3.14)\times(1)^2}{4} \times 2$

V = 1.57 ft^3

Step 2: Calculate the weight of the water that has a volume equal to 1.57 ft^3. We know that weight (force) is equal to mass multiplied by the acceleration of gravity.

W = mg

Where:

W = weight of an object

m = mass

g = acceleration of gravity

We also know that mass is equal to density multiplied by volume:

$m = \rho V$

Where:

m = mass

ρ = density

V = volume

Therefore, we can write:

$W = \rho V g$

In this case:

ρ = 62.4 lbm/ft^3

V = 1.57 ft^3

g = 32.2 ft/sec^2

Before we use the above equations, we have to remember that since we are working in the American Engineering System, mass (ρV) must be divided by 32.2.

$W = \frac{62.4 \times 1.57 \times 32.2}{32.2}$

W = 97.97 lbs or approximately 100 lbs

96. Select (d)

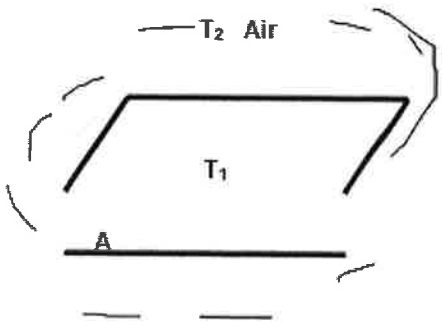
One of the major goals of an effective incident investigation program must be to prevent the occurrence of similar incidents. This can be accomplished by determining the casual factors and their subsequent root causes that led to the incident.

97. Select (a)

Class C helmets are designed for comfort. They offer limited head protection. They protect workers against fixed objects but do not protect against falling objects or electric shock.

98. Select (a)

Convection is the mechanism of interphase heat transfer, i.e., heat transfer between two different phases. If we have a surface at temperature T_1 that is transferring heat to the surrounding air at a temperature T_2 (as shown in the diagram), this heat is transferred by convection because the transfer is between a solid phase and a gaseous phase.



$Q = HA\ (T_1 - T_2)$

Where:

Q is the rate of heat transfer A is area T is temperature H is called the heat transfer coefficient.

For the problem at hand:

Q = 80 (50) (1,500 - 1,000) Q = 2×10^6 Btu/hr

99. Select (d)

Workplace violence is any act or threat of physical violence, harassment, intimidation, or other threatening disruptive behavior that occurs at the work site. It ranges from threats and verbal abuse to physical assaults and even homicide. It can affect and involve employees, clients, customers and visitors.

In most workplaces where risk factors can be identified, the risk of assault can be prevented or minimized if employers take appropriate precautions. One of the best protections employers can offer their workers is to establish a zero-tolerance policy toward workplace violence. This policy should cover all workers, patients, clients, visitors, contractors, and anyone else who may come in contact with company personnel.

By assessing their worksites, employers can identify methods for reducing the likelihood of incidents occurring. OSHA believes that a well written and implemented Workplace Violence Prevention Program, combined with engineering controls, administrative controls and training can reduce the incidence of workplace violence in both the private sector and Federal workplaces.

100. Select (b)

The relationship we use to solve this problem is:

$W = \frac{AP}{\lambda^2 r^2}$

where:

W = power density, units of power per distance squared e.g. W/m^2

A = antenna area

P = power

r = distance from antenna

λ = wavelength

For the problem at hand we have:

$W = \frac{1 \times 3000}{(0.05)^2 (100)^2}$

$W = 120\ W\ /\ m^2$

101. Select (b)

Use of a GFCI is a good example of engineering control for loss prevention. Loss reduction refers to situations where a loss has already occurred and the measures try to minimize further losses. For example, when emergency personnel respond to an emergency, loss has occurred and the emergency personnel try to minimize further losses.

102. Select (c)

Dispersion or suspension of particles in air and confinement of the dust cloud are two additional elements required for a dust cloud explosion.

103. Select (d)

The sum of all the vertical forces must be equal to zero for equilibrium to be maintained.

W - 2 (3,000) cos 45 = 0

W = 4,242 lbs.

104. Select (c)

Gantt charts are used to break down a project into different tasks and graphically show the time assigned for the completion of each task.

105. Select (d)

The benefit obtained from risk reduction must be justified through benefits to the organization.

106. Select (a)

CTD is a term used to describe physical disorders that are caused as a result of repeated movement of body parts. CTDs result when repeated stress is placed on tendons, muscles, or nerves causing inflammation or damage. Some of the more common CTDs are tendonitis (inflammation of the tendons), tenosynovitis (inflammation of the synovial sheath), and carpal tunnel syndrome (compression of the median nerve). Some of the conditions that may lead to CTDs are repetition, posture, and lack of rest.

107. Select (c)

Achievement, advancement, and responsibility are job motivational factors while church is an example of past behavioral influence.

108. Select (c)

A safety inspection usually causes a surge in safety and health activities. However, after a period of time hazards are allowed to accumulate until the next inspection.

109. Select (b)

Based on anthropometric data, (which is the study of dimensions, weights, and strengths of various human body members for the design of equipment and work

stations), the design features of a work station should accommodate from 5th percentile female to 95th percentile male.

110. Select (d)

Situations presented in statements a, b, and c are correct about trenches.

Some OSHA recommended safety tips for trenches are listed below:

- Do not enter an unprotected trench!
- Trench collapses cause dozens of fatalities and hundreds of injuries each year.
- Trenches 5 feet deep or greater require a protective system.
- Trenches 20 feet deep or greater require that the protective system be designed by a registered professional engineer.

Protective systems for trenches are the following:

- Sloping protects workers by cutting back the trench wall at an angle inclined away from the excavation.
- Shoring protects workers by installing aluminum hydraulic or other types of supports to prevent soil movement.
- Shielding protects workers by using trench boxes or other types of supports to prevent soil cave-ins.

111. Select (a)

Statements (b), (c), and (d) are true in regard to dust. Statement (a) is a characteristic of fumes.

112. Select (d)

Local Area Network (LAN) is an excellent way for making MSDS available to employees within an organization. A LAN is a network of computers for a relatively small area, usually a single building or a group of buildings.

113. Select (a)

Evaluation of physical, health, and environmental hazards of a spilled substance must be conducted from a safe distance upwind of the spill.

114. Select (b)

Adults learn best when they have time to interact, not only with the instructor but also with each other. Adults learn best when asked to share each other's personal experiences at work and elsewhere.

115. Select (c)

The dependent variable is the one that changes based on the changes in the independent variable. For example, in the equation of a straight line ($y = 2x$), y is dependent variable and x is the independent variable.

The Pearson coefficient of correlation is a number between – 1 and +1. -1 indicates a negative linear relationship between the dependent and independent variables which means that as the value of the independent variable increase, the value of the dependent variable decreases proportionately. A coefficient of correlation of +1 indicates a positive linear relationship between the dependent and independent variables. In other words, the value of the dependent variable increases proportionately as the value of the independent variable increases. A coefficient of correlation of 0 indicates that the value of the dependent variable does not change with any increase or decrease in the value of the independent variable or that no correlation exists between the two variables.

10.3 Sample Test Answer Key

1. (b)
2. (b)
3. (a)
4. (a)
5. (d)
6. (c)
7. (c)
8. (d)
9. (b)
10. (c)
11. (a)
12. (c)
13. (c)
14. (c)
15. (b)
16. (c)
17. (a)
18. (d)
19. (b)
20. (d)
21. (c)
22. (a)
23. (a)
24. (c)
25. (d)
26. (a)
27. (d)
28. (d)
29. (b)
30. (b)
31. (b)
32. (a)
33. (d)
34. (a)
35. (b)
36. (a)
37. (d)
38. (b)
39. (d)
40. (d)
41. (d)
42. (c)
43. (c)
44. (c)
45. (a)
46. (b)
47. (d)
48. (d)
49. (a)
50. (b)
51. (a)
52. (a)
53. (d)
54. (c)
55. (b)
56. (b)
57. (b)
58. (c)
59. (c)
60. (b)
61. (c)
62. (b)
63. (a)
64. (c)
65. (b)
66. (c)
67. (b)
68. (d)
69. (b)
70. (b)
71. (b)
72. (b)
73. (b)
74. (c)
75. (b)
76. (c)
77. (d)
78. (b)
79. (d)
80. (b)
81. (c)
82. (a)
83. (d)
84. (b)
85. (b)
86. (c)
87. (b)

88. (c)
89. (d)
90. (c)
91. (c)
92. (b)
93. (c)
94. (d)
95. (b)
96. (d)
97. (a)
98. (a)
99. (d)
100. (b)
101. (b)
102. (c)
103. (d)
104. (c)
105. (d)
106. (a)
107. (c)
108. (c)
109. (b)
110. (d)
111. (a)
112. (d)
113. (a)
114. (b)
115. (c)

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About the Author

H.R. Kavianian, Ph.D., CSP, CHMM, STSC is an emeritus professor of Chemical Engineering at California State University Long Beach, and has also served as an adjunct professor of safety at the University of Southern California. Dr. Kavianian was a former member of the U.S. Department of Energy's Operational Readiness Review Team for Occupational Safety and Environmental Requirements, and has served as the Chair of the Process Safety Technical Group of the American Society of Safety Professionals. In addition to safety, environmental, and chemical engineering research and development for Fortune 100 companies, and Argonne National Laboratory, Dr. Kavianian was in charge of the Defense Logistics Agency's Occupational Safety & Environmental training programs for the Department of Defense personnel in the U.S., Europe, Korea, and Japan.

In 2000, Dr. Kavianian was recognized as "Safety Professional of the Year" by Region 1 of the American Society of Safety Professionals which covers the states of California, Oregon, Washington, Alaska, and Hawaii, and in 1999 was similarly recognized by ASSP's Orange County Chapter. In 2001, the Associated Engineering Student Body selected Dr. Kavianian as the winner of the "Instructor of the Year" award for the College of Engineering at California State University Long Beach.