1. The micrometer (1 µm) is often called the micron.
   a. How many microns make up 1.0 km?
   b. What fraction of a centimeter equals 1.0 µm?
   c. How many microns are in 1.0 yd.?

2. The fastest growing plant on record is a *Hesperoyucca whipplei* that grew 3.7 m in 1.4 days. What was its growth rate in micrometers per second?

3. Spacing in a book is generally done in units of points and picas: 12 points = 1 pica, and 6 picas = 1 inch. If a figure was misplaced in the page proofs by 0.80 cm,
   a. What was the misplacement in picas?
   b. What was the misplacement in points?

4. Horses are to race over a certain English meadow for a distance of 4.0 furlongs.
   a. What is the race distance in rods?
   b. What is the race distance in chains?
   (1 furlong = 20.1168 m, 1 rod = 5.0292 m, and 1 chain = 20.117 m.)

5. The table shown is part of a conversion table for a system of volume measures once common in Spain; a volume of 1 fanega is equivalent to 55.501 dm³ (cubic decimeters). To complete the table, what numbers (to three significant figures) should be entered in
   a. the cahiz column?
   b. the fanega column?
   c. the cuartilla column?
   d. the almude column?

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<th>cahiz</th>
<th>fanega</th>
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<tr>
<td>1 cahiz</td>
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For the next three items, express 7.00 almudes in
   e. Medios.
   f. Cahizes.
   g. Cubic centimeters (cm³).

6. Hydraulic engineers in the United States often use, as a unit of volume of water, the acre-foot, defined as the volume of water that will cover 1 acre of land to a depth of 1 ft. A severe thunderstorm dumped 2.0 in. of rain in 30 min on a town of area 26 km². What volume of water, in acre-feet, fell on the town?

7. A lecture period (50 min) is close to 1 microcentury.
   a. How long is a microcentury in minutes?
   b. What is its percentage difference from the approximation?

8. Gold which has a density of 19.32 g/cm³, is the most ductile metal and can be pressed into a thin leaf or drawn out into a long fiber.
   a. If a sample of gold, with a mass of 27.63 g, is pressed into a leaf of 1.000 µm thickness, what is the area of the leaf?
   b. If, instead, the gold is drawn out into a cylindrical fiber of radius 2.500 µm, what is the length of the fiber?

9. (a) Assuming that water has a density of exactly 1 g/cm³, find the mass of one cubic meter of water in kilograms.
   (b) Suppose that it takes 10.0 h to drain a container of 5700 m³ of water. What is the "mass flow rate," in kilograms per second, of water from the container?

10. The record for the largest glass bottle was set in 1992 by a team in Millville, New Jersey--they blew a bottle with a volume of 193 U.S. fluid gallons.
    a. How much short of 1.0 million cubic centimeters is that?
    b. If the bottle were filled with water at the leisurely rate of 1.8 g/min, how long would the filling take? Water has a density of 1000 kg/m³.
1. Figure 2-15 shows four paths along which objects move from a starting point to a final point, all in the same time interval. The paths pass over a grid of equally spaced straight lines. Rank the paths according to (a) the average velocity of the objects and (b) the average speed of the objects, greatest first.

2. Figure 2-16 is a graph of a particle's position along an x axis versus time. (a) At time \( t = 0 \), what is the sign of the particle's position? Is the particle's velocity positive, negative, or 0 at (b) \( t = 1 \) s, (c) \( t = 2 \) s, and (d) \( t = 3 \) s? (e) How many times does the particle go through the point \( x = 0 \)?

3. Figure 2-17 gives the velocity of a particle moving on an x axis. What are (a) the initial and (b) the final directions of travel? (c) Does the particle stop momentarily? (d) Is the acceleration positive or negative? (e) Is it constant or varying?

4. Figure 2-18 gives the acceleration \( a(t) \) of a Chihuahua as it chases a German shepherd along an axis. In which of the time periods indicated does the Chihuahua move at constant speed?

5. Figure 2-19 gives the velocity of a particle moving along an axis. Point 1 is at the highest point on the curve; point 4 is at the lowest point; and points 2 and 6 are at the same height. What is the direction of travel at: (a) time \( t = 0 \) and (b) point 4? (c) At which of the six numbered points does the particle reverse its direction of travel? (d) Rank the six points according to the magnitude of the acceleration, greatest first.

6. The following equations give the velocity \( v(t) \) of a particle in four situations: (a) \( v = 3t \); (b) \( v = 4t^2 + 2t - 6 \); (c) \( v = 3t - 4 \); (d) \( v = 5t^2 - 3 \). To which of these situations do the equations of Table 2-1 apply?

7. In Fig. 2-20, a cream tangerine is thrown directly upward past three evenly spaced windows of equal heights. Rank the windows according to (a) the average speed of the cream tangerine while passing them, (b) the time the cream tangerine takes to pass them, (c) the magnitude of the acceleration of the cream tangerine while passing them, and (d) the change \( \Delta v \) in the speed of the cream tangerine during the passage, greatest first.

8. At \( t = 0 \), a particle moving along an x axis is at position \( x_0 = -20 \) m. The signs of the particle's initial velocity \( v_0 \) (at time \( t_0 \)) and constant acceleration \( a \) are, respectively, for four situations: (1) +, +; (2) +, −; (3) −, +; (4) −, −. In which situations will the particle (a) stop momentarily, (b) pass through the origin, and (c) never pass through the origin?

9. Hanging over the railing of a bridge, you drop an egg (no initial velocity) as you throw a second egg downward. Which curves in Fig. 2-21 give the velocity \( v(t) \) for (a) the dropped egg and (b) the thrown egg? (Curves A and B are parallel; so are C, D, and E; so are F and G.)

| ANSWERS | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. |
Name: ___________________ Assignment 3: Vectors & Motion in 2D

Directions: Write a summary of answers at the bottom. Attach complete solution for each item.

Vectors

1. (a) Two workers are trying to move a heavy crate. One pushes on the crate with a force $\mathbf{A}$, which has a magnitude of 445 newtons and is directed due west. The other pushes with a force $\mathbf{B}$, which has a magnitude of 325 newtons and is directed due north. What are the magnitude and direction of the resultant force $\mathbf{A} + \mathbf{B}$ applied to the crate?

(b) Suppose that the second worker applies a force $-\mathbf{B}$ instead of $\mathbf{B}$. What then are the magnitude and direction of the resultant force $\mathbf{A} - \mathbf{B}$ applied to the crate? In both cases express the direction relative to due west.

2. An ocean liner leaves New York City and travels 18.0° north of east for 155 km. How far east and how far north has it gone? In other words, what are the magnitudes of the components of the ship’s displacement vector in the directions (a) due east and (b) due north?

3. A golfer, putting on a green, requires three strokes to “hole the ball.” During the first putt, the ball rolls 5.0 m due east. For the second putt, the ball travels 2.1 m at an angle of 20.0° north of east. The third putt is 0.50 m due north. What displacement (magnitude and direction relative to due east) would have been needed to “hole the ball” on the very first putt?

Motion in 2D

4. Two trees have perfectly straight trunks and are both growing perpendicular to the flat horizontal ground beneath them. The sides of the trunks that face each other are separated by 1.3 m. A frisky squirrel makes three jumps in rapid succession. First, he leaps from the foot of one tree to a spot that is 1.0 m above the ground on the other tree. Then, he jumps back to the first tree, landing on it at a spot that is 1.7 m above the ground. Finally, he leaps back to the other tree, now landing at a spot that is 2.5 m above the ground. What is the magnitude of the squirrel’s displacement?

5. The altitude of a hang glider is increasing at a rate of 6.80 m/s. At the same time, the shadow of the glider moves along the ground at a speed of 15.5 m/s when the sun is directly overhead. Find the magnitude of the glider’s velocity.

6. A skateboarder, starting from rest, rolls down a 12.0-m ramp. When she arrives at the bottom of the ramp her speed is 7.70 m/s. (a) Determine the magnitude of her acceleration, assumed to be constant, (b) If the ramp is inclined at 25.0° with respect to the ground, what is the component of her acceleration that is parallel to the ground?

7. A car drives straight off the edge of a cliff that is 54 m high. The police at the scene of the accident observe that the point of impact is 130 m from the base of the cliff. How fast was the car traveling when it went over the cliff?

8. A car travels at a constant speed around a circular track whose radius is 2.6 km. The car goes once around the track in 360 s. What is the magnitude of the centripetal acceleration of the car?

9. Two cars, A and B, are traveling in the same direction, although car A is 186 m behind car B. The speed of A is 24.4 m/s, and the speed of B is 18.6 m/s. How much time does it take for A to catch B?

10. Relative to the ground, a car has a velocity of 18.0 m/s, directed due north. Relative to this car, a truck has a velocity of 22.8 m/s, directed 52.1° south of east. Find the magnitude and direction of the truck’s velocity relative to the ground.

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A. The Three Stooges, Curly, Larry, and Moe, are having a motocycle race. The Figure below is the velocity–time graph of their motion.

1. What is the instantaneous velocity of each Stooge at $t = 4.0 \text{ s}$?  
2. How far has each Stooge cycled at $t = 4.0 \text{ s}$?  
3. If the race takes place on a 600-m track, who wins?
Name: ________________________ Assignment 4: Force and Motion

Directions: Write a summary of answers at the bottom. Attach complete solution for each item.

1. A 15-g bullet is fired from a rifle. It takes $2.50 \times 10^{-3}$ s for the bullet to travel the length of the barrel, and it exits the barrel with a speed of 715 m/s. Assuming that the acceleration of the bullet is constant, find the average net force exerted on the bullet.

2. A person with a black belt in karate has a fist that has a mass of 0.70 kg. Starting from rest, this fist attains a velocity of 8.0 m/s in 0.15 s. What is the magnitude of the average net force applied to the fist to achieve this level of performance?

3. Two forces, $\vec{F}_1$ and $\vec{F}_2$, act on the 7.00-kg block shown in the drawing. The magnitudes of the forces are $F_1 = 59.0$ N and $F_2 = 33.0$ N. What is the horizontal acceleration (magnitude and direction) of the block?

4. When a parachute opens, the air exerts a large drag force on it. This upward force is initially greater than the weight of the sky diver and, thus, slows him down. Suppose the weight of the sky diver is 915 N and the drag force has a magnitude of 1027 N. The mass of the sky diver is 93.4 kg. What are the magnitude and direction of his acceleration?

5. At a time when mining asteroids has become feasible, astronauts have connected a line between their 3500-kg space tug and a 6200-kg asteroid. Using their ship’s engine, they pull on the asteroid with a force of 490 N. Initially the tug and the asteroid are at rest, 450 m apart. How much time does it take for the ship and the asteroid to meet?

6. A Mercedes-Benz 300SL ($m = 1700$ kg) is parked on a road that rises 15° above the horizontal. What are the magnitudes of (a) the normal force and (b) the static frictional force that the ground exerts on the tires?

7. A car is towing a boat on a trailer. The driver starts from rest and accelerates to a velocity of +11 m/s in a time of 28 s. The combined mass of the boat and trailer is 410 kg. The frictional force acting on the trailer can be ignored. What is the tension in the hitch that connects the trailer to the car?

8. A 6.00-kg box is sliding across the horizontal floor of an elevator. The coefficient of kinetic friction between the box and the floor is 0.360. Determine the kinetic frictional force that acts on the box when the elevator is (a) stationary, (b) accelerating upward with an acceleration whose magnitude is 1.20 m/s$^2$, and (c) accelerating downward with an acceleration whose magnitude is 1.20 m/s$^2$.

9. A penguin slides at a constant velocity of 1.4 m/s down an icy incline. The incline slopes above the horizontal at an angle of 6.9°. At the bottom of the incline, the penguin slides onto a horizontal patch of ice. The coefficient of kinetic friction between the penguin and the ice is the same for the incline as for the horizontal patch. How much time is required for the penguin to slide to a halt after entering the horizontal patch of ice?

10. A 5.00-kg block is placed on top of a 12.0-kg block that rests on a frictionless table. The coefficient of static friction between the two blocks is 0.600. What is the maximum horizontal force that can be applied before the 5.00-kg block begins to slip relative to the 12.0-kg block, if the force is applied to (a) the more massive block and (b) the less massive block?
1. A cable lifts a 1200-kg elevator at a constant velocity for a distance of 35 m. What is the work done by
   a. the tension in the cable?
   b. the elevator’s weight?

2. A person pulls a toboggan for a distance of 35.0 m along the snow with a rope directed 25.0° above the snow. The
tension in the rope is 94.0 N.
   a. How much work is done on the toboggan by the tension force?
   b. How much work is done if the same tension is directed parallel to the snow?

3. A 1.00 × 10^2 -kg crate is being pushed across a horizontal floor by a force \( \overrightarrow{F} \) that makes an angle of 30.0° below
   the horizontal. The coefficient of kinetic friction is 0.200. What should be the magnitude of \( \overrightarrow{F} \), so that the net
   work done by it and the kinetic frictional force is zero?

4. A husband and wife take turns pulling their child in a wagon along a horizontal sidewalk. Each exerts a constant
   force and pulls the wagon through the same displacement. They do the same amount of work, but the husband’s
   pulling force is directed 58° above the horizontal, and the wife’s pulling force is directed 38° above the
   horizontal. The husband pulls with a force whose magnitude is 67 N. What is the magnitude of the pulling force
   exerted by his wife?

5. A 0.075-kg arrow is fired horizontally. The bowstring exerts an average force of 65 N on the arrow over a
distance of 0.90 m. With what speed does the arrow leave the bow?

6. A fighter jet is launched from an aircraft carrier with the aid of its own engines and a steam-powered catapult. The
   thrust of its engines is 2.3 × 10^5 N. In being launched from rest it moves through a distance of 87 m and has a
   kinetic energy of 4.5 × 10^7 J at lift-off. What is the work done on the jet by the catapult?

7. A sled is being pulled across a horizontal patch of snow. Friction is negligible. The pulling force points in the
   same direction as the sled’s displacement, which is along the +x-axis. As a result, the kinetic energy of the sled
   increases by 38%. By what percentage would the sled’s kinetic energy have increased if this force had pointed 62°
   above the +x-axis?

8. An extreme skier, starting from rest, coasts down a mountain slope that makes an angle of 25.0° with the
   horizontal. The coefficient of kinetic friction between her skis and the snow is 0.200. She coasts down a distance
   of 10.4 m before coming to the edge of a cliff. Without slowing down, she skis off the cliff and lands downhill at
   a point whose vertical distance is 3.50 m below the edge. How fast is she going just before she lands?

9. A shot-putter puts a shot (weight= 71.1 N) that leaves his hand at a distance of 1.52 m above the ground.
   a. Find the work done by the gravitational force when the shot has risen to a height of 2.13 m above the
       ground. Include the correct sign for the work.
   b. Determine the change in the gravitational potential energy of the shot.

10. A 55.0-kg skateboarder starts out with a speed of 1.80 m/s. He does +80.0 J of work on himself by pushing with
    his feet against the ground. In addition, friction does −265 J of work on him. In both cases, the forces doing the
    work are nonconservative. The final speed of the skateboarder is 6.00 m/s.
    a. Calculate the change in the gravitational potential energy.
    b. How much has the vertical height of the skater changed, and is the skater above or below the starting
       point?
Name: _____________________ Assignment 6: Impulse & Momentum

Directions: Write a summary of answers at the bottom. Attach complete solution for each item.

1. A dump truck is being filled with sand. The sand falls straight downward from rest from a height of 2.00 m above the truck bed, and the mass of sand that hits the truck per second is 55.0 kg/s. The truck is parked on the platform of a weight scale. By how much does the scale reading exceed the weight of the truck and sand?

2. An 85-kg jogger is heading due east at a speed of 2.0 m/s. A 55-kg jogger is heading 32° north of east at a speed of 3.0 m/s. Find the magnitude and direction of the sum of the momenta of the two joggers.

3. A 55-kg swimmer is standing on a stationary 210-kg raft. The swimmer then runs off the raft horizontally with a velocity of +4.6 m/s relative to the shore. Find the recoil velocity that the raft would have if there were no friction and resistance due to the water.

4. A projectile (mass = 0.20 kg) is fired at and embeds itself in a target (mass = 2.50 kg). The target (with the projectile in it) flies off after being struck. What percentage of the projectile’s incident kinetic energy does the target (with the projectile in it) carry off after being struck?

5. A ball is dropped from rest at the top of a 6.10-m-tall building, falls straight downward, collides inelastically with the ground, and bounces back. The ball loses 10.0% of its kinetic energy every time it collides with the ground. How many bounces can the ball make and still reach a windowsill that is 2.44 m above the ground?

6. On earth, two parts of a space probe weigh 11 000 N and 3400 N. These parts are separated by a center-to-center distance of 12 m and may be treated as uniform spherical objects. Find the magnitude of the gravitational force that each part exerts on the other out in space, far from any other objects.

7. A spacecraft is on a journey to the moon. At what point, as measured from the center of the earth, does the gravitational force exerted on the spacecraft by the earth balance that exerted by the moon? This point lies on a line between the centers of the earth and the moon. The distance between the earth and the moon is \(3.85 \times 10^8\) m, and the mass of the earth is 81.4 times as great as that of the moon.

8. Two particles are located on the \(x\) axis. Particle 1 has a mass \(m\) and is at the origin. Particle 2 has a mass \(2m\) and is at \(x = +L\). A third particle is placed between particles 1 and 2. Where on the \(x\) axis should the third particle be located so that the magnitude of the gravitational force on both particle 1 and particle 2 doubles? Express your answer in terms of \(L\).

9. The drawing shows three particles far away from any other objects and located on a straight line. The masses of these particles are \(m_A = 363\) kg, \(m_B = 517\) kg, and \(m_C = 154\) kg. Find the magnitude and direction of the net gravitational force acting on (a) particle A, (b) particle B, and (c) particle C.

10. (a) Calculate the magnitude of the gravitational force exerted on a 425-kg satellite that is a distance of two earth radii from the center of the earth. (b) What is the magnitude of the gravitational force exerted on the earth by the satellite? (c) Determine the magnitude of the satellite’s acceleration. (d) What is the magnitude of the earth’s acceleration?
Assignment 7: FLUIDS

Directions: Write a summary of answers at the bottom. Attach complete solution for each item.

1. The *karat* is a dimensionless unit that is used to indicate the proportion of gold in a gold-containing alloy. An alloy that is one karat gold contains a weight of pure gold that is one part in twenty-four. What is the volume of gold in a 14.0-karat gold necklace whose weight is 1.27 N?

2. A 58-kg skier is going down a slope oriented 35° above the horizontal. The area of each ski in contact with the snow is 0.13 m². Determine the pressure that each ski exerts on the snow.

3. Two identical containers are open at the top and are connected at the bottom via a tube of negligible volume and a valve that is closed. Both containers are filled initially to the same height of 1.00 m, one with water, the other with mercury, as the drawing indicates. The valve is then opened. Water and mercury are immiscible. Determine the fluid level in the left container when equilibrium is reestablished.

4. The density of ice is 917 kg/m³, and the density of sea water is 1025 kg/m³. A swimming polar bear climbs onto a piece of floating ice that has a volume of 5.2 m³. What is the weight of the heaviest bear that the ice can support without sinking completely beneath the water?

5. A lighter-than-air balloon and its load of passengers and ballast are floating stationary above the earth. Ballast is weight (of negligible volume) that can be dropped overboard to make the balloon rise. The radius of this balloon is 6.25 m. Assuming a constant value of 1.29 kg/m³ for the density of air, determine how much weight must be dropped overboard to make the balloon rise 1.05 m in 15.0 s.

6. Prairie dogs are burrowing rodents. They do not suffocate in their burrows, because the effect of air speed on pressure creates sufficient air circulation. The animals maintain a difference in the shapes of two entrances to the burrow, and because of this difference, the air (\( \rho = 1.29 \text{ kg/m}^3 \)) blows past the openings at different speeds, as the drawing indicates. Assuming that the openings are at the same vertical level, find the difference in air pressure between the openings and indicate which way the air circulates.

7. In the human body, blood vessels can dilate, or increase their radii, in response to various stimuli, so that the volume flow rate of the blood increases. Assume that the pressure at either end of a blood vessel, the length of the vessel, and the viscosity of the blood remain the same, and determine the factor \( R_{\text{dilated}}/R_{\text{normal}} \) by which the radius of a vessel must change in order to double the volume flow rate of the blood through the vessel.

8. A Venturi meter is a device that is used for measuring the speed of a fluid within a pipe. The drawing shows a gas flowing at speed \( v_2 \) through a horizontal section of pipe whose cross-sectional area is \( A_2 = 0.0700 \text{ m}^2 \). The gas has a density of \( \rho = 1.30 \text{ kg/m}^3 \). The Venturi meter has a cross-sectional area of \( A_1 = 0.0500 \text{ m}^2 \) and has been substituted for a section of the larger pipe. The pressure difference between the two sections is \( P_2 - P_1 = 120 \text{ Pa} \). Find (a) the speed \( v_2 \) of the gas in the larger original pipe and (b) the volume flow rate \( Q \) of the gas.

| ANSWERS | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. |
1. On the Rankine temperature scale, which is sometimes used in engineering applications, the ice point is at 491.67 °R and the steam point is at 671.67 °R. Determine a relationship between the Rankine and Fahrenheit temperature scales.

2. A steel section of the Alaskan pipeline had a length of 65 m and a temperature of 18 °C when it was installed. What is its change in length when the temperature drops to a frigid −45 °C?

3. Concrete sidewalks are always laid in sections, with gaps between each section. For example, the drawing shows three identical 2.4-m sections, the outer two of which are against immovable walls. The two identical gaps between the sections are provided so that thermal expansion will not create the thermal stress that could lead to cracks. What is the minimum gap width necessary to account for an increase in temperature of 32 °C?

4. A copper kettle contains water at 24 °C. When the water is heated to its boiling point, the volume of the kettle expands by $1.2 \times 10^{-5} \text{ m}^3$. Determine the volume of the kettle at 24 °C.

5. If the price of electrical energy is $0.10 per kilowatt hour, what is the cost of using electrical energy to heat the water in a swimming pool (12.0 m $\times$ 9.00 m $\times$ 1.5 m) from 15 to 27 °C?

6. When 4200 J of heat are added to a 0.15-m-long silver bar, its length increases by $4.3 \times 10^{-3} \text{ m}$. What is the mass of the bar?

7. A block of material has a mass of 130 kg and a volume of $4.6 \times 10^{-2} \text{ m}^3$. The material has a specific heat capacity and coefficient of volume expansion, respectively, of 750 J/(kg·°C) and $4.6 \times 10^5 \text{ (°C)}^{-1}$. How much heat must be added to the block in order to increase its volume by $1.2 \times 10^{-5} \text{ m}^3$?

8. A 1.5-kg steel sphere will not fit through a circular hole in a 0.85-kg aluminum plate, because the radius of the sphere is 0.10% larger than the radius of the hole. If both the sphere and the plate are always kept at the same temperature, how much heat must be put into the two so the ball just passes through the hole?

9. How much heat must be added to 0.45 kg of aluminum to change it from a solid at 130 °C to a liquid at 660 °C (its melting point)? The latent heat of fusion for aluminum is $4.6 \times 10^5 \text{ J/kg}$.

10. Liquid nitrogen boils at a chilly −195.8 °C when the pressure is one atmosphere. A silver coin of mass $1.5 \times 10^2 \text{ kg}$ and temperature 25 °C is dropped into the boiling liquid. What mass of nitrogen boils off as the coin cools to −195.8 °C?
OPTIONAL [1 point each number]

1. A solid aluminum sphere has a radius of 0.50 m and a temperature of 75 °C. The sphere is then completely immersed in a pool of water whose temperature is 25 °C. The sphere cools, while the water temperature remains nearly at 25 °C, because the pool is very large. The sphere is weighed in the water immediately after being submerged (before it begins to cool) and then again after cooling to 25 °C.
   (a) Which weight is larger? Why?
   (b) Use Archimedes’ principle to find the magnitude of the difference between the weights.

2. Ice at −10.0 °C and steam at 130 °C are brought together at atmospheric pressure in a perfectly insulated container. After thermal equilibrium is reached, the liquid phase at 50.0 °C is present. Ignoring the container and the equilibrium vapor pressure of the liquid at 50.0 °C, find the ratio of the mass of steam to the mass of ice. The specific heat capacity of steam is 2020 J/(kg·C°).

3. Equal masses of two different liquids have the same temperature of 25.0 °C. Liquid A has a freezing point of −68.0 °C and a specific heat capacity of 1850 J/(kg·C°). Liquid B has a freezing point of −96.0 °C and a specific heat capacity of 2670 J/(kg·C°). The same amount of heat must be removed from each liquid in order to freeze it into a solid at its respective freezing point. Determine the difference $L_{f,A} - L_{f,B}$ between the latent heats of fusion for these liquids.
1. The drawing shows an equilateral triangle, each side of which has a length of 2.00 cm. Point charges are fixed to each corner, as shown. The +4.0 µC charge experiences a net force due to the charges $q_A$ and $q_B$. This net force points vertically downward and has a magnitude of 405 N. Determine the magnitudes and algebraic signs of the charges $q_A$ and $q_B$.

2. Four point charges have the same magnitude of $2.4 \times 10^{-12}$ C and are fixed to the corners of a square that is 4.0 cm on a side. Three of the charges are positive and one is negative. Determine the magnitude of the net electric field that exists at the center of the square.

3. Two charges, $-16$ and $+4.0$ µC, are fixed in place and separated by 3.0 m.
   a. At what spot along a line through the charges is the net electric field zero? Locate this spot relative to the positive charge. (*Hint: The spot does not necessarily lie between the two charges.*)
   b. What would be the force on a charge of +14.0 µC placed at this spot?

4. Two charges are placed on the $x$ axis. One of the charges $q_1= +8.5$ µC is at $x_1 = +3.0$ cm and the other $q_2= -21$ µC is at $x_1 = +9.0$ cm. Find the net electric field (magnitude and direction) at
   a. $x = 0$ cm
   b. $x = +6.0$ cm.

5. Suppose that the electric potential outside a living cell is higher than that inside the cell by 0.070 V. How much work is done by the electric force when a sodium ion (charge = $+e$) moves from the outside to the inside?

6. During a particular thunderstorm, the electric potential difference between a cloud and the ground is $V_{\text{cloud}} - V_{\text{ground}} = 1.3 \times 10^8$ V, with the cloud being at the higher potential. What is the change in an electron’s electric potential energy when the electron moves from the ground to the cloud?

| ANSWERS | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. |
7. Point A is at a potential of +250 V, and point B is at a potential of −150 V. An $\alpha$-particle is a helium nucleus that contains two protons and two neutrons; the neutrons are electrically neutral. An $\alpha$-particle starts from rest at A and accelerates toward B. When the $\alpha$-particle arrives at B, what kinetic energy (in electron volts) does it have?

8. Determine the electric potential energy for the array of three charges shown in the drawing, relative to its value when the charges are infinitely far away.

9. A spark plug in an automobile engine consists of two metal conductors that are separated by a distance of 0.75 mm. When an electric spark jumps between them, the magnitude of the electric field is $4.7 \times 10^7$ V/m. What is the magnitude of the potential difference $V$ between the conductors?

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