Regents Physics

Unit Review Packet

Name: ____

Table of Contents

Unit 1: Linear Motion Objectives

Focus Questions for the Unit:

- ***What variables can be manipulated to affect the movement of an object?***
  - ***How do forces govern the motion of objects?***
  - ***What are the ways that motion is described, measured, and analyzed?***

You Should KNOW:

1.) The slope of a graph has a physical significance.

2.) SI units (International System of units)

3.) An object will remain in its current state of motion (at rest or moving with constant velocity) unless it is acted upon by a force.

4.) An object that has a force acting on it will accelerate (speed up or slow down).

5.) An object in linear motion will either be traveling with constant (unchanging) velocity or with acceleration.

6.) An object in free fall near the Earth's surface accelerates due to the force of gravity.

7.) Friction (ie – air resistance) is a force that causes the actual motion of an object to deviate from its theoretical (calculated) motion.

You Should BE ABLE TO:

8.) Develop skills and protocols in selecting and using proper formulas that require calculating velocity, displacement, acceleration, or time depending on the given values

9.) Construct and interpret graphs of motion (d vs. t, v vs. t, a vs. t), including being able to calculate and analyze slope and area under the curve

10.) Describe the motion in equilibrium vs. in non-equilibrium (ie - how does velocity and acceleration look and feel in different situations?)

11.) Describe the role of forces in causing changes in motion

12.) Collect, analyze, and evaluate data quality for objects in motion

13.) Convert between units

14.) Estimate length and velocity

15.) Plot a graph and determine slope using Excel

You Should UNDERSTAND:

16.) All objects in the universe are either in equilibrium or are accelerating.

Practice Questions – Linear Motion

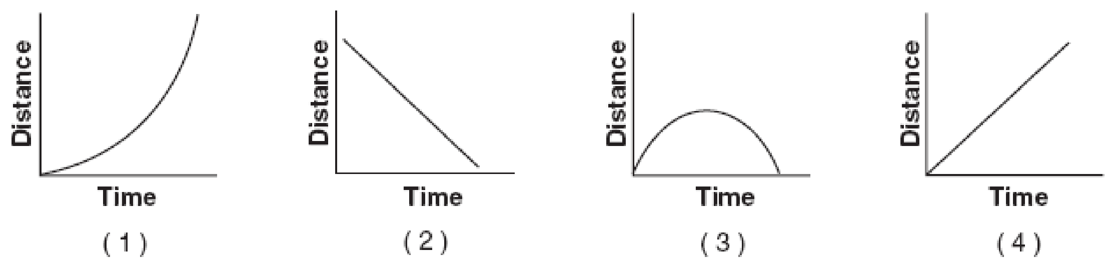
1.) A car increases its speed from 9.6 meters per second to 11.2 meters per second in 4.0 seconds. The average acceleration of the car during this 4.0-second interval is

(1) 0.40 m/s^2 (2) 2.4 m/s^2 (3) 2.8 m/s^2 (4) 5.2 m/s^2

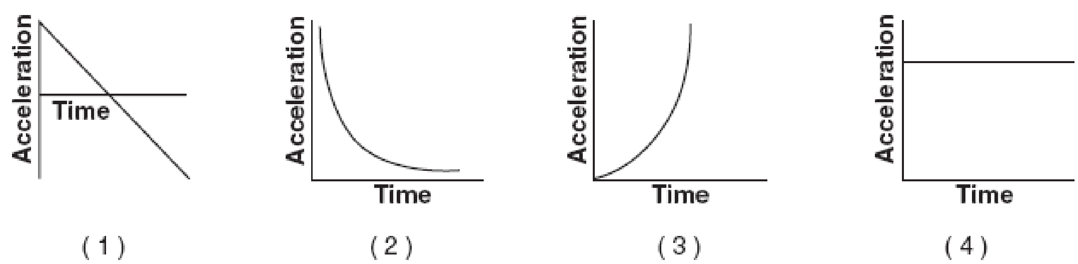
2.) What is the speed of a 2.5-kilogram mass after it has fallen freely from rest through a distance of 12 meters?

(1) 4.8 m/s (2) 15 m/s (3) 30. m/s (4) 43 m/s

3.) A cart travels with a constant nonzero acceleration along a straight line. Which graph best represents the relationship between the distance the cart travels and time of travel?



4.) Which graph best represents the relationship between the acceleration of an object falling freely near the surface of Earth and the time that it falls?



5.) An astronaut standing on a platform on the Moon drops a hammer. If the hammer falls 6.0 meters vertically in 2.7 seconds, what is its acceleration?

(1) 1.6 m/s^2 (2) 2.2 m/s^2 (3) 4.4 m/s^2 (4) 9.8 m/s^2

6.) A child walks 5.0 meters north, then 4.0 meters east, and finally 2.0 meters south. What is the magnitude of the resultant displacement of the child after the entire walk?

(1) 1.0 m (2) 5.0 m (3) 3.0 m (4) 11.0 m

7.) A race car starting from rest accelerates uniformly at a rate of 4.90 meters per second^2. What is the car's speed after it has traveled 200. meters?

(1) 1960 m/s (2) 62.6 m/s (3) 44.3 m/s (4) 31.3 m/s

8.) An observer recorded the following data for the motion of a car undergoing constant acceleration.

What was the magnitude of the acceleration of the car?

(1) 1.3 m/s^2 (3) 1.5 m/s^2
(2) 2.0 m/s^2 (4) 4.5 m/s^2

Time (s)	Speed (m/s)
3.0	4.0
5.0	7.0
6.0	8.5

9.) A ball is thrown straight downward with a speed of 0.50 meter per second from a height of 4.0 meters. What is the speed of the ball 0.70 second after it is released? [Neglect friction.]

(1) 0.50 m/s (2) 7.4 m/s (3) 9.8 m/s (4) 15 m/s

10.) A race car starting from rest accelerates uniformly at a rate of 4.90 meters per second^2. What is the car's speed after it has traveled 200. meters?

(1) 1960 m/s (2) 44.3 m/s (3) 62.6 m/s (4) 31.3 m/s

11.) The mass of a paper clip is approximately

(1) 1×10^6 kg (2) 1×10^{-3} kg (3) 1×10^3 kg (4) 1×10^{-6} kg

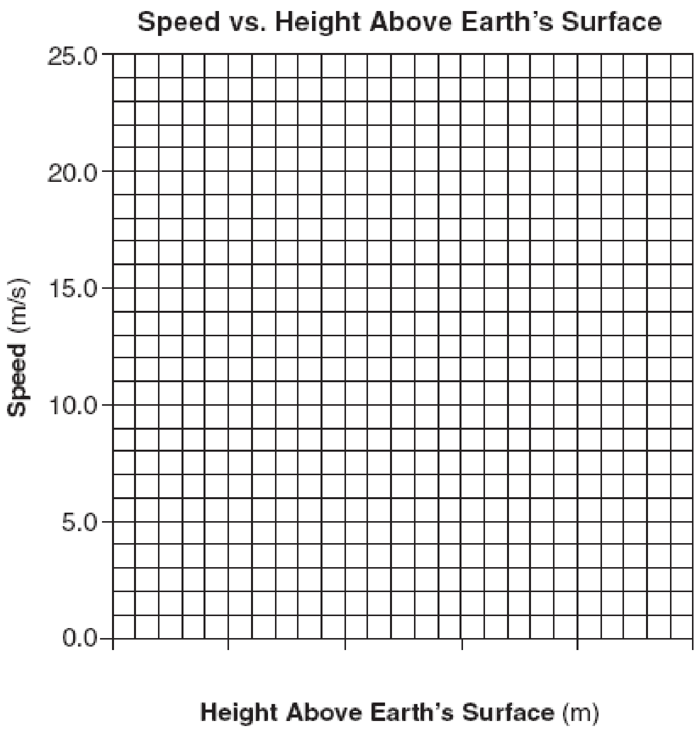
12.) An egg is dropped from a third-story window. The distance the egg falls from the window to the ground is closest to

(1) 10^0 m (2) 10^2 m (3) 10^1 m (4) 10^3 m

13.) A 1.00-kilogram mass was dropped from rest from a height of 25.0 meters above Earth's surface. The speed of the mass was determined at 5 meter intervals and recorded in the data table.

a) Plot the data points for speed versus height above Earth's surface on the grid below.

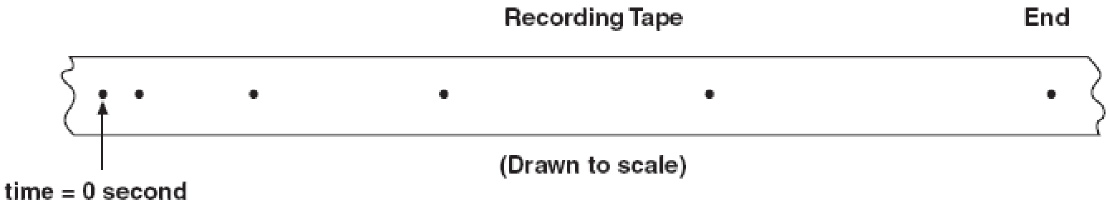
Height Above Earth's Surface (m)	Speed (m/s)
25.0	0.0
20.0	9.9
15.0	14.0
10.0	17.1
5.0	19.8
0	22.1



b) Draw the line or curve of best fit.

c) Using your graph, determine the speed of the mass after it has fallen a vertical distance of 12.5 m.

14.) A spark timer is used to record the position of a lab cart accelerating uniformly from rest. Each 0.10 second, the timer marks a dot on a recording tape to indicate the position of the cart at that instant, as shown.



a.) Using a metric ruler, measure the distance the cart traveled during the interval t = 0 second to t = 0.30 second. Record your answer to the *nearest tenth of a centimeter*.

____

b.) Calculate the magnitude of the acceleration of the cart during the time interval t = 0 second to t = 0.30 second. [Show all work, including the equation and substitution with units.]

c.) Calculate the average speed of the cart during the time interval t = 0 second to t = 0.30 second. [Show all work, including the equation and substitution with units.]

d.) On the diagram below, mark *at least four* dots to indicate the position of a cart traveling at a constant velocity.

Base your answers to questions 15 and 16 on the information below.

A 747 jet, traveling at a velocity of 70. meters per second north, touches down on a runway. The jet slows to rest at the rate of 2.0 meters per second^2.

15.) Calculate the total distance the jet travels on the runway as it is brought to rest. [Show all work, including the equation and substitution with units.]

16.) On the diagram below, point *P* represents the position of the jet on the runway. Beginning at point *P*, draw a vector to represent the magnitude and direction of the acceleration of the jet as it comes to rest. Use a scale of 1.0 centimeter = 0.50 meter/second^2.

Unit 2: Forces Objectives

Focus Questions for the Unit:

- ***What variables can be manipulated to affect the movement of an object?***
  - ***How do forces govern the motion of objects?***
  - ***What are the ways that motion is described, measured, and analyzed?***

You Should KNOW:

1.) The slope of a graph has a physical significance.
2.) SI units (International System of units)
3.) A force is a "push" or a "pull."
4.) Inertia is a property described as the resistance an object offers to changes in motion, and is proportional to mass.
5.) A vector may be resolved into perpendicular components.
6.) The resultant of two or more vectors, acting at any angle, is determined by vector addition.
7.) Acceleration is a vector quantity and so is force, therefore these quantities have to be described with both a magnitude and a direction.
8.) Acceleration due to an applied force results in a change of velocity, meaning a change in speed, direction, or both.
9.) While Object A exerts a force on Object B, Object B simultaneously exerts a force of equal magnitude and opposite direction on Object A.
10.) Weight (Force of gravity) is the measure of the effect of the acceleration due to gravity on a given mass.
11.) Normal force is the force exerted on a mass by the surface it sits on, and is proportional to the weight of the object.
12.) Friction is a force between two objects in contact with each other, and always acts in a direction to impede motion.
13.) There are two types of friction: static and kinetic, and the degree of friction between two objects is proportional to the weight of the object and the coefficient of friction of the surface the object is sitting on top of.

You Should BE ABLE TO:

14.) Develop skills and protocols in selecting and using proper formulas that require calculating net force, frictional force, acceleration, mass, weight, normal force, coefficient of friction, resultant, velocity, components, centripetal acceleration, centripetal force, period, speed, force of gravity.
15.) Construct and interpret graphs of motion (d vs. t, v vs. t, a vs. t, F_{net} vs. a, F_g vs. m) including calculating and analyzing slope
16.) Describe the motion in equilibrium vs. in non-equilibrium (ie - how does velocity and acceleration look and feel in different situations?)
17.) Draw and evaluate a scaled free body diagram using a protractor and ruler
18.) Draw the direction of the centripetal force, acceleration, and velocity for an object in circular motion.
19.) Draw the tangential direction an object will move if centripetal force is suddenly removed.
20.) Evaluate the relationships between variables in a given equation (i.e. F_g, r)
21.) Describe how Newton's Laws would feel to you (how does velocity and acceleration look and feel in different situations)

You Should UNDERSTAND:

22.) Only a net force can cause a change in the motion of an object.

Practice Questions – Forces

1.) A 2.00-kilogram object weighs 19.6 newtons on Earth. If the acceleration due to gravity on Mars is 3.71 meters per second^2, what is the object's mass on Mars?

(1) 2.64 kg (2) 19.6 N (3) 2.00 kg (4) 7.42 N

2.) A force of 1 newton is equivalent to 1

(1) $\frac{kg \bullet m}{s^2}$ (3) $\frac{kg \bullet m^2}{s^2}$

(2) $\frac{kg \bullet m}{s}$ (4) $\frac{kg^2 \bullet m^2}{s^2}$

3.) A 6.0-newton force and an 8.0-newton force act concurrently on a point. As the angle between these forces increases from 0° to 90°, the magnitude of their resultant

(1) decreases (2) increases (3) remains the same

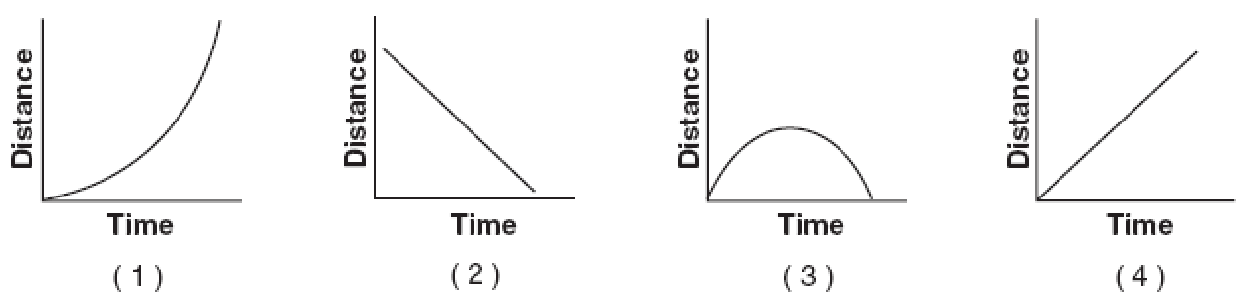
4.) Which object has the greatest inertia?

(1) a 5.0-kg object moving at a speed of 5.0 m/s
(2) a 10.-kg object moving at a speed of 3.0 m/s
(3) a 15-kg object moving at a speed of 1.0 m/s
(4) a 20.-kg object at rest

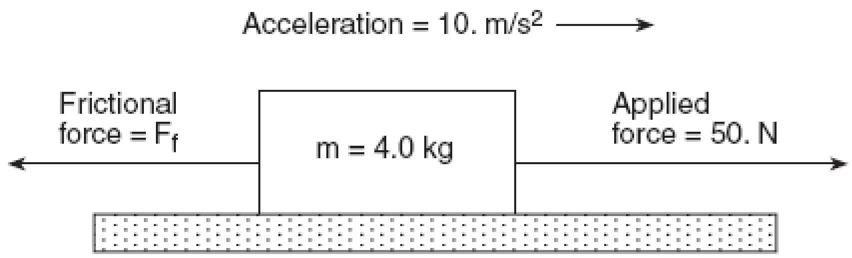
5.) What is the magnitude of the force needed to keep a 60.-newton rubber block moving across level, dry asphalt in a straight line at a constant speed of 2.0 meters per second?

(1) 40. N (3) 60. N (2) 51 N (4) 120 N

6.) A cart travels with a constant nonzero acceleration along a straight line. Which graph best represents the relationship between the distance the cart travels and time of travel?



7.) The diagram below shows a 4.0-kilogram object accelerating at 10. meters per second^2 on a rough horizontal surface.



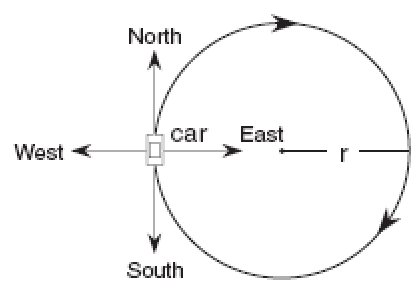
(Not drawn to scale)

What is the magnitude of the frictional force F_f acting on the object?

(1) 5.0 N (2) 20. N (3) 10. N (4) 40. N

8.) A car moves with a constant speed in a clockwise direction around a circular path of radius *r*, as represented in the diagram. When the car is in the position shown, its acceleration is directed toward the

(1) north
(2) south
(3) west
(4) east

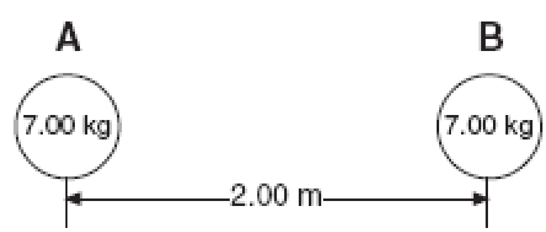


9.) A 0.50-kilogram object moves in a horizontal circular path with a radius of 0.25 meter at a constant speed of 4.0 meters per second. What is the magnitude of the object's acceleration?

(1) 8.0 m/s^2 (2) 32 m/s^2 (3) 16 m/s^2 (4) 64 m/s^2

10.) The diagram shows two bowling balls, *A* and *B*, each having a mass of 7.00 kilograms, placed 2.00 meters apart. What is the magnitude of the gravitational force exerted by ball *A* on ball *B*?

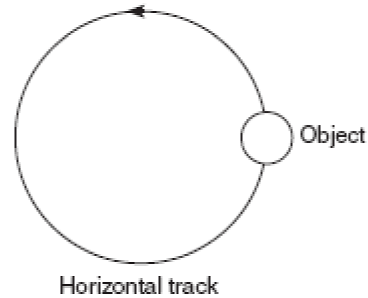
(1) 8.17×10^{-9} N
(2) 1.63×10^{-9} N
(3) 8.17×10^{-10} N
(4) 1.17×10^{-10} N

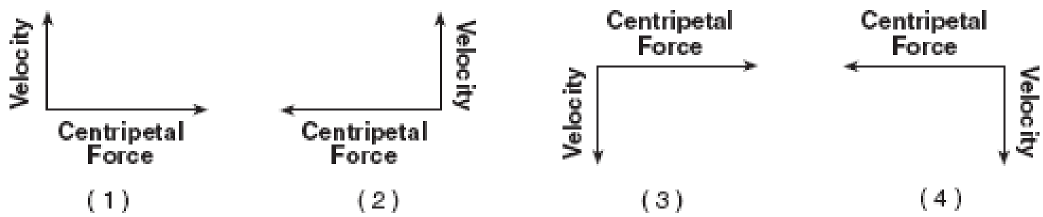


11.) As an astronaut travels from the surface of Earth to a position that is four times as far away from the center of Earth, the astronaut's

(1) mass decreases
(2) weight increases
(3) mass remains the same
(4) weight remains the same

12.) The diagram below shows an object moving counterclockwise around a horizontal, circular track. Which diagram represents the direction of both the object's velocity and the centripetal force acting on the object when it is in the position shown?





Base your answers to questions 13 through 15 on the passage and data table below.

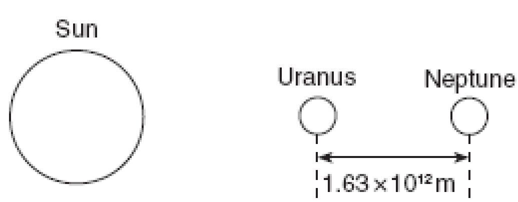
The net force on a planet is due primarily to the other planets and the Sun. By taking into account all the forces acting on a planet, investigators calculated the orbit of each planet. A small discrepancy between the calculated orbit and the observed orbit of the planet Uranus was noted. It appeared that the sum of the forces on Uranus did not equal its mass times its acceleration, unless there was another force on the planet that was not included in the calculation. Assuming that this force was exerted by an unobserved planet, two scientists working independently calculated where this unknown planet must be in order to account for the discrepancy. Astronomers pointed their telescopes in the predicted direction and found the planet we now call Neptune.

13.) What fundamental force is the author referring to in this passage as a force between planets?

Data Table

Mass of the Sun	1.99×10^{30} kg
Mass of Uranus	8.73×10^{25} kg
Mass of Neptune	1.03×10^{26} kg
Mean distance of Uranus to the Sun	2.87×10^{12} m
Mean distance of Neptune to the Sun	4.50×10^{12} m

14.) The diagram below represents Neptune, Uranus, and the Sun in a straight line. Neptune is 1.63×10^{12} meters from Uranus. Calculate the magnitude of the interplanetary force of attraction between Uranus and Neptune at this point.



(Not drawn to scale)

15.) The magnitude of the force the Sun exerts on Uranus is 1.41×10^{21} N. Explain how it is possible for the Sun to exert a greater force on Uranus than Neptune exerts on Uranus.

Unit 3: Momentum & Impulse Objectives

Focus Questions for the Unit:
- ***How do objects affect each other when they interact?***

You Should KNOW:

1.) When one object exerts a force on another, both objects experience changes in velocity.

2.) When two objects exert force on each other, it often occurs as a result of the two colliding with or recoiling from each other.

3.) When objects interact, the length of time they interact determines the magnitude of their force on each other.

4.) An impulse applied to an object will produce a change in that objects velocity in proportion to the object's mass, in other words, a change in momentum.

5.) When objects collide or recoil, there is a conservation of momentum.

You Should BE ABLE TO:

6.) Develop skills and protocols in selecting and using proper formulas that require calculating momentum, impulse, force, final velocity, and time

7.) Explain the ways interacting objects behave, such as when a golf club and a golf ball interact.

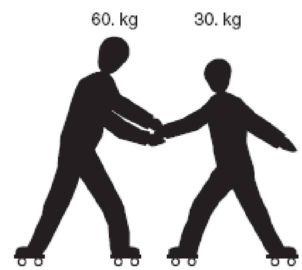
8.) Drawing and/or interpret collision diagrams.

You Should UNDERSTAND:

9.) When objects exert a force on each other, they obey the law of conservation of momentum

Practice Questions – Momentum & Impulse

1.) In the diagram, a 60.-kilogram rollerskater exerts a 10.-newton force on a 30.-kilogram rollerskater for 0.20 second. What is the magnitude of the impulse applied to the 30.-kilogram rollerskater?



(1) 50. N•s (3) 2.0 N•s
(2) 6.0 N•s (4) 12 N•s

2.) A woman with horizontal velocity *v*1 jumps off a dock into a stationary boat. After landing in the boat, the woman and the boat move with velocity *v*2. Compared to velocity *v*1, velocity *v*2 has

(1) the same magnitude and the same direction
(2) the same magnitude and opposite direction
(3) smaller magnitude and the same direction
(4) larger magnitude and the same direction

3.) At the circus, a 100.-kilogram clown is fired at 15 meters per second from a 500.-kilogram cannon. What is the recoil speed of the cannon?

(1) 75 m/s (2) 3.0 m/s (3) 15 m/s (4) 5.0 m/s

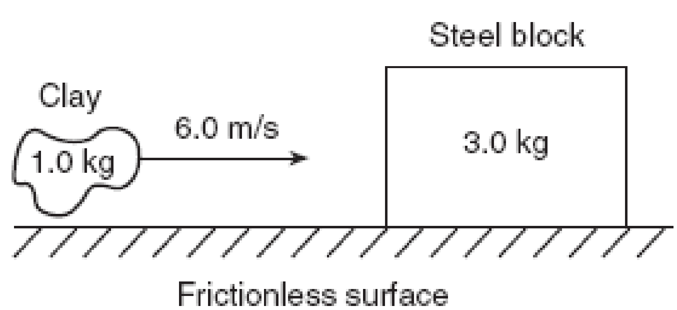
4.) A 2.0-kilogram laboratory cart is sliding across horizontal frictionless surface at a constant velocity of 4.0 meters per second east. What will be cart's velocity after a 6.0-newton westward force acts on it for 2.0 seconds?

(1) 2.0 m/s east (2) 10. m/s east (3) 2.0 m/s west (4) 10. m/s west

5.) A force of 6.0 N changes the momentum of a moving object by 3.0 kilogram•meters per second. How long did the force act on the mass?

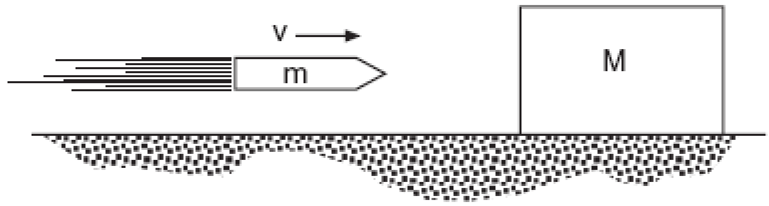
(1) 1.0 s (2) 0.25 s (3) 2.0 s (4) 0.50 s

6.) A 3.0-kilogram steel block is at rest on a frictionless horizontal surface. A 1.0-kilogram lump of clay is propelled horizontally at 6.0 meters per second toward the block as shown in the diagram. Upon collision, the clay and steel block stick together and move to the right with a speed of



(1) 1.5 m/s (3) 3.0 m/s
(2) 2.0 m/s (4) 6.0 m/s

7.) In the diagram below, a block of mass *M* initially at rest on a frictionless horizontal surface is struck by a bullet of mass *m* moving with horizontal velocity *v*.



What is the velocity of the bullet-block system after the bullet embeds itself in the block?

(1) $\left(\frac{M+v}{M}\right)m$

(2) $\left(\frac{m+M}{m}\right)v$

(3) $\left(\frac{m+v}{M}\right)m$

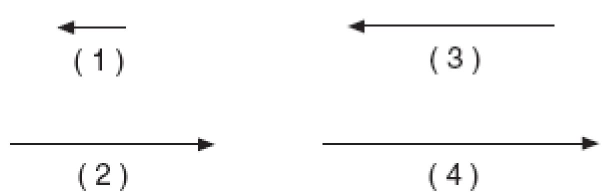
(4) $\left(\frac{m}{m+M}\right)v$

8.) Which situation will produce the greatest change of momentum for a 1.0-kilogram cart?

(1) accelerating it from rest to 3.0 m/s
(2) accelerating it from 2.0 m/s to 4.0 m/s
(3) applying a net force of 5.0 N for 2.0 s
(4) applying a net force of 10.0 N for 0.5 s

9.) In the diagram, scaled vectors re present the momentum of each of two masses, *A* and *B*, sliding toward each other on a frictionless, horizontal surface.

Which scaled vector best represents the momentum of the system after the masses collide?



10.) A 1000-kilogram car traveling due east at 15 meters per second is hit from behind and receives a forward impulse of 6000 newton-seconds. Determine the magnitude of the car's change in momentum due to this impulse. Show all work including equation, substitution, and answer with units.

Unit 4: Projectile Motion Objectives

Focus Questions for the Unit:

- ***What variables can be manipulated to affect the movement of an object?***
  - ***How do forces govern the motion of objects?***
  - ***What are the ways that motion is described, measured, and analyzed in both horizontal and vertical directions?***

You Should KNOW:

1.) The slope of a graph has a physical significance.

2.) SI units (International System of units)

3.) The path of a projectile is the result of the simultaneous effect of the horizontal and vertical components of its motion; these components act independently.

4.) A projectile's time of flight is dependent upon the vertical component of its motion.

5.) The horizontal displacement of a projectile is dependent upon the horizontal component of its motion and its time of flight.

6.) Velocity and acceleration are both rates.

You Should BE ABLE TO:

7.) Develop skills and protocols in selecting and using proper formulas that require calculating velocity (vertical & horizontal), displacement (range & height), angle, and time of flight.

8.) Construct and interpret graphs of horizontal and vertical motion (d vs. t, v vs. t) including being able to calculate and analyze the slope and area under the curve.

9.) Compare velocities and accelerations of a projectile at different times during its flight.

10.) Compare angles at which projectiles are launched at to the times of flight, heights and ranges.

11.) Represent velocity, acceleration, and force vectors graphically.

You Should UNDERSTAND:

12.) All objects in the universe are either in equilibrium or are accelerating.

<u>Practice Questions – Projectile Motion</u>

1.) A machine launches a tennis ball at an angle of 25° above the horizontal at a speed of 14 meters per second. The ball returns to level ground. Which combination of changes *must* produce an increase in time of flight of a second launch?

(1) decrease the launch angle and decrease the ball's initial speed
(2) decrease the launch angle and increase the ball's initial speed
(3) increase the launch angle and decrease the ball's initial speed
(4) increase the launch angle and increase the ball's initial speed

2.) A soccer player kicks a ball with an initial velocity of 10. meters per second at an angle of 30.° above the horizontal. The magnitude of the horizontal component of the ball's initial velocity is
(1) 5.0 m/s (2) 8.7 m/s (3) 9.8 m/s (4) 10. m/s

3.) Two spheres, *A* and *B*, are simultaneously projected horizontally from the top of a tower. Sphere *A* has a horizontal speed of 40. meters per second and sphere *B* has a horizontal speed of 20. meters per second. Which statement best describes the time required for the spheres to reach the ground and the horizontal distance they travel? [Neglect friction and assume the ground is level.]
(1) Both spheres hit the ground at the same time and at the same distance from the base of the tower.
(2) Both spheres hit the ground at the same time, but sphere *A* lands twice as far as sphere *B* from the base of the tower.
(3) Both spheres hit the ground at the same time, but sphere *B* lands twice as far as sphere *A* from the base of the tower.
(4) Sphere *A* hits the ground before sphere *B*, and sphere *A* lands twice as far as sphere *B* from the base of the tower.

4.) A plane flying horizontally above Earth's surface at 100. meters per second drops a crate. The crate strikes the ground 30.0 seconds later. What is the magnitude of the horizontal component of the crate's velocity just before it strikes the ground? [Neglect friction.]
(1) 0 m/s (2) 100. m/s (3) 294 m/s (4) 394 m/s

5.) A woman with horizontal velocity v_1 jumps off a dock into a stationary boat. After landing in the boat, the woman and the boat move with velocity v_2. Compared to velocity v_1, velocity v_2 has
(1) the same magnitude and the same direction
(2) the same magnitude and opposite direction
(3) smaller magnitude and the same direction
(4) larger magnitude and the same direction

6.) A projectile is launched into the air with an initial speed of v_i at a launch angle of 30.° above the horizontal. The projectile lands on the ground 2.0 seconds later.

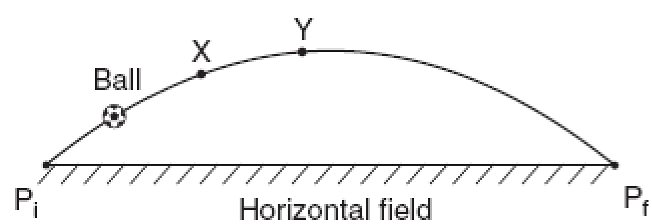
a.) On the diagram above, sketch the ideal path of the projectile.

b.) How does the maximum altitude of the projectile change as the launch angle is increased from 30.° to 45° above the horizontal? [Assume the same initial speed, v_i.]

c.) How does the total horizontal distance traveled by the projectile change as the launch angle is increased from 30.° to 45° above the horizontal? [Assume the same initial speed, v_i.]

Base your answers to questions 7 and 8 on the information and diagram below.

A soccer ball is kicked from point P_i at an angle above a horizontal field. The ball follows an ideal path before landing on the field at point P_f .



7.) On the diagram above, draw an arrow to represent the direction of the net force on the ball when it is at position *X*. Label the arrow F_{net}. [Neglect friction.]

8.) On the diagram above, draw an arrow to represent the direction of the acceleration of the ball at position *Y*. Label the arrow *a*. [Neglect friction.]

Unit 5: Energy Objectives

Focus Questions for the Unit:

- ***How does work affect the energy of objects?***
- ***How is energy conserved as objects change motion?***

You Should KNOW:

1.) The slope of a graph and area under the curve have a physical significance. (ie. F vs d & W vs t)
2.) SI units (International System of units)
3.) Power is a rate.
4.) Potential energy is the energy an object based on its position. Types of potential energy include gravitational and elastic.
5.) Kinetic energy is the energy an object has due to its motion, and is directly related to the square of the object's velocity.
6.) In an ideal mechanical system, the sum of the kinetic and potential energies (mechanical energy) is constant.
7.) In a nonideal mechanical system, as mechanical energy decreases, there is a corresponding increase in internal energy (heat).
8.) When work is done on or by a system, there is a change in the total energy of the system.
9.) Work done against friction results in an increase in the internal energy of the system.
10.) The elongation or compression of a spring depends upon the nature of the spring (its spring constant) and the magnitude of the applied force.

You Should BE ABLE TO:

11.) Develop skills and protocols in selecting and using proper formulas that require calculating work, power, kinetic energy, gravitational potential energy, elastic potential energy, total energy, internal energy, spring constant, velocity, and force.
12.) Construct and interpret graphs (F vs. d, F vs. x, W vs. t, PE vs. x, KE vs. v) and be able to calculate and analyze the slope and area under the curve.
13.) Calculate horizontal and vertical components of a force vector in order to calculate the work done in the direction of the displacement.
14.) Observe and explain energy conversions in real-world situations.
15.) Determine the initial and/or final conditions (height, velocity, energy) of given scenarios.
16.) Compare the work, power, and energies of different objects under different conditions.

You Should UNDERSTAND:

17.) Energy and matter interact through forces that result in changes in motion.
18.) All energy transfers are governed by the law of conservation of energy.

Practice Questions – Energy

1.) The diagram to the right represents a spring hanging vertically that stretches 0.075 meter when a 5.0- newton block is attached. The spring-block system is at rest in the position shown. The value of the spring constant is

(1) 38 N/m (3) 130 N/m
(2) 67 N/m (4) 650 N/m

2.) A 2 kg block sliding down a ramp from a height of 3.0 meters above the ground reaches the ground with a kinetic energy of 50. joules. The total work done by friction on the block as it slides down the ramp is approximately

(1) 6 J (2) 18 J (3) 9 J (4) 44 J

3.) The table to the right lists the mass and speed of each of four objects.
Which two objects have the same kinetic energy?

(1) *A* and *D* (3) *B* and *D*
(2) *A* and *C* (4) *B* and *C*

Data Table

Objects	Mass (kg)	Speed (m/s)
A	1.0	4.0
B	2.0	2.0
C	0.5	4.0
D	4.0	1.0

4.) Two students of equal weight go from the first floor to the second floor. The first student uses an elevator and the second student walks up a flight of stairs. Compared to the gravitational potential energy gained by the first student, the gravitational potential energy gained by the second student is

(1) less (2) greater (3) the same

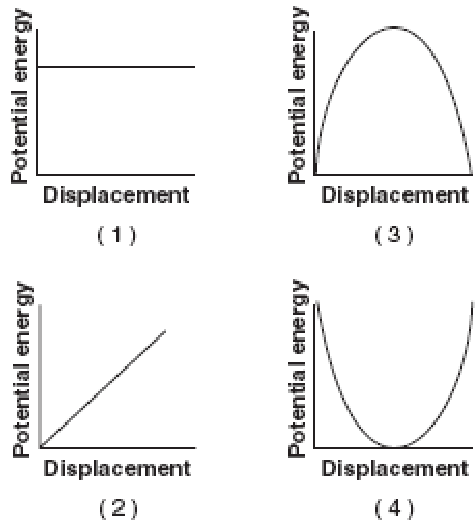
5.) A 110-kilogram bodybuilder and his 55-kilogram friend run up identical flights of stairs. The bodybuilder reaches the top in 4.0 seconds while his friend takes 2.0 seconds. Compared to the power developed by the bodybuilder while running up the stairs, the power developed by his friend is

(1) the same (3) half as much
(2) twice as much (4) four times as much

6.) A spring with a spring constant of 80. newtons per meter is displaced 0.30 meter from its equilibrium position. The potential energy stored in the spring is

(1) 3.6 J (2) 12 J (3) 7.2 J (4) 24 J

7.) A pendulum is pulled to the side and released from rest. Which graph best represents the relationship between the gravitational potential energy of the pendulum and its displacement from its point of release?



8.) A 1.00-kilogram ball is dropped from the top of a building. Just before striking the ground, the ball's speed is 12.0 meters per second. What was the ball's gravitational potential energy, relative to the ground, at the instant it was dropped? [Neglect friction.]

(1) 6.00 J (2) 72.0 J (3) 24.0 J (4) 144 J

9.) The potential energy stored in a compressed spring is to the change in the spring's length as the kinetic energy of a moving body is to the body's

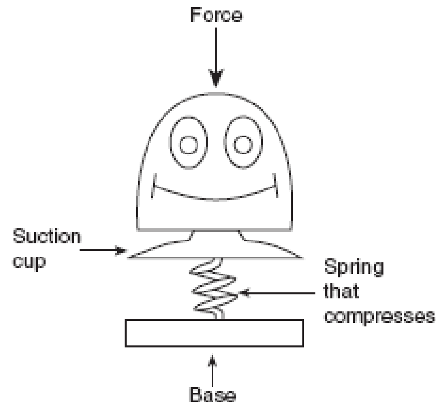
(1) speed (2) radius (3) mass (4) acceleration

10.) As a block slides across a table, its speed decreases while its temperature increases. Which two changes occur in the block's energy as it slides?

(1) a decrease in kinetic energy and an increase in internal energy
(2) an increase in kinetic energy and a decrease in internal energy
(3) a decrease in both kinetic energy and internal energy
(4) an increase in both kinetic energy and internal energy

Base your answers to #11 & 12 on the following information and diagram below:

A pop-up toy has a mass of 0.020 kilogram and a spring constant of 150 newtons per meter. A force is applied to the toy to compress the spring 0.050 meter.



11.) Calculate the potential energy stored in the compressed spring. Show all work.

12.) The toy is activated and all the compressed spring's potential energy is converted to gravitational potential energy. Calculate the maximum vertical height to which the toy is propelled. Show all work.

Unit 6: Static Electricity Objectives

Focus Question for the Unit:

- ***How is electrical charge conserved as a result of particles coming near and/or coming in contact with one another?***

You Should KNOW:

1.) SI units (International System of units).

2.) Objects with electric charge can exert electrical forces on each other.

3.) Electrical forces can be attractive or repulsive.

4.) Strength and direction of forces between objects can be represented with field lines by using a positive test particle.

5.) The inverse square law (Coulomb's Law) applies to electrical fields.

6.) Energy can be stored in electric. This energy may be transferred through conductors or through space, and may be converted to other forms.

7.) Electrical charge can be transferred resulting in an equal distribution of charge.

8.) Charge is quantized on two levels. On the atomic level, charge is restricted to multiples of the elementary charge (charge on the electron or proton).

9.) Only electrons can be transferred.

10.) Electric potential, or voltage, at any point in an electric field is the electrical potential energy per charge for a charged object at that point.

11.) Electric field lines go from positive to negative.

You Should BE ABLE TO:

12.) Develop skills and protocols in selecting and using proper formulas that require calculating force, charge, electric field strength, or potential difference (voltage) depending on the given values.

13.) Convert between charges (elementary charge ↔ coulombs).

14.) Calculate the resulting charges on objects after being brought in contact with one another.

15.) Observe and explain polarization, induction, and conduction.

16.) Evaluate the relationships between variables in a given equation (i.e. inverse square law: F_e, r).

17.) Map the electrical field of simple charge configurations.

You Should UNDERSTAND:

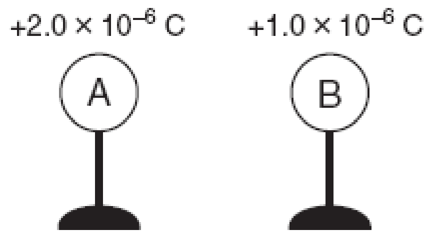
18.) All charge transfers are governed by the law of conservation of charge.

19.) Energy and matter interact through forces that result in changes in motion.

Practice Questions – Static Electricity

1.) If the distance separating an electron and a proton is halved, the magnitude of the electrostatic force between these charged particles will be
(1) unchanged (2) doubled (3) quartered (4) quadrupled

2.) Two similar metal spheres, *A* and *B*, have charges of $+2.0 \times 10^{-6}$ coulomb and $+1.0 \times 10^{-6}$ coulomb, respectively, as shown in the diagram below.



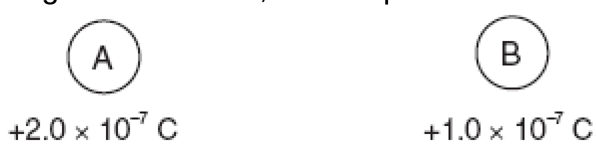
The magnitude of the electrostatic force on *A* due to *B* is 2.4 newtons. What is the magnitude of the electrostatic force on *B* due to *A*?
(1) 1.2 N (2) 2.4 N (3) 4.8 N (4) 9.6 N

3.) Metal sphere *A* has a charge of –2 units and an identical metal sphere, *B*, has a charge of –4 units. If the spheres are brought into contact with each other and then separated, the charge on sphere *B* will be
(1) 0 units (2) –2 units (3) –3 units (4) +4 units

4.) What is the net electrical charge on a magnesium ion that is formed when a neutral magnesium atom loses two electrons?
(1) -3.2×10^{-19} C
(2) -1.6×10^{-19} C
(3) $+1.6 \times 10^{-19}$ C
(4) $+3.2 \times 10^{-19}$ C

5.) If 1.0 joule of work is required to move 1.0 coulomb of charge between two points in an electric field, the potential difference between the two points is
(1) 1.0×10^{0} V
(2) 9.0×10^{9} V
(3) 6.3×10^{18} V
(4) 1.6×10^{-19} V

6.) The diagram below represents two electrically charged identical-sized metal spheres, *A* and *B*. If the spheres are brought into contact, which sphere will have a net gain of electrons?



(1) *A*, only
(2) *B*, only
(3) both *A* and *B*
(4) neither *A* nor *B*

7.) A subatomic particle could have a charge of

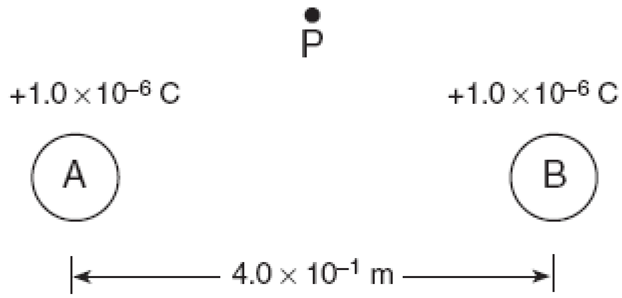
(1) 5.0×10^{-20} C
(2) 8.0×10^{-20} C
(3) 3.2×10^{-19} C
(4) 5.0×10^{-19} C

8.) Gravitational forces differ from electrostatic forces in that gravitational forces are

(1) attractive, only
(2) repulsive, only
(3) neither attractive nor repulsive
(4) both attractive and repulsive

Base your answers to questions 9 and 10 on the information and diagram below.

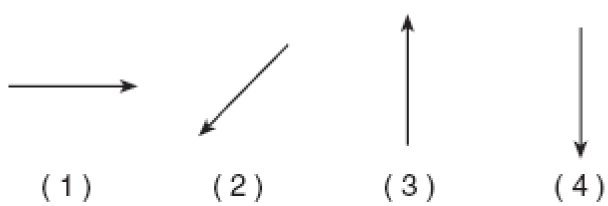
Two small metallic spheres, *A* and *B*, are separated by a distance of 4.0×10^{-1} meter, as shown. The charge on each sphere is 1.0×10^{-6} coulomb. Point *P* is located near the spheres.



9.) What is the magnitude of the electrostatic force between the two charged spheres?

(1) 2.2×10^{-2} N
(2) 5.6×10^{-2} N
(3) 2.2×10^{4} N
(4) 5.6×10^{4} N

10.) Which arrow best represents the direction of the resultant electric field at point *P* due to the charges on spheres *A* and *B*?



11.) The centers of two small charged particles are separated by a distance of 1.2×10^{-4} meter. The charges on the particles are $+8.0 \times 10^{-19}$ coulomb and $+4.8 \times 10^{-19}$ coulomb, respectively.

a) Calculate the magnitude of the **electrostatic force** between these two particles. Show all work, including the equation and substitution with units.

b) On the axes provided, sketch a graph showing the relationship between the magnitude of the electrostatic force between the two charged particles and the distance between the centers of the particles.

Unit 7: Current Electricity & Magnetism Objectives

Focus Questions for the Unit:
- ***How can electron flow be described and manipulated in a circuit?***

You Should KNOW:

1.) SI units (International System of units).
2.) Slopes have physical significance (i.e. – V vs. I).
3.) A circuit is a closed path with a potential difference, in which current can exist.
4.) The total current entering any junction of wires must equal the total current leaving.
5.) Around any closed loop in a circuit, the sum of potential drops must equal the sum of potential increases.
6.) For resistors in series, the equivalent resistance is the sum of their values.
7.) For resistors in parallel, the equivalent resistance is less than the value of any individual resistor.
8.) Resistance is directly related to temperature, length, resistivity, and voltage, but indirectly related to cross-sectional area and current.
9.) Ohm's Law (V=IR)
10.) Energy can be converted between many forms including mechanical, electromagnetic, nuclear, and thermal.
11.) Power is a rate.
12.) Magnetic field lines go from North to South
13.) Moving electric charges produce magnetic fields.
14.) Magnetic fields produce moving electric charges.
15.) Magnetic forces can be attractive or repulsive.

You Should BE ABLE TO:

16.) Develop skills and protocols in selecting and using proper formulas that require calculating resistance, voltage, current, energy, power, cross-sectional area, resistivity, and charge.
17.) Assemble simple series and parallel circuits.
18.) Compare and contrast series and parallel circuits, including the behavior of light bulbs.
19.) Measure current and voltage in a circuit using an ammeter, voltmeter, and multi-meter.
20.) Use measurements to determine the resistance of a circuit element.
21.) Draw and interpret graphs involving current, resistance, voltage, length, and power.
22.) Measure and compare the resistance of conductors of various lengths and cross-sectional areas.
23.) Draw and interpret circuit diagrams which include voltmeters and ammeters.
24.) Map the magnetic field of a permanent magnet, including the direction of the field between the N and S poles.

You Should UNDERSTAND:

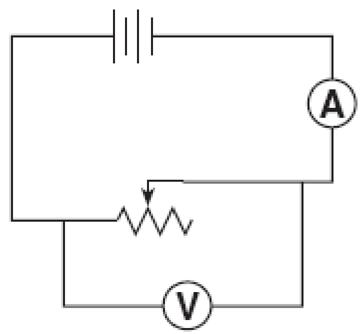
25.) Electricity is a form of energy that can be transformed by moving electric charges doing work in various devices.
26.) Electric fields provide the force that moves charged particles.

Practice Questions – Current Electricity & Magnetism

1.) Which is a vector quantity?
(1) electric charge
(2) electric field strength
(3) electric potential difference
(4) electric resistance

2.) If 60. joules of work is required to move 5.0 coulombs of charge between two points in an electric field, what is the potential difference between these points?
(1) 5.0 V (2) 12 V (3) 60. V (4) 300 V

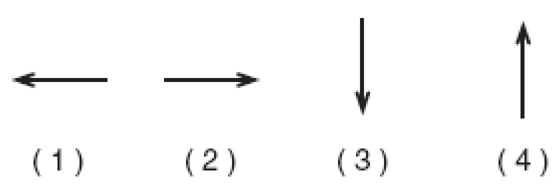
3.) The diagram below represents a simple circuit consisting of a variable resistor, a battery, an ammeter, and a voltmeter.



What is the effect of increasing the resistance of the variable resistor from 1000 Ω to 10000 Ω? [Assume constant temperature.]
(1) The ammeter reading decreases.
(2) The ammeter reading increases.
(3) The voltmeter reading decreases.
(4) The voltmeter reading increases.

4.) In the diagram below, *P* is a point near a negatively charged sphere.

Which vector best represents the direction of the electric field at point *P*?



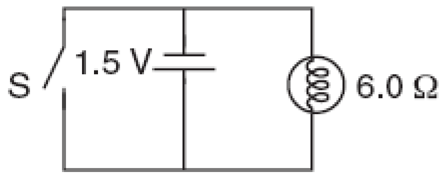
5.) Which quantity and unit are correctly paired?
(1) resistivity and $\frac{\Omega}{m}$
(2) potential difference and eV
(3) current and C•s
(4) electric field strength and $\frac{N}{C}$

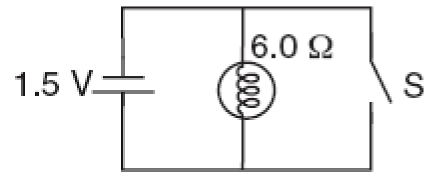
6.) The current through a 10.-ohm resistor is 1.2 amperes. What is the potential difference across the resistor?
(1) 8.3 V (2) 12 V (3) 14 V (4) 120 V

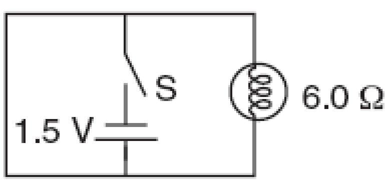
7.) A copper wire of length *L* and cross-sectional area *A* has resistance *R*. A second copper wire at the same temperature has a length of 2*L* and a cross-sectional area of ½ *A*. What is the resistance of the second copper wire?

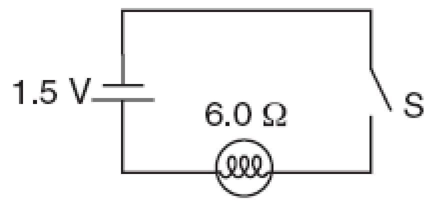
(1) *R* (2) 2*R* (3) ½ *R* (4) 4*R*

8.) A 6.0-ohm lamp requires 0.25 ampere of current to operate. In which circuit below would the lamp operate correctly when switch *S* is closed?

(1)


(3)


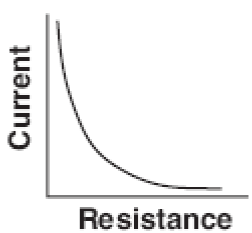
(2)


(4)


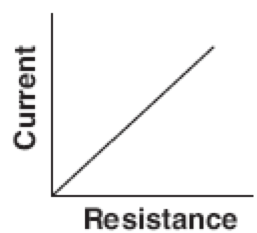
9.) What is the total current in a circuit consisting of six operating 100-watt lamps connected in parallel to a 120-volt source?

(1) 5 A (2) 20 A (3) 600 A (4) 12 000 A

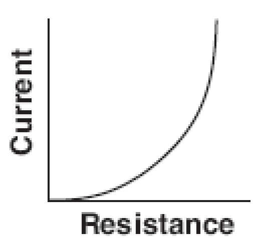
10.) An electric circuit contains a variable resistor connected to a source of constant potential difference. Which graph best represents the relationship between current and resistance in this circuit?



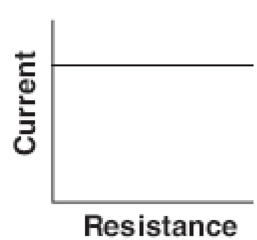
(1)



(3)

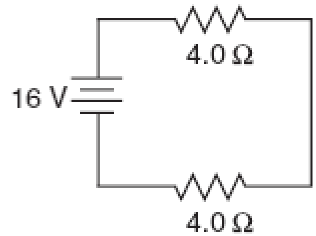


(2)



(4)

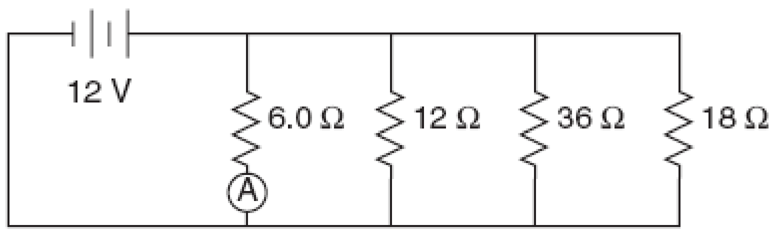
11.) In the circuit diagram below, two 4.0-ohm resistors are connected to a 16-volt battery as shown.



The rate at which electrical energy is expended in this circuit is

(1) 8.0 W (2) 16 W (3) 32 W (4) 64 W

Base your answers to questions 12 through 14 on the diagram below, which represents an electric circuit consisting of four resistors and a 12-volt battery.



12.) What is the current measured by ammeter *A*?

(1) 0.50 A (2) 2.0 A (3) 72 A (4) 4.0 A

13.) What is the equivalent resistance of this circuit?

(1) 72 Ω (2) 18 Ω (3) 3.0 Ω (4) 0.33 Ω

14.) How much power is dissipated in the 36-ohm resistor?

(1) 110 W (2) 48 W (3) 3.0 W (4) 4.0 W

15.) At 20°C, four conducting wires made of different materials have the same length and the same diameter. Which wire has the *least* resistance?

(1) aluminum (2) nichrome (3) gold (4) tungsten

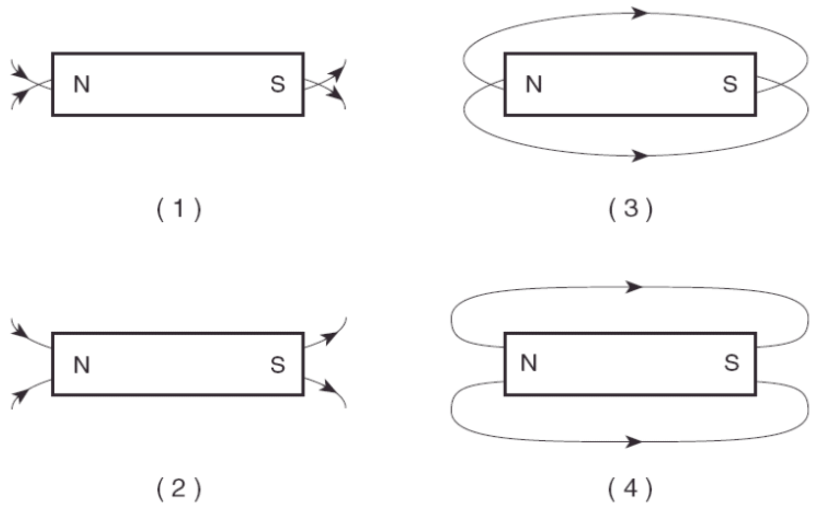
16.) A balloon is rubbed against a student's hair and is then touched to a wall. The balloon "sticks" to the wall due to

(1) magnetic forces between the particles of the wall
(2) magnetic forces between the particles of the balloon and the particles of the wall
(3) electrostatic forces between the particles of the wall
(4) electrostatic forces between the particles of the balloon and the particles of the wall

17.) A moving electron is surrounded by

(1) an electric field, only
(2) a magnetic field, only
(3) both an electric field and a magnetic field
(4) none of the above

18.) Which diagram best represents magnetic flux lines around a bar magnet?

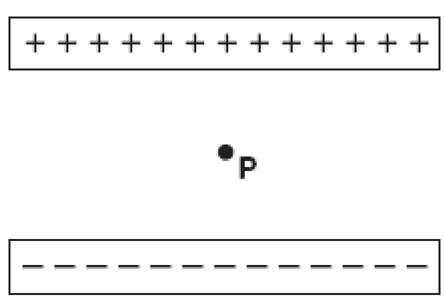


19.) Calculate the resistance of a 1.00-kilometer length of nichrome wire with a cross-sectional area of 3.50 x □10^{-6} meter^2 at 20°C. [Show all work, including the equation and substitution
with units.]

20.) A generator produces a 115-volt potential difference and a maximum of 20.0 amperes of current. Calculate the total electrical energy the generator produces operating at maximum capacity for 60. seconds. [Show all work, including the equation and substitution with units.]

Base your answers to questions 21 and 22 on the information below.

The magnitude of the electric field strength between two oppositely charged parallel metal plates is 2.0 x□10^3 newtons per coulomb. Point *P* is located midway between the plates.



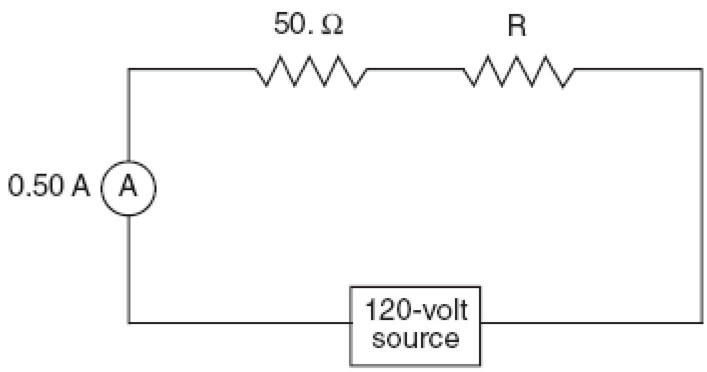
21.) On the diagram above, sketch *at least five* electric field lines to represent the field between the two oppositely charged plates. [Draw an arrowhead on each field line to show the proper direction.]

22.) An electron is located at point *P* between the plates. Calculate the magnitude of the force exerted on the electron by the electric field. [Show all work, including the equation and substitution with units.]

23.) An electric circuit contains a source of potential difference and 5-ohm resistors that combine to give the circuit an equivalent resistance of 15 ohms. In the space provided below, draw a diagram of this circuit using circuit symbols given in the *Reference Tables for Physical Setting/Physics*. [Assume the availability of any number of 5-ohm resistors and wires of negligible resistance.]

Base your answers to questions 24 through 26 on the information and diagram below.

A 50.-ohm resistor, an unknown resistor *R*, a 120-volt source, and an ammeter are connected in a complete circuit. The ammeter reads 0.50 ampere.



24.) Calculate the equivalent resistance of the circuit. [Show all work, including the equation and substitution with units.]

25.) Determine the resistance of resistor R.

26.) Calculate the power dissipated by the 50.-ohm resistor. [Show all work, including the equation and substitution with units.]

Unit 8: Waves Objectives

Focus Questions for the Unit:

- ***What are the characteristics of an electromagnetic wave and a mechanical wave and what properties do they determine?***
- ***What happens when waves meet?***
- ***What happens when a wave changes media?***

You Should KNOW:

1.) SI units (International System of units).
2.) The Doppler Effect is an observed shift in frequency received due to motion of a vibrating source toward or away from a receiver.
3.) In a transverse wave the medium moves at right angles (perpendicular) to the direction in which the wave travels (i.e. light, radio).
4.) In a longitudinal wave the medium moves back and forth (parallel) to the direction in which the wave travels (i.e. sound).
5.) Waves carry energy from a vibrating source to a receiver without transferring matter from one to the other. The amplitude is directly related to the energy being transferred.
6.) Interference patterns occur when waves from different sources arrive at the same point at the same time (Principle of Superposition).
7.) Frequency is directly related to pitch.
8.) Amplitude is directly related to loudness.
9.) Every object vibrates at its own set of natural frequencies (resonance).
10.) Temperature affects the speed of sound in air .
11.) Sound cannot travel through a vacuum. Sound requires a medium in which to travel through.
12.) Electromagnetic waves do not require a medium to travel through. These waves can travel in a vacuum.
13.) When a wave reaches a boundary between two media, part of the wave is reflected and part is refracted in the second media.
14.) Frequency remains constant as a wave passes into a new medium (only speed and wavelength change).
15.) Index of refraction is the ratio of the speed of light in a vacuum to the speed of light in a medium.
16.) In total internal reflection, an incident wave on a boundary is at an angle such that none of the wave can be refracted, so only reflection occurs.

You Should BE ABLE TO:

17.) Develop skills and protocols in selecting and using proper formulas that require calculating angles, index of refraction, speed, frequency, wavelength, period, and distance.
18.) Compare the characteristics of two transverse waves such as amplitude, frequency, wavelength, speed, period, and phase.
19.) Draw wave forms with various characteristics.
20.) Identify nodes and antinodes in standing waves .
21.) Differentiate between transverse and longitudinal waves.
22.) Predict the superposition of two waves interfering constructively and destructively (indicating nodes, antinodes, and standing waves) .
23.) Observe, sketch, and interpret the behavior of wave fronts as they reflect, refract, and diffract .
24.) Draw ray diagrams to represent the reflection and refraction of waves
25.) Determine empirically and mathematically (using Snell's Law) the index of refraction of a transparent medium .
26.) Relate the frequency of an electromagnetic wave to its wave type and/or wavelength on the EM spectrum.

You Should UNDERSTAND:

27.) Mechanical and electromagnetic waves have specific properties that can be used to explain natural phenomena and their applications in technology/society.

Practice Questions – Waves

1.) A dampened fingertip rubbed around the rim of a crystal stemware glass causes the glass to vibrate and produce a musical note. This effect is due to

(1) resonance (2) reflection (3) refraction (4) rarefaction

2.) Which type of wave requires a material medium through which to travel?

(1) radio wave (2) light wave (3) microwave (4) mechanical wave

3.) Compared to the speed of a sound wave in air, the speed of a radio wave in air is

(1) less (2) greater (3) the same

4.) If the amplitude of a wave is increased, the frequency of the wave will

(1) decrease (2) increase (3) remain the same

5.) Which unit is equivalent to meters per second?

(1) Hz•s (2) s/Hz (3) Hz•m (4) m/Hz

6.) Which characteristic is the same for ever color of light in a vacuum?

(1) energy (2) speed (3) frequency (4) period

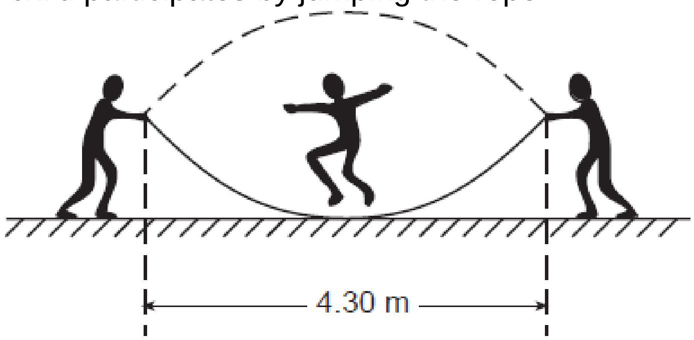
7.) What is the speed of light (f = 5.09×10^{14} Hz) in flint glass?

(1) 1.81×10^8 m/s (2) 3.00×10^8 m/s (3) 1.97×10^8 m/s (4) 4.98×10^8 m/s

8.) A television remote control is used to direct pulses of electromagnetic radiation to a receiver on a television. This communication from the electromagnetic radiation

(1) is a longitudinal wave
(2) possesses energy inversely proportional to its frequency
(3) diffracts and accelerates in air
(4) transfers energy without transferring mass

9.) While playing, two children create a standing wave in a rope, as shown in the diagram to the right. A third child participates by jumping the rope.



What is the wavelength of this standing wave?

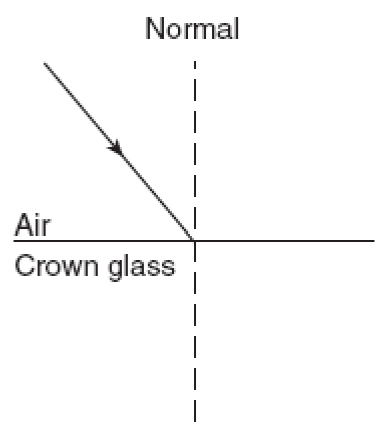
(1) 2.15 m (3) 6.45 m
(2) 4.30 m (4) 8.60 m

10.) A wave of constant wavelength diffracts as it passes through an opening in a barrier. As the size of the opening is increased, the diffraction effects

(1) decrease (2) increase (3) remain the same

11.) A car's horn produces a sound wave of constant frequency. As the car speeds up going away from a stationary spectator, the sound wave detected by the spectator

(1) decreases in amplitude and decreases in frequency
(2) decreases in amplitude and increases in frequency
(3) increases in amplitude and decreases in frequency
(4) increases in amplitude and increases in frequency

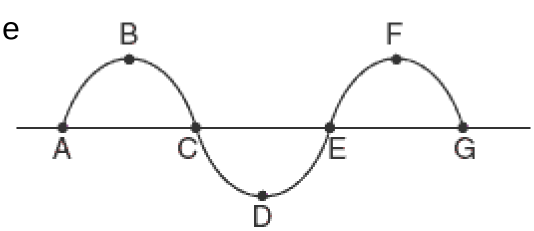


12.) A ray of light (f = 5.09×10^{14} Hz) traveling in air is incident at an angle of 40.° on an air-crown glass interface as shown. What is the angle of refraction for this light ray?

(1) 25° (3) 40°
(2) 37° (4) 78°

13.) The time required for a wave to complete one full cycle is called the wave's
(1) frequency (2) velocity (3) period (4) wavelength

14.) The diagram to the right represents a transverse wave. The wavelength of the wave is equal to the distance between points

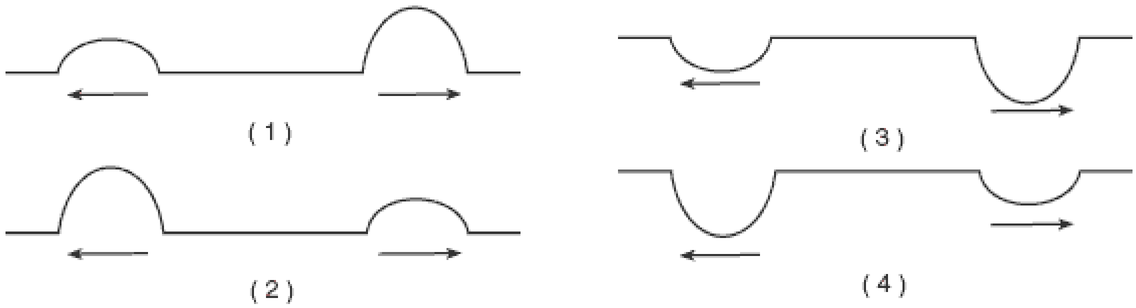


(1) *A* and *G* (3) *C* and *E*

(2) *B* and *F* (4) *D* and *F*

15.) The diagram below represents two pulses approaching each other from opposite directions in the same medium.

Which diagram best represents the medium after the pulses have passed through each other?



16.) An electromagnetic AM-band radio wave could have a wavelength of

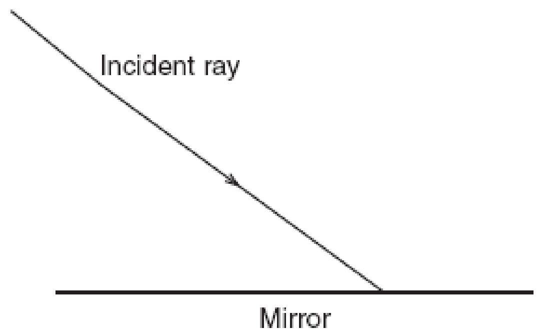
(1) 0.005 m (2) 500 m (3) 5 m (4) 5,000,000 m

17.) The product of a wave's frequency and its period is

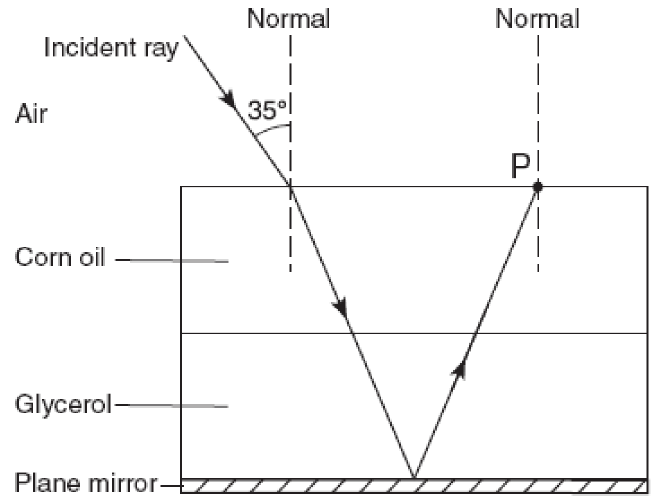
(1) one (2) its wavelength (3) its velocity (4) Planck's constant

18.) A beam of monochromatic light has a wavelength of 5.89×10^{-7} meter in air. Calculate the wavelength of this light in diamond. [Show all work, including the equation and substitution with units.]

19.) The diagram below represents a ray of light incident on a plane mirror. Using a protractor and straightedge, on the diagram, construct the reflected ray for the incident ray shown.



20.) A ray of monochromatic light having a frequency of 5.09×10^{14} Hertz is incident on an interface of air and corn oil at an angle of 35° as shown. The ray is transmitted through parallel layers of corn oil and glycerol and is then reflected from the surface of a plane mirror, located below and parallel to the glycerol layer. The ray then emerges from the corn oil back into the air at point *P*.



a) Calculate the angle of refraction of the light ray as it enters the corn oil from air. [Show all work, including the equation and substitution with units.]

b) Explain why the ray does *not* bend at the corn oil-glycerol interface.

c) On the diagram, use a protractor and straightedge to construct the refracted ray representing light emerging at point *P* into air.

Practice Question Answers

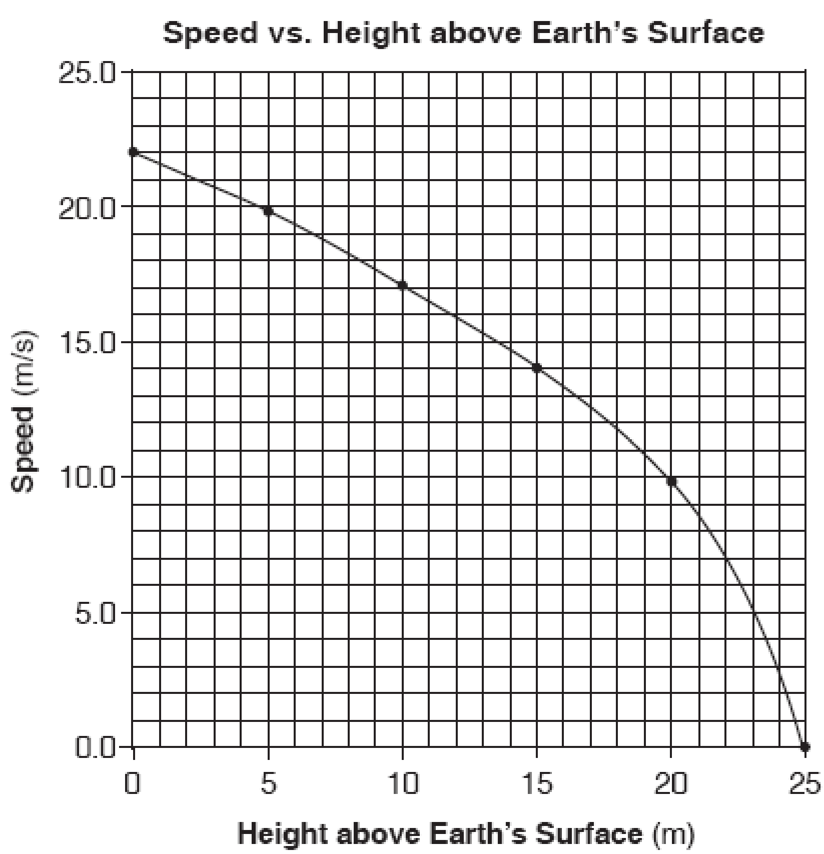
Linear Motion: p. 4-8

1.) 1
2.) 2
3.) 1
4.) 4
5.) 1
6.) 2
7.) 3
8.) 3
9.) 2
10.) 2
11.) 2
12.) 3

13.) a.) & b.)

[1] Allow 1 credit for correctly plotting all points ± 0.3 grid space.

[1] Allow 1 credit for drawing the line or curve of best fit.



c.)

[1] Allow 1 credit for 15.7 m/s ± 0.3 m/s *or* an answer that is consistent with the student's graph.

14.) a.) 5.4 cm ± 0.2 cm

Example of a 2-credit response:

$d = v_i t + \frac{1}{2}at^2$

$a = \frac{2d}{t^2}$

$a = \frac{2(5.4\text{ cm})}{(0.30\text{ s})^2}$

$a = 120\text{ cm/s}^2$ *or* 1.2 m/s^2

Note: Allow credit for an answer that is consistent with the student's response to question 63.

b.)

Example of a 2-credit response:

$\bar{v} = \frac{d}{t}$

$\bar{v} = \frac{5.4\text{ cm}}{0.30\text{ s}}$

$\bar{v} = 18\text{ cm/s}$ *or* 0.18 m/s

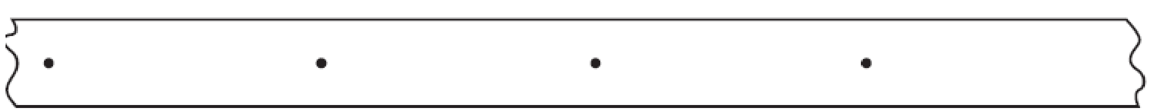
Note: Allow credit for an answer that is consistent with the student's response to question 63 or 64.

c.)

Allow 1 credit for *at least four* dots that are equally spaced ± 0.2 cm.

Example of a 1-credit response:

Recording Tape



(Drawn to scale)

d.)

15.)

Example of a 2-credit response:

$$v_f^2 = v_i^2 + 2ad$$

$$d = \frac{v_f^2 - v_i^2}{2a}$$

$$d = \frac{(0\ \text{m/s})^2 - (70.\ \text{m/s})^2}{2(-2.0\ \text{m/s}^2)}$$

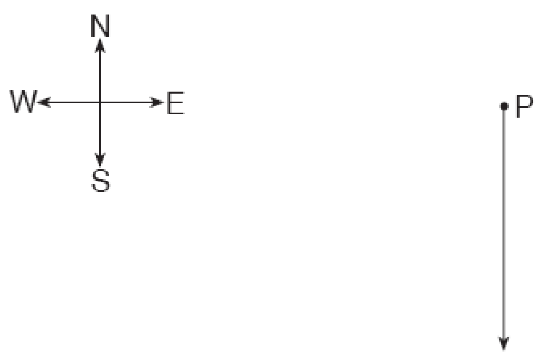
$$d = 1200\ \text{m}$$

16.)

[2] Allow a maximum of 2 credits, allocated as follows:

- Allow 1 credit for a direction south.
- Allow 1 credit for a vector drawn 4.0 cm ± 0.2 cm long.

Example of a 2-credit response:



Note: The vector need *not* begin at point *P* to receive this credit.

<u>Forces: p. 10-12</u>

1.) 3
2.) 1
3.) 1
4.) 4
5.) 1
6.) 1
7.) 3
8.) 4
9.) 4
10.) 3
11.) 3
12.) 2

13.) gravitation (gravity)
14.)

Example of a 2-credit response:

$$F = \frac{Gm_1m_2}{r^2}$$

$$F = \frac{(6.67 \times 10^{-11}\ \text{N}\bullet\text{m}^2/\text{kg}^2)(8.73 \times 10^{25}\ \text{kg})(1.03 \times 10^{26}\ \text{kg})}{(1.63 \times 10^{12}\ \text{m})^2}$$

$$F = 2.26 \times 10^{17}\ \text{N}$$

15.)

Allow 1 credit for indicating that the Sun is larger in mass.

Note: Do *not* allow credit for just "larger."

<u>Momentum & Impulse: p. 14-15</u>

1.) 3
2.) 3
3.) 2
4.) 3
5.) 4
6.) 1
7.) 4
8.) 3
9.) 2
10.)

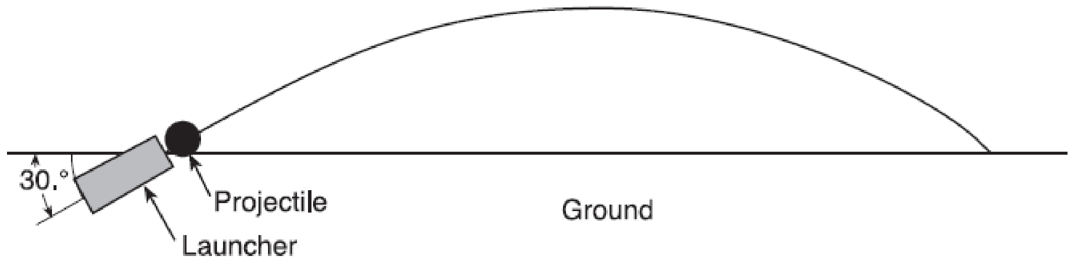
Allow 1 credit for 6000 $\frac{\text{kg}\bullet\text{m}}{\text{s}}$.

<u>Projectile Motion: p. 17-18</u>

1.) 4
2.) 2
3.) 2
4.) 2
5.) 3
6.) a.)

[1] Allow 1 credit for a parabolic-shaped path.

Example of a 1-credit response:



b.) the projectile's maximum altitude will *increase*.
c.) the total horizontal distance traveled will *increase*.

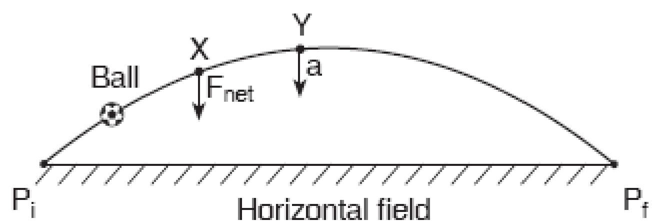
7.)

[1] Allow 1 credit for drawing an arrow at X toward the ground and perpendicular to the ground.

8.)

[1] Allow 1 credit for drawing an arrow at Y toward the ground and perpendicular to the ground.

Example of a 2-credit response for questions 7 and 8.



Note: The arrows need *not* be labeled to receive credit.

<u>Energy: p. 20-22</u>

1.) 2
2.) 3
3.) 4
4.) 3
5.) 1
6.) 1
7.) 4
8.) 2
9.) 1
10.) 1

11.)

Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$PE_s = \frac{1}{2}kx^2$

$PE_s = \frac{1}{2}(150\,\text{N/m})(0.050\,\text{m})^2$

$PE_s = 0.19\ \text{J}$ *or* $1.9 \times 10^{-1}\ \text{J}$ *or* $0.1875\ \text{J}$

12.)

Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$\Delta PE = mg\Delta h$$

$$\Delta h = \frac{\Delta PE}{mg}$$

$$\Delta h = \frac{0.19\ \text{J}}{0.020\ \text{kg}\left(9.81\ \text{m/s}^2\right)}$$

$$\Delta h = 0.97\ \text{m}$$

Note: Allow credit for an answer that is consistent with the student's response to question 66.

<u>Static Electricity: p. 24-25</u>

1.) 4
2.) 2
3.) 3
4.) 1
5.) 1
6.) 1
7.) 3
8.) 1
9.) 2
10.) 3

11.) a.)

Example of a 2-credit response:

$$F = \frac{kq_1q_2}{r^2}$$

$$F = \frac{(8.99 \times 10^9 \text{ N} \bullet \text{m}^2/\text{C}^2)(8.0 \times 10^{-19} \text{ C})(4.8 \times 10^{-19} \text{ C})}{(1.2 \times 10^{-4} \text{ m})^2}$$

$$F = 2.4 \times 10^{-19} \text{ N}$$

b.)

[1] Allow 1 credit for a graph showing an inverse square relationship.

Example of a 1-credit response:

<u>Current Electricity: p. 27-31</u>

1.) 2
2.) 2
3.) 1
4.) 1
5.) 4
6.) 2
7.) 4
8.) 4
9.) 1
10.) 1
11.) 3
12.) 2
13.) 3
14.) 4
15.) 3
16.) 4
17.) 3
18.) 4

19.)

Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$$R = \frac{(150. \times 10^{-8}\ \Omega \bullet \text{m})\ (1.00 \times 10^{3}\ \text{m})}{3.50 \times 10^{-6}\ \text{m}^2}$$

$$R = 429\ \Omega$$

20.)

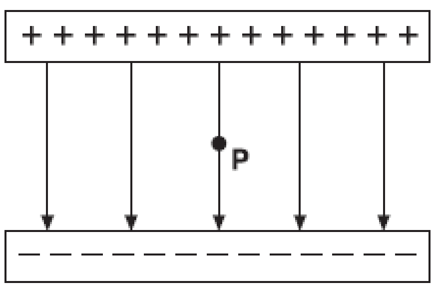
Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$W = VIt$
$W = (115\ \text{V})\ (20.0\ \text{A})\ (60.\ \text{s})$
$W = 1.4 \times 10^5\ \text{J}$ *or* $138\ 000\ \text{J}$

21.) Allow 1 credit for drawing *at least five* straight parallel lines perpendicular to the plates and pointing toward the negative plate. The lines must originate and end on the plates.

Example of a 1-credit response:



Note: Curved lines beyond the edges of the plates are acceptable.
Parallel lines need not be equally spaced.

22.)

Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$E = \frac{F_e}{q}$$

$$F_e = Eq$$

$$F_e = (2.0 \times 10^3\ \text{N/C})\ \ (1.6 \times 10^{-19}\ \text{C})$$

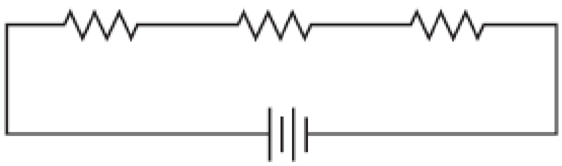
$$F_e = 3.2 \times 10^{-16}\ \text{N}$$

23.)

Allow a maximum of 2 credits, allocated as follows:

- Allow 1 credit for drawing a complete circuit, including a source of potential difference.
- Allow 1 credit for connecting resistors with an equivalent resistance of 15 Ω .

Example of a 2-credit response:



24.)

Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$$R = \frac{120\text{ V}}{0.50\text{ A}}$$

$$R = 240\ \Omega$$

25.)

Allow 1 credit for 190 Ω *or* an answer that is consistent with the student's response to question 67.

26.) Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$P = I^2R$
$P = (0.50\text{ A})^2\ (50.\ \Omega)$
$P = 12\text{ W}$ *or* 12.5 W

Waves: p. 33-36

1.) 1
2.) 4
3.) 1
4.) 3
5.) 3
6.) 2
7.) 1
8.) 4

9.) 4
10.) 1
11.) 1
12.) 1
13.) 3
14.) 2
15.) 2
16.) 2
17.) 1

18.) Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$$

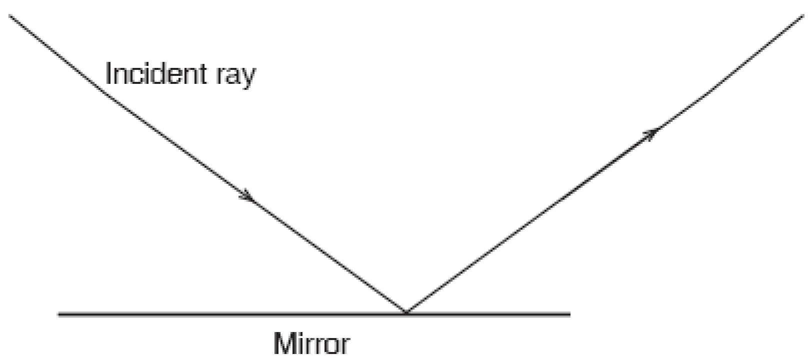
$$\lambda_2 = \frac{n_1 \lambda_1}{n_2}$$

$$\lambda_2 = \frac{(1.00)(5.89 \times 10^{-7}\text{ m})}{2.42}$$

$$\lambda_2 = 2.43 \times 10^{-7}\text{ m}$$

19.) Allow 1 credit for a reflected ray at $36° \pm 2°$ to the mirror.

Example of a 1-credit response:



Note: Allow credit even if the reflected ray does *not* have an arrowhead.
No normal needs to be drawn.

20.) a.) **Example of a 2-credit response:**

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2}$$

$$\sin\theta_2 = \frac{1.00 \sin 35°}{1.47}$$

$$\theta_2 = 23°$$

Allow 1 credit. Acceptable responses include, but are not limited to:

— The light does not bend because light travels at the same speed in both layers.

— The absolute indices of refraction are the same.

b.)

c.)

Allow 1 credit for drawing the refracted ray at an angle of 35° ± 2° to the normal.

Example of a 1-credit response: