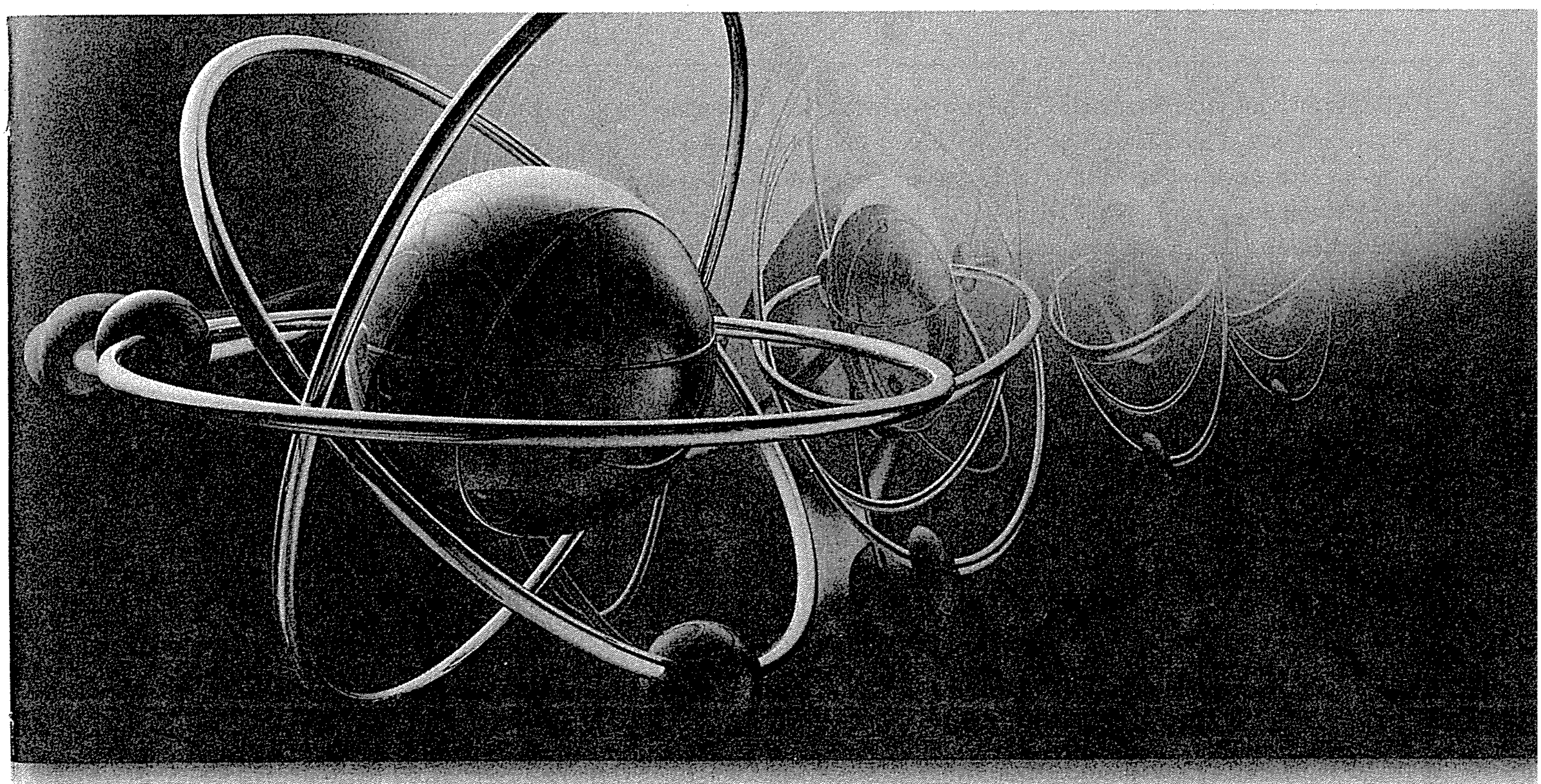
Prentice Hall Brief Review

Physics: The Physical Setting

Answer Key



2013

Contents

To the Teacher:

The Answer Key for the *Brief Review in Physics: The Physical Setting* provides answers to all of the questions in the book, including the sample Regents Examinations provided in the back of the book.

To determine concepts that might require more intense review, students can take the Diagnostic Tests provided for each topic. The Diagnostic Tests include questions that are not in the book itself, so you will be able to check students' understanding of some of the concepts in the topic without simply repeating questions they have seen in the book.

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PEARSON

1 2 3 4 5 6 7 8 9 10 V011 16 15 14 13 12

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DIAGNOSTIC TEST TOPIC 2

1. 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 **(3)** 3.0 m
(2) 5.0 m **(4)** 11.0 m

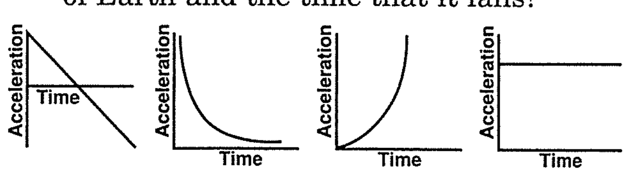
2. The speed of an object undergoing constant acceleration increases from 8.0 meters per second to 16.0 meters per second in 10. seconds. How far does the object travel during the 10. seconds?
(1) 3.6×10^2 m **(3)** 1.2×10^2 m
(2) 1.6×10^2 m **(4)** 8.0×10^1 m

3. A rock falls from rest a vertical distance of 0.72 meter to the surface of a planet in 0.63 second. The magnitude of the acceleration due to gravity on the planet is
(1) 1.1 m/s^2 **(3)** 3.6 m/s^2
(2) 2.3 m/s^2 **(4)** 9.8 m/s^2

4. 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 **(3)** 9.8 m/s
(2) 7.4 m/s **(4)** 15 m/s

5. A 1.0-kilogram ball is dropped from the roof of a building 40. meters tall. What is the ball's time of fall? [Neglect friction.]
(1) 2.9 s **(3)** 4.1 s
(2) 2.0 s **(4)** 8.2 s

6. 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?



(1) (2) (3) (4)

7. A 5.0-newton force could have perpendicular components of
(1) 1.0 N and 4.0 N **(3)** 3.0 N and 4.0 N
(2) 2.0 N and 3.0 N **(4)** 5.0 N and 5.0 N

8. A force of 1 newton is equivalent to 1
(1) $\frac{\text{kg} \cdot \text{m}}{\text{s}^2}$ **(3)** $\frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$
(2) $\frac{\text{kg} \cdot \text{m}}{\text{s}}$ **(4)** $\frac{\text{kg}^2 \cdot \text{m}^2}{\text{s}^2}$

9. Which cart has the greatest inertia?
(1) a 1-kg cart traveling at 4 m/s
(2) a 2-kg cart traveling at 3 m/s
(3) a 3-kg cart traveling at 2 m/s
(4) a 4-kg cart traveling at 1 m/s

10. A 2-kilogram box on a horizontal frictionless surface is acted upon by a 9-newton horizontal force to the left and a 1-newton horizontal force to the right. The acceleration of the box is
(1) 5 m/s^2 to the right
(2) 5 m/s^2 to the left
(3) 4 m/s^2 to the right
(4) 4 m/s^2 to the left

Base your answers to questions 11 and 12 on the information below.

An object is thrown horizontally off a cliff with an initial velocity of 5.0 meters per second. The object strikes the ground 3.0 seconds later. [Neglect friction.]

11. What is the vertical speed of the object as it reaches the ground?
(1) 130 m/s **(3)** 15 m/s
(2) 29 m/s **(4)** 5.0 m/s

12. How far from the base of the cliff will the object strike the ground?
(1) 2.9 m **(3)** 15 m
(2) 9.8 m **(4)** 44 m

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DIAGNOSTIC TEST TOPIC 2 (CONTINUED)

Base your answers to questions 13 and 14 on the information below.

A child kicks a ball with an initial velocity of 8.5 meters per second at an angle of 35° with the horizontal. The ball has an initial vertical velocity of 4.9 meters per second and a total time of flight of 1.0 second. [Neglect friction.]

13. The horizontal component of the ball's initial velocity is

(1) 3.6 m/s **(3)** 7.0 m/s
(2) 4.9 m/s **(4)** 13 m/s

14. The maximum height reached by the ball is

(1) 1.2 m **(3)** 4.9 m
(2) 2.5 m **(4)** 8.5 m

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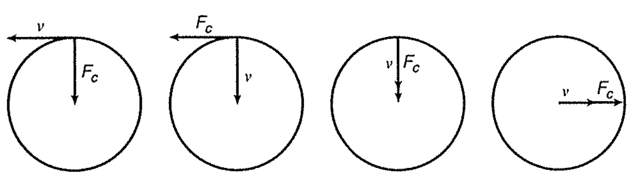
15. A car travels at constant speed around a horizontal circular track. Which diagram best represents the direction of the car's velocity, v, and the direction of the centripetal force, F_c, acting on the car at one particular moment?



(1) (2) (3) (4)

16. A 1750-kilogram car travels at a constant speed of 15.0 meters per second around a horizontal, circular track with a radius of 45.0 meters. The magnitude of the centripetal force acting on the car is

(1) 5.00 N **(3)** 8750 N
(2) 583 N **(4)** 3.94×10^5 N

17. A distance of 3.00 meters separates the centers of two 15.0-kilogram spheres. The magnitude of the gravitational force that one sphere exerts on the other sphere is

(1) 1.11×10^{-10} N **(3)** 1.67×10^{-9} N
(2) 3.34×10^{-10} N **(4)** 5.00×10^{-9} N

18. A 1200-kilogram space vehicle travels at 4.8 meters per second along the level surface of Mars. If the magnitude of the gravitational field strength on the surface of Mars is 3.7 newtons per kilogram, the magnitude of the normal force acting on the vehicle is

(1) 320 N **(3)** 4400 N
(2) 930 N **(4)** 5800 N

19. An 80-kilogram skier slides on waxed skis along a horizontal surface of snow at constant velocity while pushing with his poles. What is the horizontal component of the force pushing him forward?

(1) 0.05 N **(3)** 40 N
(2) 0.4 N **(4)** 4 N

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

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

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

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

22. A 0.40-kilogram ball was thrown with a speed of 20. meters per second by a 50.-kilogram student. What was the magnitude of the impulse imparted to the ball by the student?

(1) 8.0 N•s **(3)** 4.0×10^2 N•s
(2) 78 N•s **(4)** 1.0×10^3 N•s

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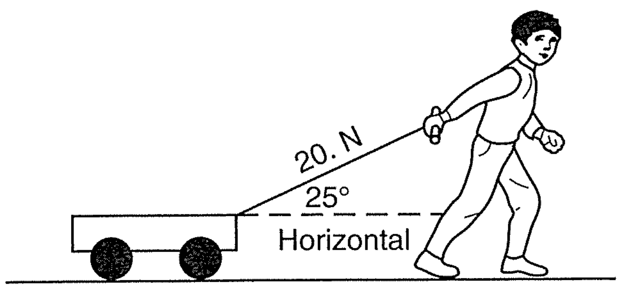
DIAGNOSTIC TEST TOPIC 3

1. A student does 60. joules of work pushing a 3.0-kilogram box up the full length of a ramp that is 5.0 meters long. What is the magnitude of the force the student applied to the box parallel to the ramp to do this work?
   (1) 20. N (3) 12 N
   (2) 15 N (4) 4.0 N

2. As shown in the diagram below, a child applies a constant 20.-newton force along the handle of a wagon which makes a 25° angle with the horizontal.



   How much work does the child do in moving the wagon a horizontal distance of 4.0 meters?
   (1) 5.0 J (3) 73 J
   (2) 34 J (4) 80. J

3. A 60.-kilogram student climbs a ladder a vertical distance of 4.0 meters in 8.0 seconds. What is the total work done against gravity by the student during the climb?
   (1) 2.4×10^3 J (3) 2.4×10^2 J
   (2) 2.9×10^2 J (4) 3.0×10^1 J

4. One watt is equivalent to one
   (1) N•m (3) J•s
   (2) N/m (4) J/s

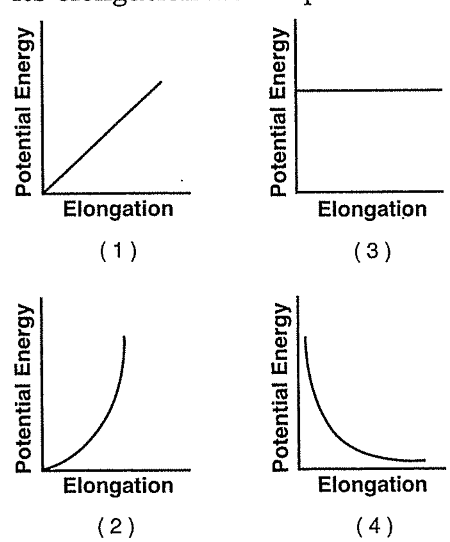
5. A 3.0-kilogram block is initially at rest on a frictionless, horizontal surface. The block is moved 8.0 meters in 2.0 seconds by the application of a horizontal force with a magnitude of 12 newtons. What is the average power developed while moving the block?
   (1) 24 W (3) 48 W
   (2) 32 W (4) 96 W

6. An electrical generator in a science classroom makes a light bulb glow when a student turns a hand crank on the generator. During its operation, this generator converts
   (1) chemical energy to electrical energy
   (2) mechanical energy to electrical energy
   (3) electrical energy to mechanical energy
   (4) electrical energy to chemical energy

7. What is the gravitational potential energy with respect to the surface of the water of a 75.0-kilogram diver located 3.00 meters above the water?
   (1) 2.17×10^4 J (3) 2.25×10^2 J
   (2) 2.21×10^3 J (4) 2.29×10^1 J

8. A 0.1-kilogram apple is attached to a branch of a tree 2 meters above a spring on the ground below. When the apple falls all of its gravitational potential energy with respect to the top of the spring is transferred to the spring. The apple compresses the spring 0.1 meter from its rest position. What is the spring constant of this spring?
   (1) 10 N/m (3) 100 N/m
   (2) 40 N/m (4) 400 N/m

9. Which graph best represents the relationship between the elastic potential energy stored in a spring and its elongation from equilibrium?



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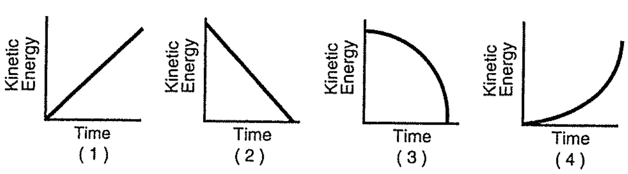
DIAGNOSTIC TEST TOPIC 3 (CONTINUED)

10. A 5-newton force causes a spring to stretch 0.2 meter. What is the potential energy stored in the stretched spring?
(1) 1 J **(3)** 0.2 J
(2) 0.5 J **(4)** 0.1 J

11. A 1.0-kilogram rubber ball traveling east at 4.0 meters per second hits a wall and bounces back toward the west at 2.0 meters per second. Compared to the kinetic energy of the ball before it hits the wall, the kinetic energy of the ball after it hits the wall is
(1) one-fourth as great
(2) one-half as great
(3) the same
(4) four times as great

12. During an emergency stop, a 1.5×10^3-kilogram car lost a total of 3.0×10^5 joules of kinetic energy. What was the speed of the car at the moment the brakes were applied?
(1) 10. m/s **(3)** 20. m/s
(2) 14 m/s **(4)** 25 m/s

13. An object falls freely near Earth's surface. Which graph best represents the relationship between the object's kinetic energy and its time of fall?

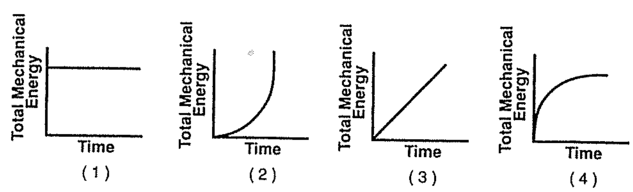


14. A car travels at constant speed v up a hill from point A to point B. As the car travels from A to B, its gravitational potential energy
(1) increases and its kinetic energy decreases
(2) increases and its kinetic energy remains the same
(3) remains the same and its kinetic energy decreases
(4) remains the same and its kinetic energy remains the same

15. A horizontal force of 5.0 newtons to the right acts on a 3.0-kilogram mass over a distance of 6.0 meters along a horizontal, frictionless surface. What is the change in kinetic energy of the mass during its movement over the 6.0-meter distance?
(1) 6.0 J **(3)** 30. J
(2) 15 J **(4)** 90. J

16. A block weighing 60. newtons is located 0.80 meter above the horizontal on a rough incline. The block is released from rest. If 12 joules of heat is generated as the block slides down the incline, the maximum kinetic energy of the block at the bottom of the incline is
(1) 12 J **(3)** 48 J
(2) 36 J **(4)** 60. J

17. A wooden crate is pushed at constant speed across a level wooden floor. Which graph best represents the relationship between the total mechanical energy of the crate and the duration of time the crate is pushed?



18. A 0.50-kilogram ball is thrown vertically upward with an initial kinetic energy of 25 joules. Approximately how high will the ball rise? [Neglect air resistance.]
(1) 2.6 m **(3)** 13 m
(2) 5.1 m **(4)** 25 m

19. A constant force is used to keep a block sliding at constant velocity along a rough horizontal track. As the block slides, there could be an increase in its
(1) gravitational potential energy, only
(2) internal energy, only
(3) gravitational potential energy and kinetic energy
(4) internal energy and kinetic energy

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DIAGNOSTIC TEST TOPIC 4

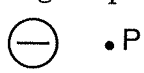
1. A metal sphere has a net negative charge of 1.1×10^{-6} coulomb. Approximately how many more electrons than protons are on the sphere?

(1) 1.8×10^{12} **(3)** 6.9×10^{12}
(2) 5.7×10^{12} **(4)** 9.9×10^{12}

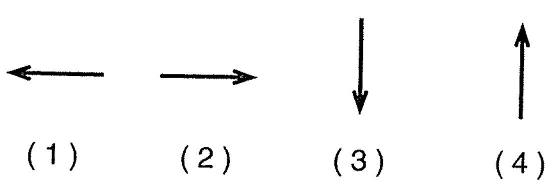
2. An object with a net charge of 4.80×10^{-6} coulomb experiences an electrostatic force having a magnuitude of 6.00×10^{-2} newton when placed near a negatively charged metal sphere. What is the electric field strength at this location?

(1) 1.25×10^{4} N/C directed away from the sphere
(2) 1.25×10^{4} N/C directed toward the sphere
(3) 2.88×10^{-8} N/C directed away from the sphere
(4) 2.88×10^{-8} N/C directed toward the sphere

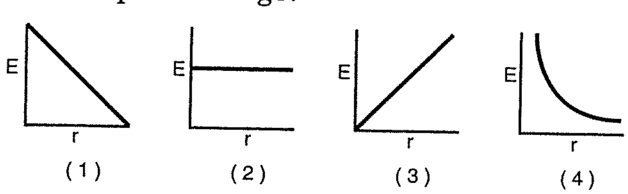
3. In the diagram below, *P* is a point near a negatively charged sphere.



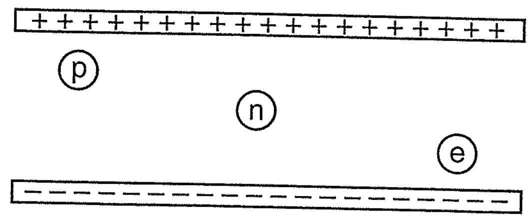
Which vector best represents the direction of the electric field at point *P*?



4. Which graph best represents the relationship between the magnitude of the electric field strength, *E*, around a point charge and the distance, *r*, from the point charge?



5. In the diagram below, proton *p*, neutron *n*, and electron *e* are located as shown between two oppositely charged plates.



The magnitude of acceleration will be greatest for the

(1) neutron, because it has the greatest mass
(2) neutron, because it is neutral
(3) electron, because it has the smallest mass
(4) proton, because it is farthest from the negative plate

6. If 4.8×10^{-17} joule of work is required to move an electron between two points in an electric field, what is the electric potential difference between these points?

(1) 1.6×10^{-19} V **(3)** 3.0×10^{2} V
(2) 4.8×10^{-17} V **(4)** 4.8×10^{2} V

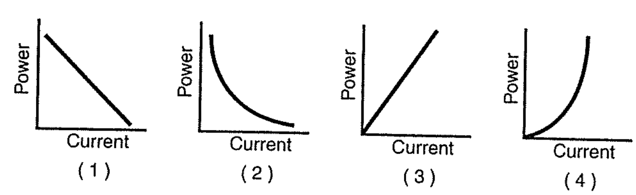
7. A 330.-ohm resistor is connected to a 5.00-volt battery. The current through the resistor is

(1) 0.152 mA **(3)** 335 mA
(2) 15.2 mA **(4)** 1650 mA

8. What is the resistance at 20.°C of a 2.0-meter length of tungsten wire with a cross-sectional area of 7.9×10^{-7} meter^2?

(1) $5.7 \times 10^{-1}\ \Omega$ **(3)** $7.1 \times 10^{-2}\ \Omega$
(2) $1.4 \times 10^{-1}\ \Omega$ **(4)** $4.0 \times 10^{-2}\ \Omega$

9. Which graph best represents the relationship between the electrical power and the current in a resistor that obeys Ohm's Law?



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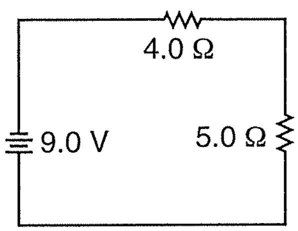
DIAGNOSTIC TEST TOPIC 4 (CONTINUED)

10. The current through a lightbulb is 2.0 amperes. How many coulombs of electric charge pass through the lightbulb in one minute?

(1) 60. C **(3)** 120 C
(2) 2.0 C **(4)** 240 C

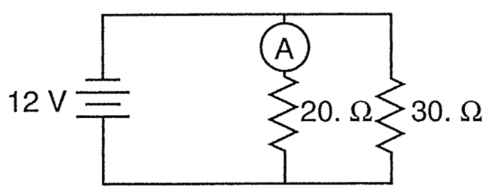
11. A 9.0-volt battery is connected to a 4.0-ohm resistor and a 5.0-ohm resistor as shown in the diagram below.



What is the current in the 5.0-ohm resistor?

(1) 1.0 A **(3)** 2.3 A
(2) 1.8 A **(4)** 4.0 A

Base your answers to questions 12 through 14 on the circuit diagram below.



12. What is the equivalent resistance of the circuit?

(1) 10. Ω **(3)** 25 Ω
(2) 12 Ω **(4)** 50. Ω

13. What is the current reading of the ammeter?

(1) 1.0 A **(3)** 0.40 A
(2) 0.60 A **(4)** 0.20 A

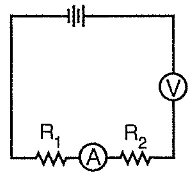
14. What is the power of the 30.-ohm resistor?

(1) 4.8 W **(3)** 30. W
(2) 12 W **(4)** 75 W

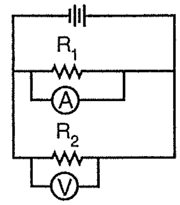
15. Two identical resistors connected in series have an equivalent resistance of 4 ohms. The same two resistors, when connected in parallel, have an equivalent resistance of

(1) 1 Ω **(3)** 8 Ω
(2) 2 Ω **(4)** 4 Ω

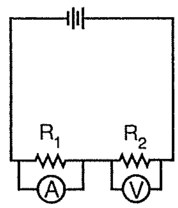
16. In which circuit represented below are meters properly connected to measure the current through resistor R_1 and the potential difference across resistor R_2?



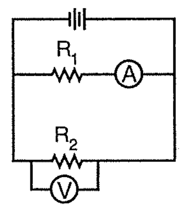
(1)



(3)



(2)



(4)

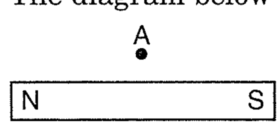
17. A potential drop of 50. volts is measured across a 250-ohm resistor. What is the power developed in the resistor?

(1) 0.20 W **(3)** 10. W
(2) 5.0 W **(4)** 50. W

18. An electric iron operating at 120 volts draws 10. amperes of current. How much heat energy is delivered by the iron in 30. seconds?

(1) 3.0×10^2 J **(3)** 3.6×10^3 J
(2) 1.2×10^3 J **(4)** 3.6×10^4 J

19. The diagram below shows a bar magnet.



Which arrow best represents the direction of the needle of a compass placed at point *A*?

(1) ↑ **(3)** →
(2) ↓ **(4)** ←

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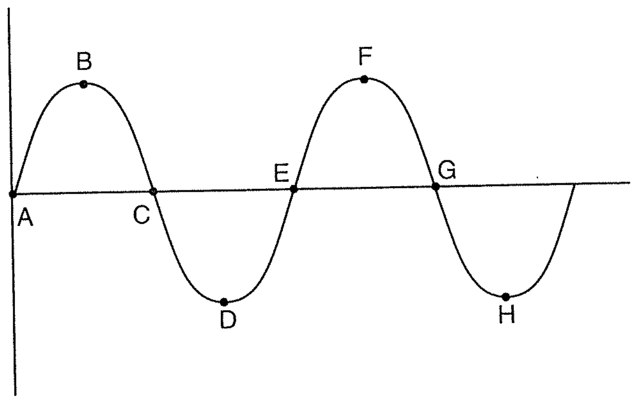
DIAGNOSTIC TEST TOPIC 5

1. A person observes 4.0 waves arriving at the beach every 20. seconds. The frequency of these waves is
   (1) 0.20 Hz (3) 16 Hz
   (2) 5.0 Hz (4) 80. Hz

2. The energy of a water wave is most closely related to its
   (1) frequency (3) period
   (2) wavelength (4) amplitude

Base your answers to questions 3 and 4 on the diagram below of a transverse wave traveling in a string.



3. 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*

4. Which two labeled points are 180° out of phase?
   (1) *A* and *D* (3) *D* and *F*
   (2) *B* and *F* (4) *D* and *H*

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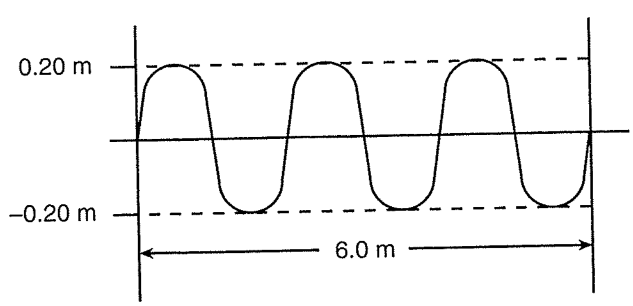
5. The diagram below represents a wave.



What is the speed of the wave if its frequency is 8.0 hertz?
   (1) 48 m/s (3) 3.2 m/s
   (2) 16 m/s (4) 1.6 m/s

6. A 512-hertz sound wave travels 100. meters to an observer through air at STP. What is the wavelength of this sound wave?
   (1) 0.195 m (3) 1.55 m
   (2) 0.646 m (4) 5.12 m

7. Which unit is equivalent to meters per second?
   (1) Hz•s (3) s/Hz
   (2) Hz•m (4) m/Hz

8. A police car traveling at a speed of 30.0 meters per second sounds its siren, which has a frequency of 1.00×10^3 hertz. As the police car approaches a stationary pedestrian, the pedestrian detects a siren frequency of
   (1) 30.0 Hz (3) 1.00×10^3 Hz
   (2) 9.19×10^2 Hz (4) 1.10×10^3 Hz

9. Two waves having the same frequency and amplitude are traveling in the same medium. Maximum constructive interference occurs at points where the phase difference between the two superposed waves is
   (1) 0° (3) 180°
   (2) 90° (4) 270°

10. Standing waves in water are produced most often by periodic water waves
   (1) being absorbed at the boundary with a new medium
   (2) refracting at a boundary with a new medium
   (3) diffracting around a barrier
   (4) reflecting from a barrier

11. Radio waves diffract around buildings more than light waves do because, compared to light waves, radio waves
   (1) move faster
   (2) move slower
   (3) have a higher frequency
   (4) have a longer wavelength

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DIAGNOSTIC TEST TOPIC 5 (CONTINUED)

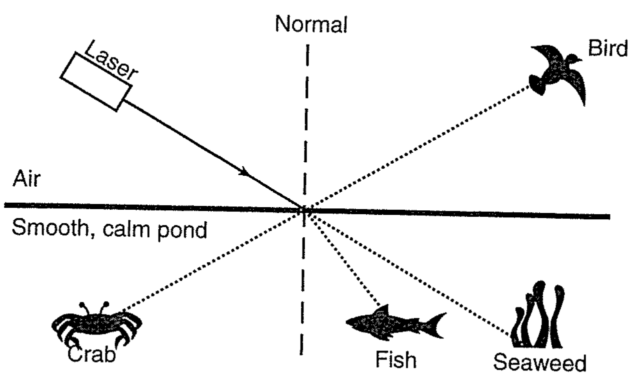
12. If the speed of a wave doubles as it passes from shallow water into deeper water, its wavelength will be
(1) unchanged **(3)** halved
(2) doubled **(4)** quadrupled

13. As a sound wave passes from water, where the speed is 1.49×10^3 meters per second, into air, the wave's speed
(1) decreases and its frequency remains the same
(2) increases and its frequency remains the same
(3) remains the same and its frequency decreases
(4) remains the same and its frequency increases

14. Orange light has a frequency of 5.0×10^{14} hertz in a vacuum. What is the wavelength of this light?
(1) 1.5×10^{23} m **(3)** 6.0×10^{-7} m
(2) 1.7×10^6 m **(4)** 2.0×10^{-15} m

15. A change in the speed of a wave as it enters a new medium produces a change in
(1) frequency **(3)** wavelength
(2) period **(4)** phase

16. A laser beam is directed at the surface of a smooth, calm pond as represented in the diagram below.



Which organisms could be illuminated by the laser light?
(1) the bird and the fish
(2) the bird and the seaweed
(3) the crab and the seaweed
(4) the crab and the fish

17. What is the wavelength of a light ray with frequency 5.09×10^{14} hertz as it travels through Lucite™?
(1) 3.93×10^{-7} m **(3)** 3.39×10^{14} m
(2) 5.89×10^{-7} m **(4)** 7.64×10^{14} m

18. A ray of light ($f = 5.09 \times 10^{14}$ Hz) traveling in air is incident at an angle of 40.° on an air-crown glass interface. What is the angle of refraction for this light ray?
(1) 25° **(3)** 40°
(2) 37° **(4)** 78°

19. The speed of light ($f = 5.09 \times 10^{14}$ Hz) in a transparent material is 0.75 times its speed in air. The absolute index of refraction of the material is approximately
(1) 0.75 **(3)** 2.3
(2) 1.3 **(4)** 4.0

20. Which quantity is equivalent to the product of the absolute index of refraction of water and the speed of light in water?
(1) wavelength of light in a vacuum
(2) frequency of light in water
(3) sine of the angle of incidence
(4) speed of light in a vacuum

21. What is the period of a 60.-hertz electromagnetic wave traveling at 3.0×10^8 meters per second?
(1) 1.7×10^{-2} s **(3)** 6.0×10^1 s
(2) 2.0×10^{-7} s **(4)** 5.0×10^6 s

22. Which pair of terms best describes light waves traveling from the Sun to Earth?
(1) electromagnetic and transverse
(2) electromagnetic and longitudinal
(3) mechanical and transverse
(4) mechanical and longitudinal

23. An electromagnetic AM-band radio wave could have a wavelength of
(1) 0.005 m **(3)** 500 m
(2) 5 m **(4)** 5 000 000 m

Name ______________________ Date ______________

DIAGNOSTIC TEST TOPIC 6

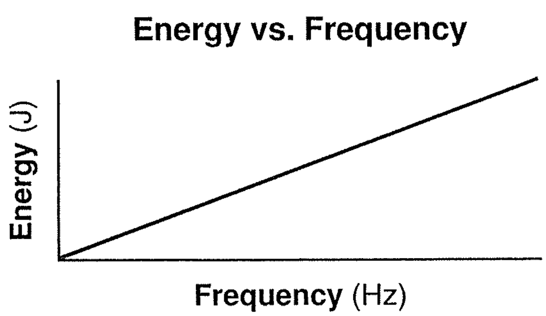
1. All photons in a vacuum have the same
(1) speed (3) energy
(2) wavelength (4) frequency

2. Which characteristic of electromagnetic radiation is directly proportional to the energy of a photon?
(1) wavelength (3) period
(2) frequency (4) path

3. A photon of which electromagnetic radiation has the most energy?
(1) ultraviolet (3) infrared
(2) X-ray (4) microwave

4. Light of wavelength 5.0×10^{-7} meter consists of photons having an energy of
(1) 1.1×10^{-48} J (3) 4.0×10^{-19} J
(2) 1.3×10^{-27} J (4) 1.7×10^{-5} J

5. The graph below represents the relationship between the energy and the frequency of photons.



The slope of the graph would be
(1) 6.63×10^{-34} J·s
(2) 6.67×10^{-11} N•m²/kg²
(3) 1.60×10^{-19} J
(4) 1.60×10^{-19} C

6. Compared to a photon of red light, a photon of blue light has a
(1) greater energy
(2) longer wavelength
(3) smaller momentum
(4) lower frequency

7. An X-ray photon collides with an electron in an atom, ejecting the electron and emitting another photon. Compared to the energy and wavelength of the X-ray photon, the emitted photon has
(1) less energy and a shorter wavelength
(2) less energy and a longer wavelength
(3) more energy and a shorter wavelength
(4) more energy and a longer wavelength

8. Which phenomenon best supports the theory that matter has a wave nature?
(1) photon momentum
(2) photon diffraction
(3) electron momentum
(4) electron diffraction

9. How much energy is required to move an electron in a mercury atom from the ground state to energy level *h*?
(1) 1.57 eV (3) 10.38 eV
(2) 8.81 eV (4) 11.95 eV

10. Which type of photon is emitted when an electron in a hydrogen atom drops from the $n = 2$ to the $n = 1$ energy level?
(1) ultraviolet (3) infrared
(2) visible light (4) radio wave

11. Excited hydrogen atoms are all in the $n = 3$ state. How many different photon energies could possibly be emitted as these atoms return to the ground state?
(1) 1 (3) 3
(2) 2 (4) 4

12. A mercury atom in the ground state absorbs 20.00 electronvolts of energy and is ionized by losing an electron. How much kinetic energy does this electron have after the ionization?
(1) 6.40 eV (3) 10.38 eV
(2) 9.62 eV (4) 13.60 eV

Name ______________________ Date ______________

DIAGNOSTIC TEST TOPIC 6 (CONTINUED)

13. A hydrogen atom with an electron initially in the $n = 2$ level is excited further until the electron is in the $n = 4$ level. This energy level change occurs because the atom has
(1) absorbed a 0.85-eV photon
(2) emitted a 0.85-eV photon
(3) absorbed a 2.55-eV photon
(4) emitted a 2.55-eV photon

14. What fundamental force holds quarks together to form particles such as protons and neutrons?
(1) electromagnetic force
(2) gravitational force
(3) weak force
(4) strong force

15. The total conversion of 1.00 kilogram of the Sun's mass into energy yields
(1) 9.31×10^2 MeV
(2) 8.38×10^{19} MeV
(3) 3.00×10^8 J
(4) 9.00×10^{16} J

16. A tritium nucleus is formed by combining two neutrons and a proton. The mass of this nucleus is 9.106×10^{-3} universal mass unit less than the combined mass of the particles from which it is formed. Approximately how much energy is released when this nucleus is formed?
(1) 8.48×10^{-2} MeV
(2) 2.73 MeV
(3) 8.48 MeV
(4) 273 MeV

17. Baryons may have charges of
(1) $+1e$ and $+\frac{4}{3}e$ **(3)** $-1e$ and $+1e$
(2) $+2e$ and $3e$ **(4)** $-2e$ and $-\frac{2}{3}e$

18. Protons and neutrons are examples of
(1) positrons **(3)** mesons
(2) baryons **(4)** quarks

19. A particle unaffected by an electric field could have a quark composition of
(1) *css* **(3)** *udc*
(2) *bbb* **(4)** *uud*

Base your answers to questions 20 and 21 on the information below.

A lambda particle consists of an up, a down, and a strange particle. A lambda particle has a mass of 1.116 GeV/c^2, that is 1.116 gigaelectronvolts divided by the speed of light in a vacuum squared.

20. The lambda particle is classified as a
(1) baryon with a charge of +1e
(2) meson with a charge of −1e
(3) lepton with a charge of 0e
(4) hadron with a charge of 0e

21. What is the mass of a lambda particle in kilograms?
(1) 1.02×10^{-30} kg **(3)** 1.98×10^{-27} kg
(2) 1.98×10^{-30} kg **(4)** 1.86×10^{-27} kg

Base your answers to questions 22 and 23 on the information below.

The positron is the antiparticle of the electron. When a positron and an electron combine, they annihilate each other and become energy in the form of gamma rays.

22. The total energy produced by this annihilation process is
(1) 2.73×10^{-22} J **(3)** 8.20×10^{-14} J
(2) 5.47×10^{-22} J **(4)** 1.64×10^{-13} J

23. What conservation law prevents annihilation from happening with two electrons?
(1) conservation of mass
(2) conservation of charge
(3) conservation of momentum
(4) conservation of energy

Answers To Diagnostic Test 2

1. 2	2. 3	3. 3
4. 2	5. 1	6. 4
7. 3	8. 1	9. 4
10. 4	11. 2	12. 3
13. 3	14. 1	15. 1
16. 3	17. 3	18. 3
19. 3	20. 4	21. 2
22. 1		

Answers To Diagnostic Test 3

1. 3	2. 3	3. 1
4. 4	5. 3	6. 2
7. 2	8. 4	9. 2
10. 2	11. 1	12. 3
13. 3	14. 2	15. 3
16. 2	17. 1	18. 2
19. 2		

Answers To Diagnostic Test 4

1. 3	2. 2	3. 1
4. 4	5. 3	6. 3
7. 2	8. 2	9. 4
10. 3	11. 1	12. 2
13. 2	14. 1	15. 1
16. 4	17. 3	18. 4
19. 3		

Answers To Diagnostic Test 5

1. 1	2. 4	3. 2
4. 3	5. 2	6. 2
7. 2	8. 4	9. 1
10. 4	11. 4	12. 2
13. 1	14. 3	15. 3
16. 1	17. 1	18. 1
19. 2	20. 4	21. 1
22. 1	23. 3	

Answers To Diagnostic Test 6

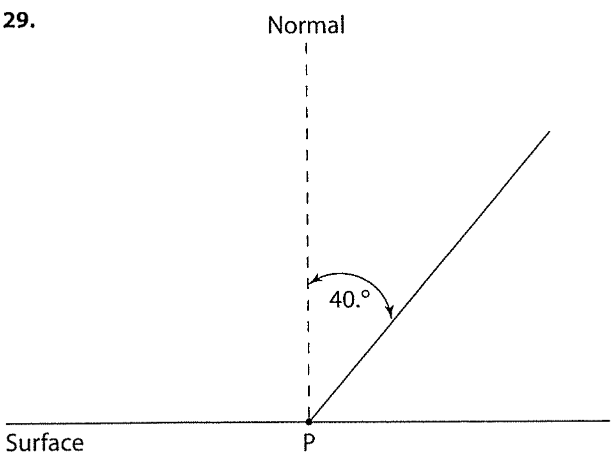
1. 1	2. 2	3. 2
4. 3	5. 1	6. 1
7. 2	8. 4	9. 2
10. 1	11. 3	12. 2
13. 3	14. 4	15. 4
16. 3	17. 3	18. 2
19. 1	20. 4	21. 3
22. 4	23. 2	

Answers To Topic 1

Review Questions

1. 4
2. 2
3. 4
4. 3
5. 3
6. 2
7. 1 GJ
8. 6000 km
9. 2
10. 3
11. 3
12. 700 nm
13. $F = \frac{mv^2}{r} = \frac{\text{kg}\cdot(\text{m/s})^2}{\text{m}} = \frac{\frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}}{\text{m}} = \frac{\text{kg}\cdot\text{m}}{\text{s}^2}$
14. $PE_s = \frac{1}{2}kx^2$

    $k = \frac{2PE_s}{x^2} = \frac{\text{kg}\cdot\text{m}^2/\text{s}^2}{\text{m}^2} = \frac{\text{kg}}{\text{s}^2}$
15. 1
16. $\frac{v^2}{d} = \frac{(\text{m/s})^2}{\text{m}} = \frac{\text{m}^2/\text{s}^2}{\text{m}} = \frac{\text{m}}{\text{s}^2}$
17. 1
18. 1.6 cm
19. $52.5\text{ cm}\left(\frac{1\text{ m}}{100\text{ cm}}\right) = 0.525\text{ m or }5.25 \times 10^{-1}\text{ m}$
20. 2
21. 0.4040 kg
22. 2
23. 1 hr 15 min = 75 min, so $75\text{ min}\left(\frac{60.\text{ s}}{1\text{ min}}\right) =$ $4500\text{ s} = 4.5 \times 10^3\text{ s}$
24. $18\text{ min}\left(\frac{60.\text{ s}}{1\text{ min}}\right) = 1100\text{ s} = 1.1 \times 10^3\text{ s}$
25. 2.5 N
26. 1.4 N
27. (a) 25° (b) $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ and $c = \frac{37.\text{ cm}}{\sin 25°} = 88\text{ cm}$
28. (a) 25° (b) 0.42 (c) 0.91
29.



30. Using the scale in the drawing, 1.0 cm = 1.4 m, (a) 7.3 m (b) 3.6 m, or using a trigonometric function,

    (a) $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ and $c = \frac{6.1\text{ m}}{\sin 60.°} = 7.0\text{ m}$

    (b) $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$ and $c = \frac{6.1\text{ m}}{\tan 60.°} = 3.5\text{ m}$
31. $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$, so $a = (50.\text{ m})\sin 30.° = 25\text{ m}$
32. $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$,

    so adjacent $= \frac{\text{opposite}}{\tan\theta} = \frac{35\text{ m}}{\tan 20.°} = 96\text{ m}$
33. 4
34. 3
35. 1
36. 4
37. 2
38. 1
39. 4
40. 4
41. 2
42. 13.3 m
43. 0.029 kg
44. 3
45. 2
46. 40.00 m
47. $A = lw = (41.6\text{ cm})(2.3\text{ cm}) = 96\text{ cm}^2$
48. $A = lw = (13.2\text{ m})(10.6\text{ m}) = 140.\text{ m}^2$

    $\frac{140.\text{ m}^2}{24\text{ students}} = \frac{5.8\text{ m}^2}{\text{student}}$; the answer is yes.
49. 2.1×10^{-2} m
50. 1.5×10^3 kg
51. 7.7×10^5 N
52. 4.98×10^2 s
53. 3
54. 3
55. 1
56. 2
57. 2
58. 2
59. 3
60. 3
61. 3
62. 3
63. 3
64. 3
65. 2
66. 4
67. 3
68. $\frac{7 \times 10^2\text{ m/s}}{1 \times 10^{-3}\text{ m/s}} = 7 \times 10^5$
69. $\frac{1.7 \times 10^{17}\text{ W}}{100\text{ W/bulb}} = 1.7 \times 10^{15}$ bulbs
70. 3
71. $\frac{10^{-19}\text{ C}}{10^{-31}\text{ kg}} = 10^{12}$ C/kg
72. $\frac{3.00 \times 10^8\text{ m/s}}{3.31 \times 10^2\text{ m/s}} = 10^6$
73. $\frac{10^{22}\text{ kg}}{10^{24}\text{ kg}} = 10^{-2}$
74. 1
75. Percent Error $= \frac{\text{absolute error}}{\text{accepted value}} \times 100$

    $= \frac{0.25 \times 10^8\text{ m/s}}{2.25 \times 10^8\text{ m/s}} \times 100 = 11\%$
76. Percent Error $= \frac{\text{absolute error}}{\text{accepted value}} \times 100$

    $= \frac{0.2\text{ m/s}^2}{9.81\text{ m/s}^2} \times 100 = 2\%$
77. Range = 4.73 min − 4.07 min = 0.66 min

x_i (min)	f_i	x_if_i (min)	$x_i - \bar{x}$ (min)	$(x_i - \bar{x})^2$ (min²)	$(x_i - \bar{x})^2 f_i$ (min²)
4.66	1	4.66	0.32	0.1024	0.1024
4.73	1	4.73	0.39	0.1521	0.1521
4.51	1	4.51	0.17	0.0289	0.0289
4.32	1	4.32	−0.02	0.0004	0.0004
4.17	1	4.17	−0.17	0.0289	0.0289
4.15	1	4.15	−0.19	0.0361	0.0361
4.12	1	4.12	−0.22	0.0484	0.0484
4.07	1	4.07	−0.27	0.0729	0.0729
	$\Sigma f_i = 8$	$\Sigma x_if_i = 34.73$			$\Sigma(x_i - \bar{x})^2 f_i = 0.4701$

The chart at left is for instructional purposes. Students may determine values using a scientific calculator.

78. $\bar{x} = \frac{34.73 \text{ min}}{8} = 4.34 \text{ min}$

79. $\sigma = \sqrt{\frac{0.4701 \text{ min}^2}{8}} = 0.24 \text{ min}$

80. Range = 96°F − 63°F = 33 °F. The chart below is for instructional purposes. Students may determine values using a scientific calculator.

x_i (°F)	f_i	$x_i f_i$ (°F)	$x_i - \bar{x}$ (°F)	$(x_i - \bar{x})^2$ (°F)^2	$(x_i - \bar{x})^2 f_i$ (°F)^2
63	5	315	−16	256	1280.
70.	3	210.	−9	81	243
78	4	312	−1	1	4
79	3	237	0	0	0
80.	6	480.	1	1	6
84	4	336	5	25	100.
96	5	480.	17	289	1445
	$\Sigma f_i = 30.$	$\Sigma x_i f_i = 2370.$			$\Sigma(x_i - \bar{x})^2 f_i = 3078$

81. $\bar{x} = \frac{2370. \text{ °F}}{30.} = 79.0\text{°F}$

82. $\sigma = \sqrt{\frac{3078 \text{ °F}^2}{30.}} = 10.1 \text{ °F}$

83. Range = 26 cm − 18 cm = 8 cm. The chart below is for instructional purposes. Students may determine values using a scientific calculator.

x_i (cm)	f_i	$x_i f_i$ (cm)	$x_i - \bar{x}$ (cm)	$(x_i - \bar{x})^2$ (cm^2)	$(x_i - \bar{x})^2 f_i$ (cm^2)
18	6	108	−3	9	54
19	4	76	−2	4	16
20.	4	80.	−1	1	4
21	3	63	0	0	0
24	5	120.	3	9	45
26	3	782	5	25	75
	$\Sigma f_i = 25$	$\Sigma x_i f_i = 525$			$\Sigma(x_i - \bar{x})^2 f_i = 194$

84. $\bar{x} = \frac{525 \text{ cm}}{25} = 21.0 \text{ cm}$

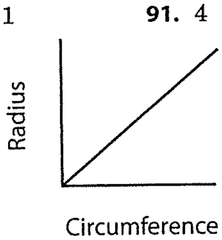
85. $\sigma = \sqrt{\frac{194 \text{ cm}^2}{25}} = 2.8 \text{ cm}$

86. Nonlinear horizontal scale, skipped 300 on vertical scale, (m) as a unit not labeled on the vertical axis, dependent variable should be first in the title.

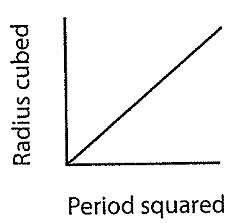
87. 4 **88.** 3 **89.** 3

90. 1 **91.** 4

92.



93.



94. (a) $F = \frac{mv^2}{r}$

$Fr = mv^2$

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

(b) $A = \pi r^2$

$r^2 = \frac{A}{\pi}$

$r = \sqrt{\frac{A}{\pi}}$

(c) $C = 2\pi r$

$r = \frac{C}{2\pi}$

(d) $F = G\frac{m_1 m_2}{r^2}$

$Fr^2 = Gm_1m_2$

$r = \sqrt{\frac{Gm_1m_2}{F}}$

95. (a) $\bar{v} = \frac{d}{t}$

$d = \bar{v}t$

(b) $P = \frac{Fd}{t}$

$Pt = Fd$

$d = \frac{Pt}{F}$

(c) $v_f^2 = v_i^2 + 2ad$

$2ad = v_f^2 - v_i^2$

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

96. (a) $KE = \frac{1}{2}mv^2$

$2\,KE = mv^2$

$v^2 = \frac{2KE}{m}$

$v = \sqrt{\frac{2KE}{m}}$

(b) $p = mv$

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

(c) $n = \frac{c}{v}$

$v = \frac{c}{n}$

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

97. (a) $RI = V$

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

$W = VIt$

(b) $I = \frac{W}{Vt}$

$P = I^2R$

(c) $I^2 = \frac{P}{R}$

$I = \sqrt{\frac{P}{R}}$

98. $3.335\,640\,95 \times 10^{-9}$ s

99. 2

100. 10.°

101. $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ so opposite = hypotenuse($\sin\theta$) = (1.4 m)sin10.° = 0.24 m

102. $A = A_{triangle} + A_{rectangle} + A_{triangle}$

$A = \frac{1}{2}bh + bh + \frac{1}{2}bh$

$A = \frac{1}{2}(2.0\text{ s})(10.\text{ m/s}) + (6.0\text{ s})(10.\text{ m/s}) + \frac{1}{2}(2.0\text{ s})(5\text{ s})$

$A = 70\text{ m}$

103. slope $= \frac{\Delta v}{\Delta t} = \frac{5.0\text{ m/s}}{2.0\text{ s}} = 2.5\text{ m/s}^2$

Answers To Topic 2

Review Questions

1. 1
2. 4
3. $c^2 = a^2 + b^2$

$c = \sqrt{a^2 + b^2} = \sqrt{(15\text{ m})^2 + (15\text{ m})^2} = 21\text{ m}$

4. 3
5. 1
6. 4
7. 3
8. 4
9. $a = \frac{\Delta v}{t}$

$t = \frac{\Delta v}{a} = \frac{28\text{ m/s} - 8.0\text{ m/s}}{2.0\text{ m/s}^2} = 10.\text{ s}$

10. 4
11. D
12. 1
13. 2
14. $v_f^2 = v_i^2 + 2ad = 2(3.2\text{ m/s}^2)(40.\text{ m})$

$v_f = 16\text{ m/s}$

15. $a = \frac{\Delta v}{t} = \frac{25\text{ m/s} - 10.\text{ m/s}}{5.0\text{ s} - 3.0\text{ s}} = 7.5\text{ m/s}^2$
16. 18 m/s
17. The area under the curve is equal to the distance traveled.

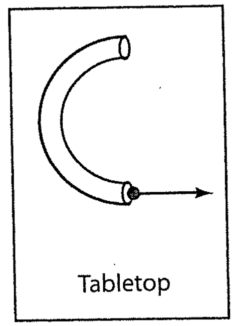
$A = A_{\text{triangle}} + A_{\text{rectangle}}$

$A_{\text{triangle}} = \frac{1}{2}bh = \frac{1}{2}(1.0\text{ s})(10.\text{ m/s}) = 5.0\text{ m}$

$A_{\text{rectangle}} = bh = (2.0\text{ s})(10.\text{ m/s}) = 20.\text{ m}$

$A = 25\text{ m}$

18. AB
19. 3
20. $\bar{v} = \frac{d}{t} = \frac{3.0\text{ m} - 2.0\text{ m}}{2.0\text{ s} - 1.0\text{ s}} = 1.0\text{ m/s}$
21. 3
22. 3
23. 3
24. C
25. B
26. C
27. A
28. 2
29. 2
30. 4
31. 4
32. 3 m
33. 2 s to 3 s
34. 1
35. 3 s to 4 s
36. 4
37. 3
38. 2
39. $v_f = v_i + at = (9.81\text{ m/s}^2)(3.00\text{ s}) = 29.4\text{ m/s}$
40. 1
41. 3
42. 1
43. 4
44. 1
45. 3
46. 2
47. 2
48. 3
49. 1
50. 2
51. $A_y = A\sin\theta = (300.\text{ N})(\sin 60.°) = 260\text{ N}$
52. 2
53. 4
54. 4
55. 1
56. 2
57.



58. 3
59. 3
60. 4
61. 4
62. 2
63. $a = \frac{F_{\text{net}}}{m} = \frac{10.0\text{ N}}{20.0\text{ kg}} = 0.500\text{ m/s}^2$
64. 3
65. 1
66. 4
67. 4
68. 40. N
69. 4
70. For every action force there is an equal but opposite reaction force.
71. 2
72. 3
73. 2
74. 3
75. 1
76. 2
77. B
78. Both arrows take the same amount of time to strike the plane.
79. $d = v_i t + \frac{1}{2}at^2$

$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(45\text{ m})}{9.81\text{ m/s}^2}} = 3.0\text{ s}$

80. 3
81. 3
82. 2
83. 1
84. $A_x = A\cos\theta = (150.\text{ m/s})(\cos 30.°) = 130.\text{ m/s}$
85. 1
86. 1
87. $a_{\text{horizontal}} + 0.0\text{ m/s}^2$ and $a_{\text{vertical}} = 9.81\text{ m/s}^2$
88. $a = \frac{v^2}{r} = \frac{(6.0\text{ m/s})^2}{3.0\text{ m}} = 12\text{ m/s}^2$, directed toward the center of curvature
89. $F = \frac{mv^2}{r} = \frac{(2.0\text{ kg})(6.0\text{ m/s})^2}{3.0\text{ m}} = 24\text{ N}$
90. 2
91. 1
92. 4
93. 3
94. D
95. A
96. 3
97. 2
98. 1
99. 3
100. S
101. Q
102. 1
103. 3
104. 3
105. $\frac{F}{9}$
106. 4
107. 3
108. B
109. $g = \frac{F_g}{m}$

$F_g = mg = (5.00\text{ kg})(9.81\text{ m/s}^2) = 49.1\text{ N}$

110. 4
111. acceleration due to gravity or gravitational field strength
112. $g = \frac{F_g}{m} = \frac{96\text{ N}}{60.\text{ kg}} = 1.6\text{ m/s}^2$
113. 4
114. 2
115. 3
116. 3
117. 2
118. 1
119. 2
120. A and D

121. $F_f = \mu F_N$
$F_f = (0.30)(25\ \text{N})$
$F_f = 7.5\ \text{N}$

122. 2.5 N

123. The crate is accelerating because a net force is acting on it.

124. 1 125. 2

126. $F_f = \mu F_N$
$F_f = (.15)(10.\ \text{kg})(9.81\ \text{m/s}^2)$
$F_f = 15\ \text{N}$ *or* $14.7\ \text{N}$

127. 10. N

128. $g = \frac{F_g}{m}$
$F_g = mg = (5.0\ \text{kg})(9.81\ \text{m/s}^2) = 49\ \text{N}$

129. The normal force is equal in magnitude to the cart's weight, but opposite in direction.

130. $F_f = \mu F_N$
$\mu = \frac{F_f}{F_N} = \frac{10.\ \text{N}}{49\ \text{N}} = 0.20$

131. $F_f = \mu F_N$
$F_N = \frac{F_f}{\mu} = \frac{5.2\ \text{N}}{0.30} = 17\ \text{N}$; in this case, the weight equals the normal force.

132. 3 133. 1 134. 2
135. 3 136. 4 137. 3

138. $J = F_{net}t$
$F_{net} = \frac{J}{t} = \frac{6.0\ \text{N}\cdot\text{s}}{3.0\ \text{s}} = 2.0\ \text{N east}$

139. 2 140. 3 s to 4 s

141. + 3 N · s 142. 1

143. $J = \Delta p = m\Delta v$
$\Delta v = \frac{J}{m} = \frac{30.0\ \text{N}\cdot\text{s}}{5.00\ \text{kg}} = 6.00\ \text{m/s}$
Therefore, the final speed of the mass could be 94 m/s or 106 m/s.

144. 2

145. $p_{before} = p_{after}$
$m_a v_{a_i} = m_b v_{b_i} = p_{after}$
$(2.0\ \text{kg})(6.0\ \text{m/s}) + (3.0\ \text{kg})v_{b_i} = 0\ \text{kg}\cdot\text{m/s}$
$(3.0\ \text{kg})v_{b_i} = -12\ \text{kg}\cdot\text{m/s}$
$v_{b_i} = -4.0\ \text{m/s}$

146. $p_{before} = p_{after}$
$m_a v_{a_i} + m_b v_{b_i} = (m_a + m_b)v_f$
$(0.180\ \text{kg})(0.80\ \text{m/s}) + (0.100\ \text{kg})(0.0\ \text{m/s}) = (0.180\ \text{kg} + 0.100\ \text{kg})v_f$
$v_f = 0.51\ \text{m/s}$ to the right

147. 1

Regents Practice Questions

1. 2 2. 3 3. 1
4. 4 5. 3 6. 1
7. 4 8. 3 9. 2
10. 2 11. 4 12. 3
13. 1 14. 3 15. 3
16. 1 17. 1 18. 2
19. 3 20. 2 21. 2
22. 3 23. 3 24. 3
25. 4 26. 1 27. 4
28. 2 29. 2 30. 1
31. 4 32. 3 33. 1
34. 1 35. 1 36. 3
37. 1 38. 4 39. 2
40. 4 41. 4 42. 3
43. 3 44. 2 45. 3
46. 4 47. 3 48. 2
49. 4 50. 3 51. 3
52. 3

53. 30.° ± 2°

54. 140 m ± 20 m

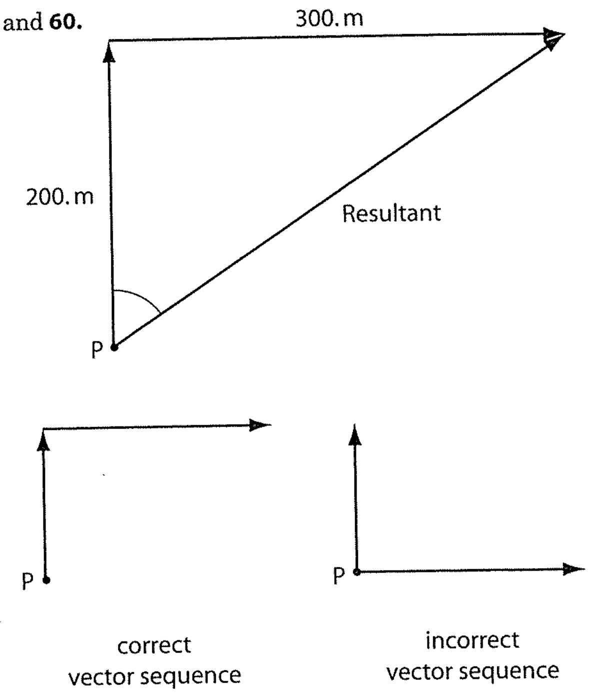
55. 240 m

56. $d = v_i t + \frac{1}{2}at^2$
$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(240\ \text{m})}{9.81\ \text{m/s}^2}} = 7.0\ \text{s}$

57. $v_f = v_i = at = (9.81\ \text{m/s}^2)(7.0\ \text{s}) = 69\ \text{m/s}$ or
$v_f = \sqrt{v_i^2 + 2ad} = \sqrt{2(9.81\ \text{m/s}^2)(240\ \text{m})} = 69\ \text{m/s}$

58. 1

59. and 60.



61. 361 m ± 15 m

62. 56° ± 2°

63. $v_f = v_i + at$
$t = \frac{v_f - v_i}{a} = \frac{0.0\ \text{m/s} - 20.\ \text{m/s}}{9.81\ \text{m/s}^2} = 2.0\ \text{s}$

64. Because the stone averages 10. m/s while it is moving upwards,
$d = \bar{v}t = (10.\ \text{m/s})(2.0\ \text{s}) = 20.\ \text{m}$ or
$d = v_i t + \frac{1}{2}at^2$
$= (20.\ \text{m/s})(2.0\ \text{s}) + \frac{1}{2}(-9.81\ \text{m/s}^2)(2.0\ \text{s})^2$
$= 40.\ \text{m} - 20.\ \text{m} = 20.\ \text{m}$

65. The time it takes for the stone to fall to the level of the student equals its time of rise, 2.0 seconds, because neglecting air resistance the force of gravity on the stone is constant.

66. The speed of the stone at the time it returns to the level of the student is 20. m/s because the force of gravity acting on the stone is constant. However,

the stone is traveling in the opposite direction so its velocity is −20. m/s, or 20. m/s downward.

67. In a 6.0-second time interval, the stone rises for 2.0 seconds as determined in question 62, and falls for 4.0 seconds, assuming the cliff is high enough so that the stone does not hit the ground before 4.0 seconds has elapsed.

$v_f = v_i = at = 0.0\text{ m/s} + (-9.81\text{ m/s}^2)(4.0\text{ s})$

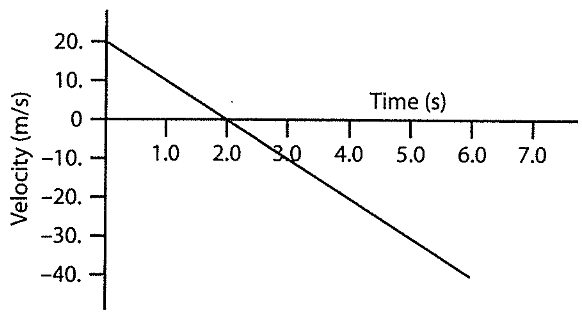
$= 39\text{ m/s downward, or } -39\text{ m/s}$

68. $d = \frac{1}{2}at^2$ (from rest)

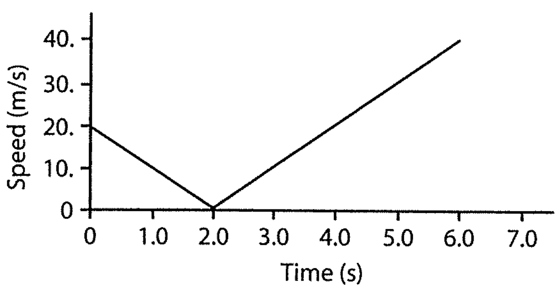
$d = \frac{1}{2}(-9.81\text{ m/s}^2)(4.0\text{ s})^2 = -78\text{ m}$

The stone falls 78 meters downward from its highest point, or 58 meters below the position of the student.

69.



70.



71. $a = \frac{\Delta v}{t} = \frac{40.\text{ m/s}}{20.\text{ s}} = 2.0\text{ m/s}^2$

72. The area under the curve is equal to the distance traveled.

$A = A_{\text{triangle}} + A_{\text{rectangle}}$

$A_{\text{triangle}} = \frac{1}{2}bh = \frac{1}{2}(20.\text{ s})(40.\text{ m/s}) = 400\text{ m}$

$A_{\text{rectangle}} = bh = (2.0\text{ s})(40.\text{ m/s}) = 800.\text{ m}$

$A = 1200\text{ m}$

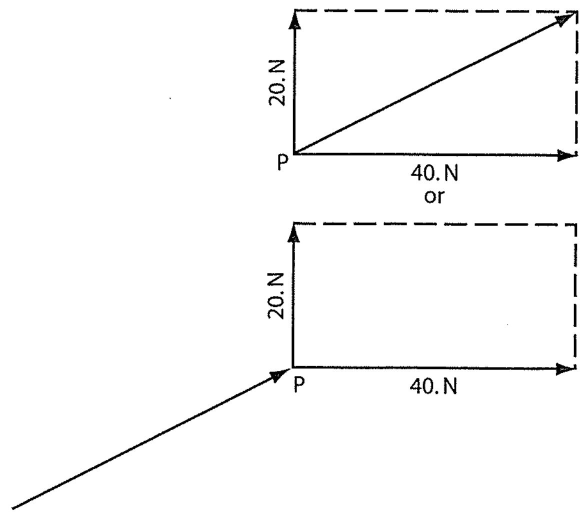
73. 20. m/s

74. decelerating to rest

75. BC

76. 5.0 N ± 0.2 N

77.



78. 45 N ± 2 N

79. 27° ± 2°

80. $a = \frac{F_{\text{net}}}{m} = \frac{45\text{ N}}{10.\text{ kg}} = 4.5\text{ m/s}^2$

81. $c^2 = a^2 + b^2$

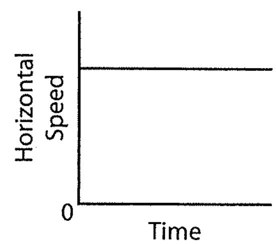
$c = \sqrt{a^2 + b^2} = \sqrt{(9.0\text{ m/s})^2 + (9.0\text{ m/s})^2} = 13\text{ m/s}$

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

$d = \bar{v}t = (9.0\text{ m/s})(1.84\text{ s}) = 17\text{ m}$

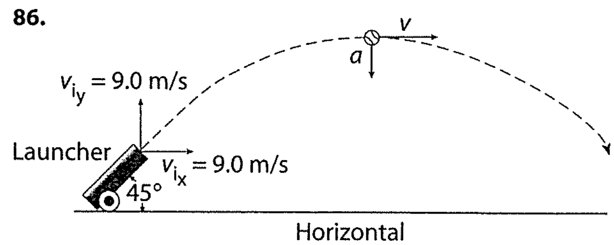
83. The vertical acceleration is a constant, -9.81 m/s^2.

84.



85. As the ball rises the vertical component of its velocity decreases and the horizontal component of its velocity remains the same.

86.



87. See question 86.

88. 0.0 N

89. $F = \frac{mv^2}{r} = \frac{(1.00 \times 10^3\text{ kg})(20.0\text{ m/s})^2}{100.\text{ m}}$

$= 4.00 \times 10^3$ N directed toward the center of curvature

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

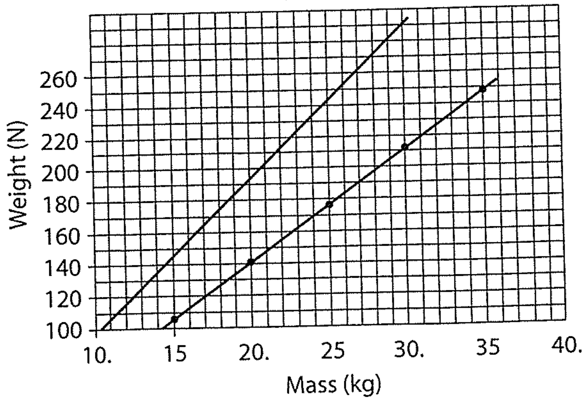
$d = \bar{v}t = (20.0\text{ m/s})(20.0\text{ s}) = 400.\text{ m}$

91. The magnitude of the car's centripetal acceleration from D to A is twice as great as the magnitude of its centripetal acceleration from B to C.

92. Because the car is moving at constant speed, the magnitude of its momentum is always the same.

93. The magnitude of the centripetal acceleration is the same because it is not dependent on mass.

94. **Weight vs. Mass**



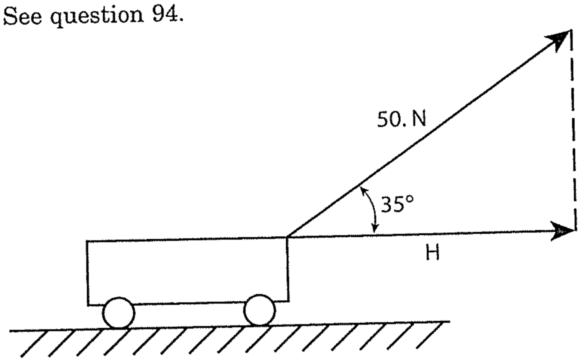
95. See question 94.

96. See question 94.

97. $g = \frac{F_g}{m} = \frac{170.\ \text{N}}{24\ \text{kg}} = 7.1\ \text{m/s}^2$

98. See question 94.

99.



100. See question 99.

101. 41 N ± 3 N

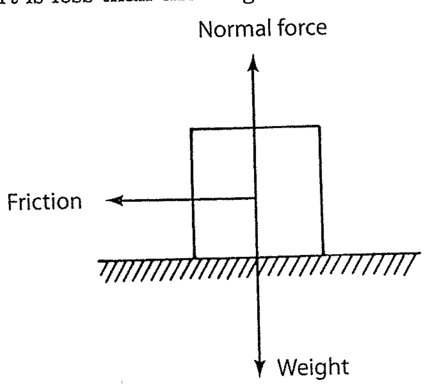
102. 41 N ± 3 N

103. $F_f = \mu F_N$

$F_N = \frac{F_f}{\mu} = \frac{41\ \text{N}}{0.68} = 60.\ \text{N}$

104. The magnitude of the normal force acting on the cart is less than the weight of the cart.

105.



106. $a = \frac{F_{net}}{m}$ and $g = \frac{F_g}{m}$, so $m = \frac{F_g}{g}$

$a = \frac{F_{net}g}{F_g} = \frac{(2.4\ \text{N})(9.81\ \text{m/s}^2)}{4.2\ \text{N}} = 5.6\ \text{m/s}^2$

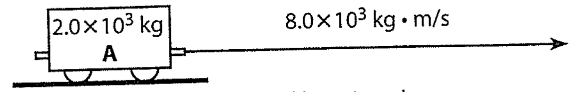
107. $F_f = \mu F_N$

$\mu = \frac{F_f}{F_N} = \frac{2.4\ \text{N}}{4.2\ \text{N}} = 0.57$

108. $p = mv = (2.00 \times 10^3\ \text{kg})(4.0\ \text{m/s})$

$= 8.0 \times 10^3\ \text{kg}\cdot\text{m/s}$

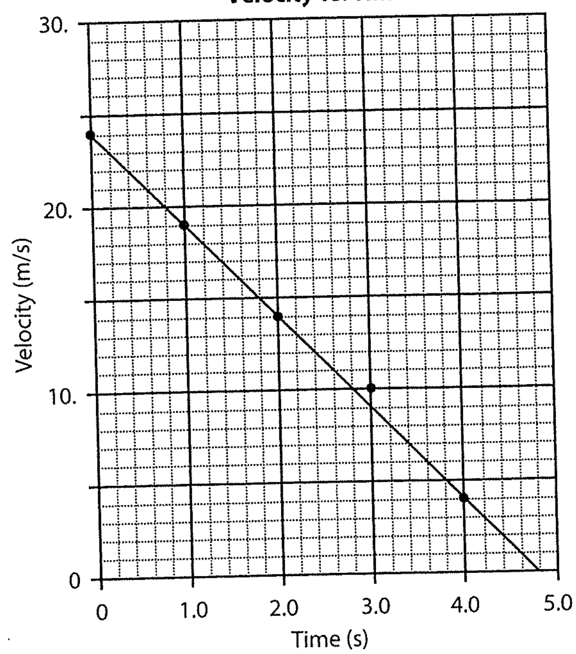
109.



The vector should be 8.0 cm long.

110. Momentum is conserved. The initial momentum of the system was $8.0 \times 10^3\ \text{kg}\cdot\text{m/s} + (-6.0 \times 10^3\ \text{kg}\cdot\text{m/s}) = +2.0 \times 10^3\ \text{kg}\cdot\text{m/s}$, so the final momentum of the system is $+2.0 \times 10^3\ \text{kg}\cdot\text{m/s}$.

111. **Velocity vs. Time**



112. See question 111.

113. $a = \frac{\Delta v}{t} = \frac{1\ \text{m/s} - 21\ \text{m/s}}{4.6\ \text{s} - 0.6\ \text{s}} = -5.0\ \text{m/s}^2 (\pm 0.3\ \text{m/s}^2)$

114. $A_{triangle} = \frac{1}{2}bh = \frac{1}{2}(4.8\ \text{s})(24\ \text{m/s}) = 58\ \text{m}$

115. $\Delta p = m\Delta v = (1500\ \text{kg})(-24.0\ \text{m/s})$

$= -3.6 \times 10^4\ \text{kg}\cdot\text{m/s}$

116. $F_{net}t = \Delta p$

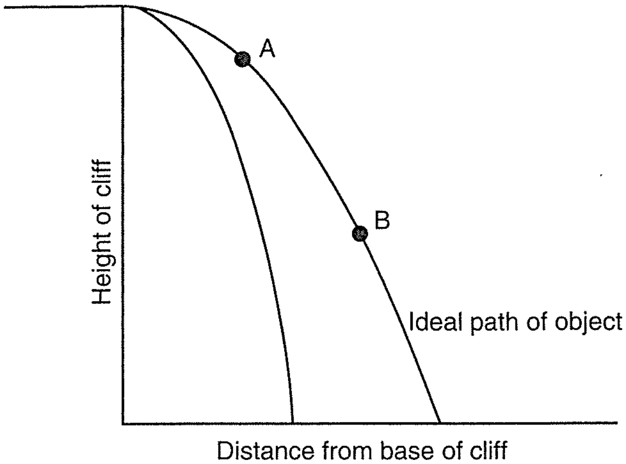
$F = \frac{\Delta p}{t} = \frac{-3.6 \times 10^4\ \text{kg}\cdot\text{m/s}}{4.8\ \text{s}} = -7.5 \times 10^3\ \text{N}$

117. The impulse is equal to the change in momentum.

118. The magnitude of the horizontal component of the object's velocity is the same at points *A* and *B*.

119. The magnitude of the vertical component of the object's velocity at point *A* is less than it is at point *B*.

120.



121. 0.5 m/s

122. $\bar{v} = \frac{d}{t} = \frac{60.\text{ km}}{4.0\text{ h}} = 15\text{ km/h}$

123. 1 **124.** 1 **125.** 2

126. 4 **127.** 4 **128.** 3

129. 4 **130.** 50.0 N

131. 2 **132.** 1

133. Block *A* has a mass of 1 kilogram and block *B* has a mass of 2 kilograms.

134. $A_x = A\cos\theta = (100.\text{ N})(\cos 30.°) = 86.6\text{ N}$

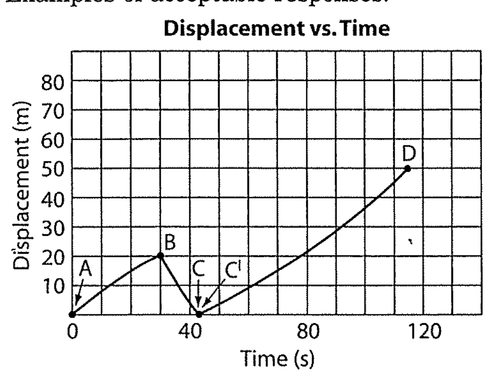
In equilibrium $F_{net} = 0$

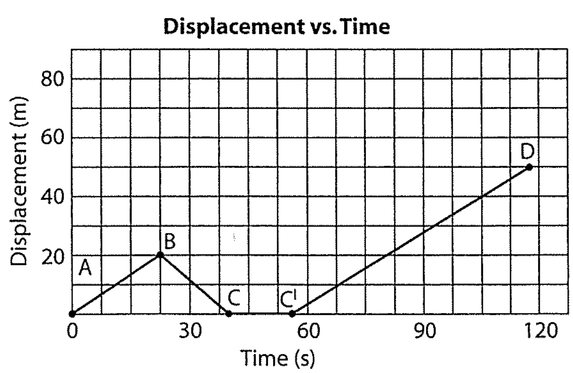
$F_{net} = F_x + F_f = 0$ and $F_f = 86.6$ N (magnitude)

135. 2 **136.** 1 **137.** 75 m

138. 6.0 m/s^2 **139.** 3 **140.** 1

141. Examples of acceptable responses:





142. See question 141.

143. Range: 0.50 s to 1.00 s

144. 0.7615 s and 0.76 s

145. $\sigma = 0.11$ s

146. 32

147. 80.%

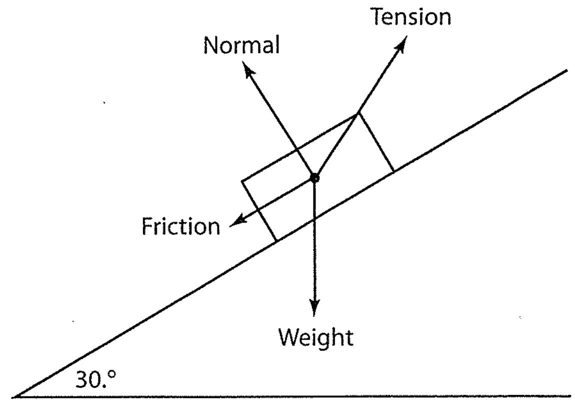
148. $d = \frac{1}{2}at^2$ (from rest)

$a = \frac{2d}{t^2} = \frac{2(2.848\text{ m})}{(0.7615\text{ s})^2} = 9.823\text{ m/s}^2$

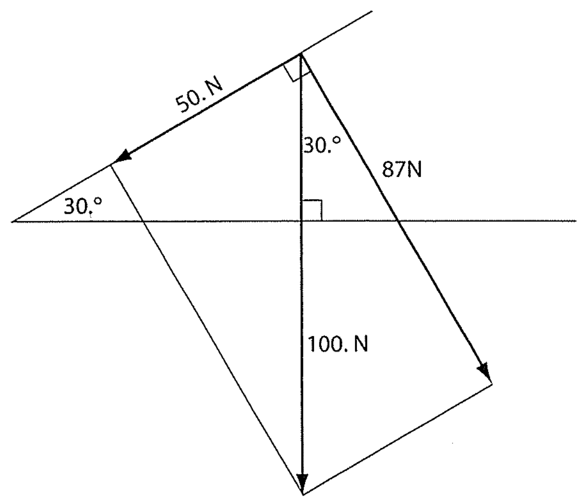
149. Percent Error $= \frac{\text{absolute error}}{\text{accepted value}} \times 100$

$= \frac{0.01\text{ m/s}^2}{9.81\text{ m/s}^2} \times 100 = 0.1\%$

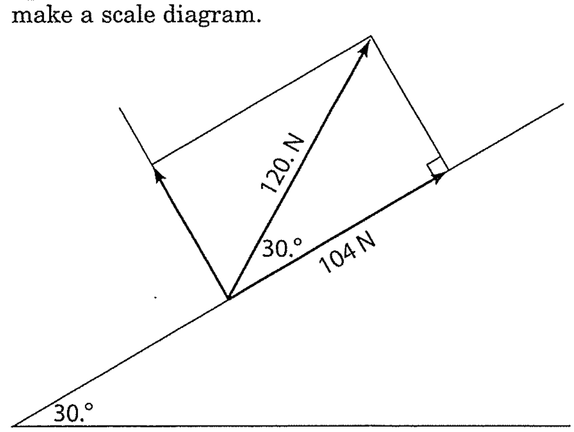
150.



151. $F_{g_{parallel}} = F_g \sin\theta = (100.\text{ N})(\sin 30.°) = 50.0\text{ N}$, or make a scale diagram.



152. $F_x = F\cos\theta = (120.\text{ N})(\cos 30.°) = 104\text{ N}$, or make a scale diagram.



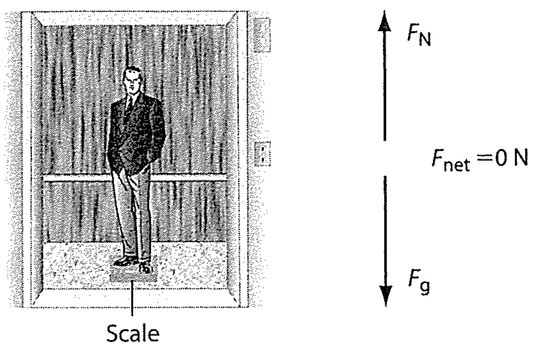
153. $a = \frac{F_{net}}{m}$ and $g = \frac{F_g}{m}$

$F_{net} = 104\text{ N} - 50.\text{ N} - 10.\text{ N} = 44\text{ N}$

$m = \frac{F_g}{g} = \frac{100.\text{ N}}{9.81\text{ m/s}^2} = 10.2\text{ kg}$

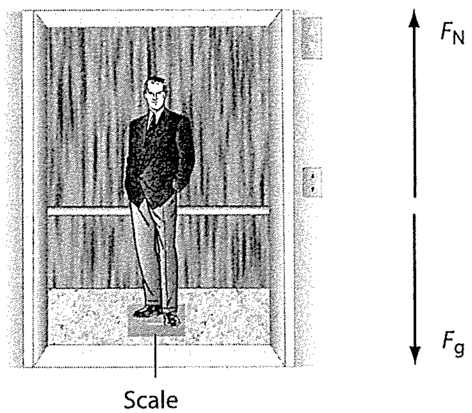
$a = \frac{44\text{ N}}{10.2\text{ kg}} = 4.3\text{ m/s}^2$ up the incline

154.



155. $F_{net} = 0$ N

156.



157. The reading on the scale when the elevator is accelerating upward is greater than when the elevator is stationary.

158. $\bar{v}_x = \frac{d_x}{t}$ and $t = \frac{t_1 + t_2 + t_3}{3}$

$$= \frac{0.453 \text{ s} + 0.347 \text{ s} + 0.390 \text{ s}}{3} = 0.397 \text{ s}$$

$$\bar{v}_x = \frac{1.00 \text{ m}}{0.397 \text{ s}} = 2.52 \text{ m/s}$$

159. $d = \frac{1}{2}at^2$ from rest

$$t = \sqrt{\frac{2d_y}{a_y}} = \sqrt{\frac{2(0.926 \text{ m})}{9.81 \text{ m/s}^2}} = 0.434 \text{ s}$$

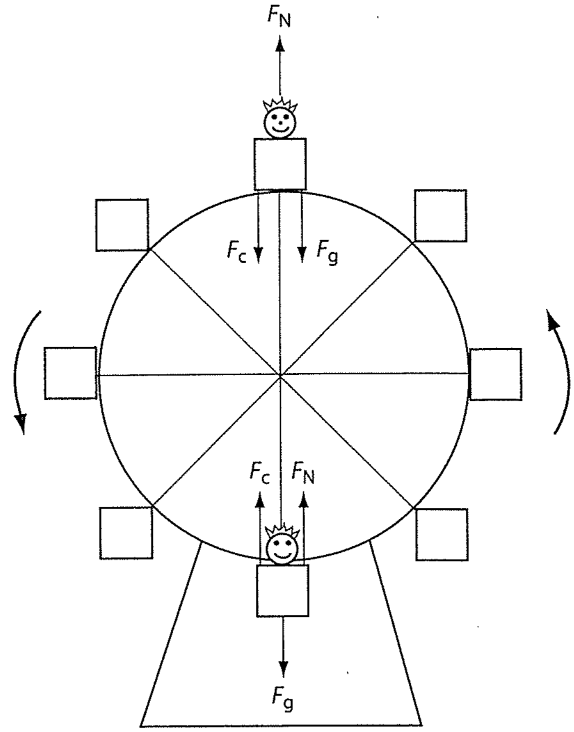
160. $\bar{v}_x = \frac{d_x}{t}$

$$d_x = \bar{v}_x t = (2.52 \text{ m/s})(0.434 \text{ s}) = 1.09 \text{ m}$$

161. Although the time was recorded to the nearest thousandth of a second, the broad range in the values indicates that more data should have been taken. The calculated horizontal speed of the car represents an average over an interval; the car was actually traveling slower when it was projected from the edge of the tabletop.

162. (a) The car would have a greater initial potential energy and, consequently, a greater final kinetic energy and horizontal speed. (b) Releasing the car from a greater height on the elevated track would have no effect on the time required for the car to hit the floor once it left the tabletop. The time of fall depends only on the height of the tabletop. (c) With the greater horizontal speed noted in (a), the car would travel a greater horizontal distance after it was projected from the tabletop.

163.



164. See question 163.

165. $F_{net} = F_c = F_N - F_g$

166. $F_{net} = -F_c = F_N - F_g$

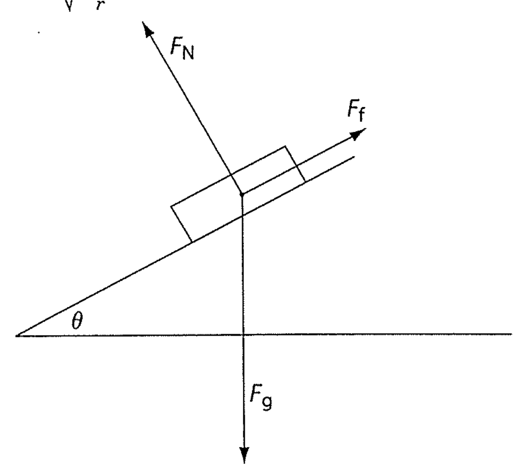
167. $F_c = F_g$

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

$$\frac{v^2}{r} = \frac{Gm_E}{r^2}$$

$$v = \sqrt{\frac{Gm_E}{r}}$$

168.



169. $F_{\parallel} = F_g \sin\theta$

$F_{\perp} = F_g \cos\theta$

170. $F_f = \mu F_N$

$$\mu = \frac{F_g \sin\theta}{F_g \cos\theta} = \tan\theta$$

171. Julia is correct. Average speed, a scalar quantity, is total distance traveled divided by time of travel. Velocity is a vector quantity. As an object moves in a circular path, its velocity continually changes due to a change in direction of travel, although the object may be moving at a constant speed.

172. All of the washers could be collectively massed using the triple-beam balance. Dividing by the number of washers would yield the average mass of a washer. It is the weight of the suspended washers that provides the centripetal force acting on the moving rubber stopper. Substituting the mass in kilograms of the appropriate number of washers into the formula $F_g = mg$ yields the value of the centripetal force.

173. $F_c = \frac{mv^2}{r}$

$\bar{v} = \frac{d}{t} = \frac{2\pi r}{T}$

substituting

$$F_c = \frac{m\left(\frac{2\pi r}{T}\right)^2}{r}$$

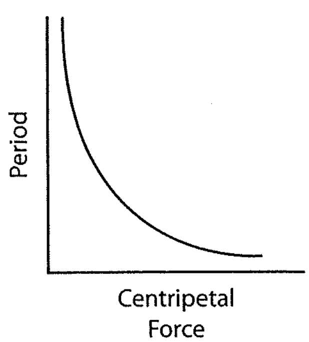
$$F_c = \frac{4\pi^2 mr}{T^2}$$

174. a pair of goggles for each student and a meter stick to measure the radius

175. It is difficult to note exactly one revolution for a rapidly moving object. Significant error can be introduced in starting and stopping the watch due to human reaction time. It is preferable to spread that error over thirty revolutions to minimize its effects.

176. Constant quantities: mass of stopper, radius of curvature. Column headings might be Number of Washers, Magnitude of Centripetal Force (N), Time for Thirty Revolutions (s), and Period of Revolution(s).

177.



178. They did not determine (a) the relationship between the magnitude of the centripetal force and the mass of a moving object or (b) the relationship between the magnitude of the centripetal force and the radius of curvature of the path of a moving object.

179. $F_f = \mu F_N \quad F_N = mg \quad F_c = \frac{mv^2}{r}$ [1]

$\mu = \frac{v^2}{rg}$ [1]

$\mu = \frac{(20.\text{ m/s})^2}{(80.\text{ m})(9.81\text{ m/s}^2)}$ [1]

$\mu = 0.51$ [1]

or

$F_c = ma_c \quad a_c = \frac{v^2}{r}$

$F_c = \frac{mv^2}{r} = \frac{(1600\text{ kg})(20.\text{ m/s}^2)}{80.\text{ m}} = 8.0 \times 10^3\text{ N}$ [1]

$F_N = mg = (1600\text{ kg})(9.81\text{ m/s}^2) = 1.6 \times 10^4\text{ N}$ [1]

$F_f = F_c$ [1]

$F_f = \mu F_N \quad \mu = \frac{F_f}{F_N} = \frac{8.0 \times 10^3\text{ N}}{1.6 \times 10^4\text{ N}} = 0.50$ [1]

180. Changing the mass of the car would have no effect on the maximum speed at which it could round the curve.

Answers To Topic 3

Review Questions

1. 4 **2.** 2 **3.** 2
4. 80. N **5.** 3 **6.** 100. J
7. 4 **8.** 3

9. $W = Fd$ and $\bar{v} = \frac{d}{t}$, therefore
$W = F\bar{v}t = (20.0\text{ N})(4.0\text{ m/s})(6.0\text{ s}) = 480\text{ J}$

10. 0 N

11. $W = Fd = (8.0\text{ N})(3.0\text{ m}) = 24\text{ J}$

12. 4.0 m

13. 3 **14.** 3 **15.** 4
16. 20. m/s **17.** 3 **18.** 3
19. 1.2×10^3 W **20.** 3

21. $P = \frac{Fd}{t}$ and $t = \frac{Fd}{P} = \frac{(5.0 \times 10^2\text{ N})(5.0\text{ m})}{250\text{ W}} = 10.\text{ s}$

22. 4

23. $P = \frac{W}{t} = \frac{Fd}{t} = \frac{(500.\text{ N})(18\text{ m})}{50.0\text{ s}} = 180\text{ W}$

24. 1

25. $P = F\bar{v}$

$\bar{v} = \frac{P}{F} = \frac{2.00 \times 10^3\text{ W}}{4.0 \times 10^2\text{ N}} = 5.0\text{ m/s}$

26. 2 **27.** 4 **28.** 3
29. 2 **30.** 4 **31.** 3
31. 3 **32.** 2

33. $\Delta PE = mg\Delta h = (5.00\text{ kg})(9.81\text{ m/s}^2)(2.00\text{ m}) = 98.1\text{ J}$

34. 1 **35.** 4 **36.** 2
37. 3 **38.** 4

39. $F = kx = (25\text{ N/m})(0.25\text{ m}) = 6.3\text{ N}$

40. 4 **41.** 4 **42.** 4
43. 4

44. 12.7 cm = 0.127 m

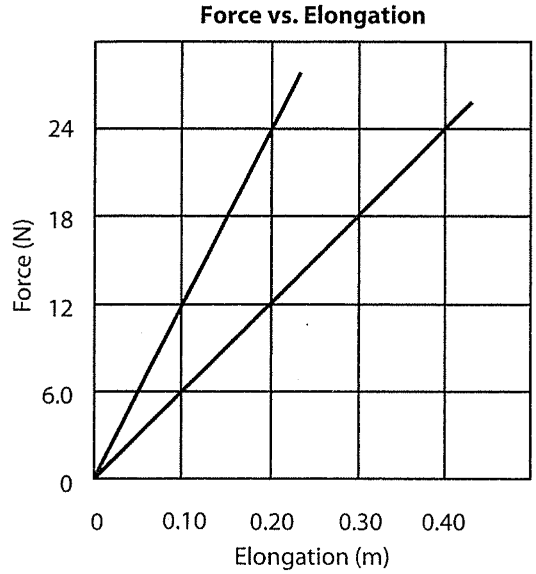
45. 1 **46.** 2 **47.** 3
48. 3 **49.** 3

50. $PE_s = \frac{1}{2}kx^2 = \frac{1}{2}(120\text{ N/m})(0.20\text{ m})^2 = 0.024\text{ J}$

51. 2 **52.** 4 **53.** 1
54. 1

55. slope $= k = \frac{\Delta F}{\Delta x} = \frac{24\text{ N}}{0.40\text{ m}} = 60.\text{ N/m}$

56. Example of Acceptable Response



57. 4 **58.** 3

59. $KE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(96\ \text{J})}{3.0\ \text{kg}}} = 8.0\ \text{m/s}$

60. 1 **61.** 2 **62.** 12 J

63. 1 **64.** 3 **65.** 3

66. 4 **67.** 1 **68.** 2

69. 2

70. $PE_A + KE_A = PE_B + KE_B$

$PE_A = KE_B$

$mgh = KE_B$

$h = \frac{KE_B}{mg} = \frac{1962\ \text{J}}{(20.0\ \text{kg})(9.81\ \text{m/s}^2)} = 10.0\ \text{m}$

71. 3

72. $PE_A + KE_A = PE_B + KE_B$

$KE_B = PE_A = mgh = F_g h = (600\ \text{N})(0.5\ \text{m}) = 300\ \text{J}$

73. 3 **74.** 4 **75.** 2

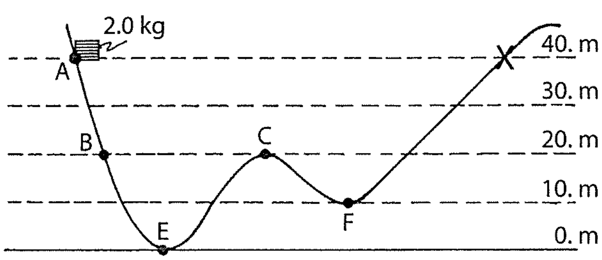
76. 2 **77.** 3 **78.** 3

79. 19.6 J **80.** 2 **81.** 3

82. $\Delta PE = mg\Delta h = (2.0\ \text{kg})(9.81\ \text{m/s}^2)(40.\text{m}) = 780\ \text{J}$

83. 2

84.



85. 4 **86.** 3

87. $KE = \frac{1}{2}mv^2 = \frac{1}{2}(10.0\ \text{kg})(10.0\ \text{m/s})^2 = 500.\ \text{J}$

88. $F = ma = \frac{m\Delta v}{t} = \frac{(10.0\ \text{kg})(10.0\ \text{m/s})}{4.0\ \text{s}} = 25\ \text{N}$

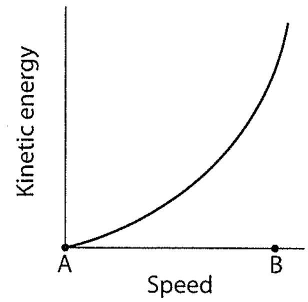
89. $\bar{v} = \frac{d}{t}$

$d = \bar{v}t = (5.00\ \text{m/s})(4.0\ \text{s}) = 20.\ \text{m}$

90. $J = \Delta p = m\Delta v = (10.0\ \text{kg})(-10.0\ \text{m/s}) =$ $100.\ \text{N} \cdot \text{s}$

91. 2 **92.** 3

93.



94. $PE_A + KE_A = PE_B + KE_B$

$PE_A = KE_B$

$mgh = \frac{1}{2}mv^2$

$h = \frac{v^2}{2g} = \frac{(10.0\ \text{m/s})^2}{2(9.81\ \text{m/s}^2)} = 5.10\ \text{m}$

95. $F_c = \frac{mv^2}{r} = \frac{(1.00\ \text{kg})(10.0\ \text{m/s})^2}{10.0\ \text{m}} = 10.0\ \text{N}$

96. 2 **97.** 2

98. $PE_A + KE_A = PE_B + KE_B + W$

$PE_A = PE_B + F_f d$

$F_f = \frac{PE_A - PE_B}{d} = \frac{mgh_A - mgh_B}{d} = \frac{mg(h_A - h_B)}{d}$

$F_f = \frac{(4.00 \times 10^{-2}\ \text{kg})(9.81\ \text{m/s}^2)(0.80\ \text{m} - 0.50\ \text{m})}{3.60\ \text{m}}$

$= 3.3 \times 10^{-2}\ \text{N}$

99. $W = Fd$ and $F = F_f = \mu F_N = \mu mg$

$W = \mu mgd = (0.67)(1.00 \times 10^3\ \text{kg})(9.81\ \text{m/s}^2)$ $(250\ \text{m}) = 1.6 \times 10^6\ \text{J}$

100. 491 J **101.** 109 J **102.** 1

103. 3 **104.** 1

Regents Practice Questions

1. 3 **2.** 2 **3.** 3

4. 1 **5.** 3 **6.** 2

7. 4 **8.** 1 **9.** 2

10. 2 **11.** 3 **12.** 4

13. 3 **14.** 4 **15.** 4

16. 3 **17.** 3 **18.** 2

19. 4 **20.** 2 **21.** 4

22. 1 **23.** 1 **24.** 2

25. 1 **26.** 2 **27.** 2

28. 3 **29.** 1 **30.** 3

31. 4 **32.** 2 **33.** 4

34. 1 **35.** 1

36. $W = Fd$ and $F_x = F\cos\theta$

$W = (F\cos\theta)(d) = (120\ \text{N})(\cos 37°)(10.\ \text{m}) = 960\ \text{J}$

37. $W = \Delta PE = mg\Delta h = (20.\ \text{N})(3.0\ \text{m}) = 60.\ \text{J}$

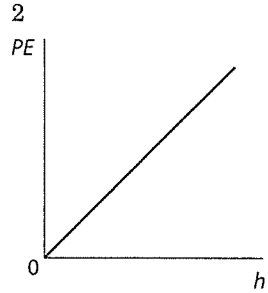
38. $W = Fd$ and $d = vt$

$d = (4.0\ \text{m/s})(6.0\ \text{s}) = 24\ \text{m}$

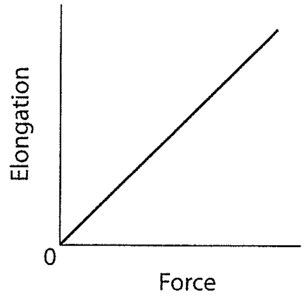
$W = (20.\ \text{N})(24\ \text{m}) = 480\ \text{J}$

39. 2

40.

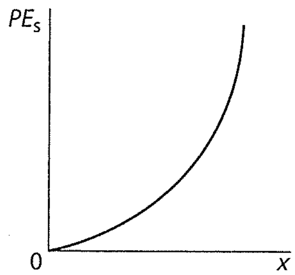


41.

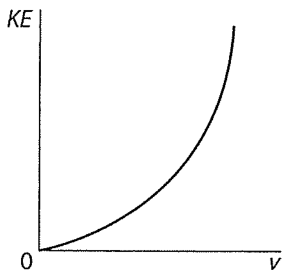


42. the length of the spring before any weight was added

43.



44.



45. $k = \frac{\Delta F}{\Delta x} = \frac{0.50 \text{ N}}{0.20 \text{ m}} = 2.5 \text{ N/m}$

46. $PE_s = \frac{1}{2}kx^2 = \frac{1}{2}(2.5 \text{ N/m})(0.20 \text{ m})^2 = 5.0 \times 10^{-2} \text{ J.}$

47. 0.050 J

48. 2

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

$d = \bar{v}t = (1 \text{ m/s})(3 \text{ s}) = 3 \text{ m}$

50. 0.0 N

51. $p = mv = (2.0 \text{ kg})(4 \text{ m/s}) = 8 \text{ kg} \cdot \text{m/s}$

52. $KE = \frac{1}{2}mv^2 = \frac{1}{2}(2.0 \text{ kg})(4.0 \text{ m/s})^2 = 16 \text{ J}$

53. $\overline{BC}$ or $\overline{DE}$

54. 0.0 J

55. $P = \frac{W}{t}$

$W = Pt = (10.0 \text{ W})(2.0 \text{ s}) = 20. \text{ J}$

56. 6.0 N

57. $a = \frac{F}{m} = \frac{6.0 \text{ N}}{3.0 \text{ kg}} = 2.0 \text{ m/s}^2$

58. $\Delta PE = mg\Delta h = (3.0 \text{ kg})(9.81 \text{ m/s}^2)(4.0 \text{ m}) = 120 \text{ J}$

59. 3

60. $PE_1 + KE_1 = PE_3 + KE_3$

$PE_1 = KE_3 = \frac{1}{2}mv^2 = \frac{1}{2}(2.00 \text{ kg})(6.00 \text{ m/s})^2 = 36.0 \text{ J}$

61. A

62. $a = \frac{v^2}{r} = \frac{(6.00 \text{ m/s})^2}{10.0 \text{ m}} = 3.6 \text{ m/s}^2$

63. The sum of the kinetic and potential energies of the bob at position 1 is equal to the sum of the kinetic and potential energies of the bob at position 2.

64. $(8.0 \text{ cm})(3.0 \text{ m/cm}) = 24 \text{ m}$

65. $\Delta PE = mg\Delta h = (650 \text{ kg})(9.81 \text{ m/s}^2)(24 \text{ m})$
$= 1.5 \times 10^5 \text{ J}$

66. The kinetic energy of the car at the top of the second hill is less than the kinetic energy of the car at the top of the third hill.

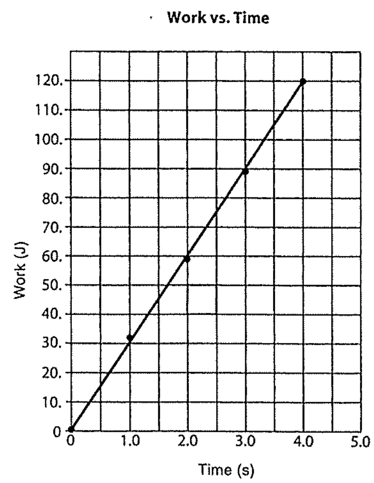
67. $\Delta PE = mg\Delta h = (6.00 \text{ kg})(9.81 \text{ m/s}^2)(55.0 \text{ m})$
$= 3240 \text{ J}$

68. $KE = \frac{1}{2}mv^2 = \frac{1}{2}(6.00 \text{ kg})(30.0 \text{ m/s})^2 = 2700 \text{ J}$

69. 540 J

70. The "lost" energy was converted into heat because work was done against friction.

71.



72. slope $= \frac{\Delta W}{\Delta t} = \frac{120. \text{ J} - 60. \text{ J}}{4.0 \text{ s} - 2.0 \text{ s}} = 30. \text{ W}$

73. The slope represents the power developed.

74. 2.5 s

75. The work that must be done to stop a moving object is equal to the kinetic energy of the object. Kinetic energy is given by the formula $KE = \frac{1}{2}mv^2$, so if two objects have the same initial velocity v, the more massive object has the greater kinetic energy. Thus, it requires more work to stop the ferry boat.

76. If no outside work is done on a pendulum, such as giving it a push while swinging, the pendulum cannot possess more energy at any point in its swing than at its point of release. At the instant the bob is released, it has no kinetic energy. All of its energy is potential energy, $PE = mgh$, where h is the height of the bob above the lowest point of its swing. When the bob swings through one cycle and returns to the student, the maximum energy the bob can have is mgh. Thus, the ideal pendulum would return to the tip of the student's nose. In reality, some energy is converted to work done against friction. As a result, the bob rises to some height less than its height at the time of its release.

77. The power developed by the teacher is found by determining the time rate of doing work.

$P = \frac{W}{t} = \frac{Fd}{t} = \frac{(700. \text{ N})(6.0 \text{ m})}{7.0 \text{ s}} = 600 \text{ W.}$

The teacher develops the same power as the power consumed when six 100-watt light bulbs are turned on.

78. $1.00\ \text{kW} \cdot \text{h} = \frac{1.00 \times 10^3\ \text{J}}{\text{s}} \cdot \text{h}$

$= \frac{1.00 \times 10^3\ \text{J}}{\text{s}} \cdot 1\ \text{h}\left(\frac{60\ \text{min}}{1\ \text{h}}\right)\left(\frac{60\ \text{s}}{1\ \text{min}}\right)$

$= 3.6 \times 10^5\ \text{J}$

79. $PE_i + KE_i = PE_{top} + KE_{top}$

$mgh + 0 = mg(2r) + \frac{1}{2}mv_{top}^2$

$gh = g(2r) + \frac{1}{2}v_{top}^2$

And if the car just makes it around the top of the loop, the normal force of the track on the car is zero. Gravity provides the centripetal force.

$F_g = F_c$

$mg = \frac{mv^2}{r}$

$v^2 = gr$

Substituting,

$gh = g(2r) + \frac{1}{2}gr$

$h = \frac{5r}{2}$

80. During the collision momentum is conserved.

$p_i = p_f$

$m_B v_{B_i} = (m_B + m_W)v_f$

$v_f = \frac{m_B v_{B_i}}{m_B + m_W}$

Mechanical energy is conserved after the collision.

$E_i = E_f$

$PE_{BW_i} + KE_{BW_i} = PE_{BW_f} + KE_{BW_f}$

$\frac{1}{2}(m_B + m_W)v_f^2 = (m_B + m_W)gh$

$h = \frac{v_f^2}{2g} = \frac{\left(\frac{m_B v_{B_i}}{m_B + m_w}\right)^2}{2g}$

81. $T = 2\pi\sqrt{\frac{m}{k}}$

$\left(\frac{T}{2\pi}\right)^2 = \frac{m}{k}$

$k = \frac{m}{\left(\frac{T}{2\pi}\right)^2}$ and

$PE_s = \frac{1}{2}kx^2 = \frac{mx^2}{2\left(\frac{T}{2\pi}\right)^2} = \frac{2\pi^2 mx^2}{T^2}$ or $2m\left(\frac{\pi x}{T}\right)^2$

82. $PE_s = KE$

$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ *or* $\frac{1}{2}kx^2 = \frac{1}{2}mv^2$

$k = \frac{mv^2}{x^2}$ $\quad k = \frac{mv^2}{x^2}$

83. $KE = \frac{1}{2}mv^2$ and $p = mv$

$v = \sqrt{\frac{2KE}{m}}$ and $p = m\sqrt{\frac{2KE}{m}} = \sqrt{2mKE}$

84. $PE = mgh$

85. $PE_B + KE_B = PE_A + KE_A$

$\frac{1}{2}mv_B^2 = mgh$

$v_B = \sqrt{2gh}$

86. $PE_B + KE_B = PE_C + KE_C + PE_S$

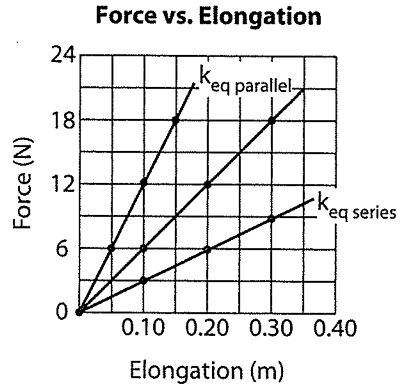
$\frac{1}{2}mv_B^2 = mg(-y) + \frac{1}{2}ky^2$

$mv_B^2 = 2mg(-y) + ky^2$

87. $ky^2 = mv_B^2 + 2mgy$

$k = \frac{m}{y^2}(v_B^2 + 2gy)$

88. **Force vs. Elongation**



89. See question 88.

90. $PE_B + KE_B = PE_A + KE_A$

$\frac{1}{2}mv_B^2 = mg\ell$

$v_B = \sqrt{2g\ell}$

91. $PE = mgh = mg(2r) = 2mgr$

92. $PE_C + KE_C = PE_B + KE_B$

$2mgr + \frac{1}{2}mv_C^2 = 0 + \frac{1}{2}mv_B^2$

but $\frac{1}{2}mv_B^2 = mg\ell$

so

$2mgr + \frac{1}{2}mv_C^2 = mg\ell$

$\frac{1}{2}mv_C^2 = mg\ell - 2mgr$

$v_C^2 = 2g\ell - 4gr$

$v_C = \sqrt{2g(\ell - 2r)}$

93. 1.2×10^4 N *or* 11,800 N

94. $F_f = \mu F_N$

$F_f = (0.67)(12{,}000\ \text{N})$

$F_f = 8{,}000$ N *or* 8,040 N

95. $W = Fd$

$W = (8{,}000\ \text{N})(16\ \text{m})$

$W = 1.3 \times 10^5$ J *or* 128,000 J

96. $W = KE = \frac{1}{2}mv^2$ $\quad a = \frac{F_{net}}{m}$

$v = \sqrt{\frac{2KE}{m}}$ $\quad a = 6.7\ \text{m/s}^2$

$v = \sqrt{\frac{2(1.3 \times 10^5\ \text{J})}{1.2 \times 10^3\ \text{kg}}}$ *or* $v_f^2 = v_i^2 + 2ad$

$v_i = \sqrt{v_f^2 - 2ad}$

$v = 15$ m/s $\quad v_i = \sqrt{0 - 2(-6.7\ \text{m/s}^2)(16\ \text{m})}$

$v_i = 14.6$ m/s

97. $p_{before} = p_{after}$

or

$m_{before}\, v_{before} = m_{after}\, v_{after}$

$(50.\ \text{kg})(6.0\ \text{m/s}) = (60.\ \text{kg})\ v_{after}$

$v_{after} = (50.\ \text{kg})\ (6.0\ \text{m/s})/(60.\ \text{kg})$

$v_{after} = 5.0$ m/s

98. $KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}(60.\ \text{kg})\ (5.0\ \text{m/s})^2$

$KE = 750$ J

99. 750 J

100. $p_{before} = p_{after}$

$m_1\, v_{1i} + m_2\, v_{2i} = (m_1 + m_2)v_f$

$(1000.\ \text{kg})\ (6.0\ \text{m/s}) + (5000.\ \text{kg})\ (0.0\ \text{m/s}) = (1000.\ \text{kg} + 5000.\ \text{kg})\ v_f$

$6000\ \text{kg} \cdot \text{m/s} = (6000.\ \text{kg})\ v_f$

$v_f = 1.0$ m/s

101. $KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}(6000.\text{ kg})(1.0\text{ m/s})^2$

$KE = 3000\text{ J}$ *or* $3.0 \times 10^3\text{ J}$

102. The *KE* of the combined carts after the collision is less than the *KE* of the carts before the collision.

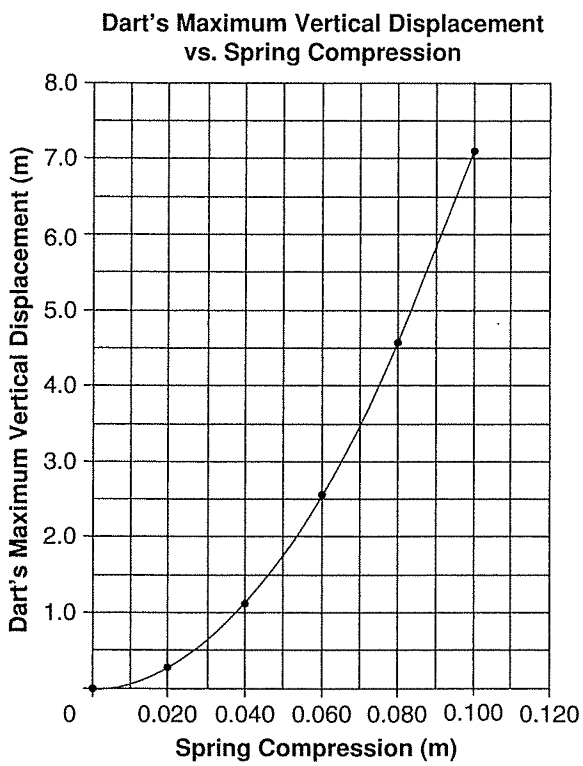
$KE_{before} > KE_{after}$

103. — *B*, because the mass has the greatest speed
— *B*, because the total potential energy is least
— *B*, the speed at *A* and *C* is zero

104. — *A*, because it is the highest point of travel

105. — *C*, because the spring is stretched the maximum amount
— *C*, because the KE and gravitational PE are a minimum

106 and 107.



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

$PE_s = \frac{1}{2}(140\text{ N/m})(0.070\text{ m})^2$

$PE_s = 0.34\text{ J}$

109. 5.6 N

ANSWERS TO TOPIC 4

Review Questions

1. 3 **2.** 2

3. proton +e
electron −e
neutron 0e

4. 1 **5.** 3 **6.** 3

7. 1 **8.** 1 **9.** 3

10. $+2\mu C$ **11.** 2 **12.** 1

13. 4 **14.** 1 **15.** 1

16. 4

17. $F_e = \frac{kq_1q_2}{r^2}$

$= \frac{(8.99 \times 10^9\text{ N}\cdot\text{m}^2/\text{C}^2)(3.0 \times 10^{-7}\text{ C})(4.0 \times 10^{-7}\text{ C})}{(2.0 \times 10^{-2}\text{ m})^2}$

$= 2.7\text{ N}$

18. 4 **19.** 1 **20.** 2

21. 2 **22.** 2 **23.** 3

24. $V = \frac{W}{q} = \frac{6.0\text{ J}}{2.0\text{ C}} = 3.0\text{ V}$

25. 4

26. $V = \frac{W}{q} = \frac{4.0\text{ J}}{2.0\text{ C}} = 2.0\text{ V}$

27. 200. eV

28. potential difference

29. $I = \frac{q}{t} = \frac{20.0\text{ C}}{4.0\text{ s}} = 5.0\text{ A}$

30. 3 **31.** 1 **32.** 1

33. 1 **34.** 3

35. $I = \frac{V}{R}$ and $I = \frac{q}{t}$

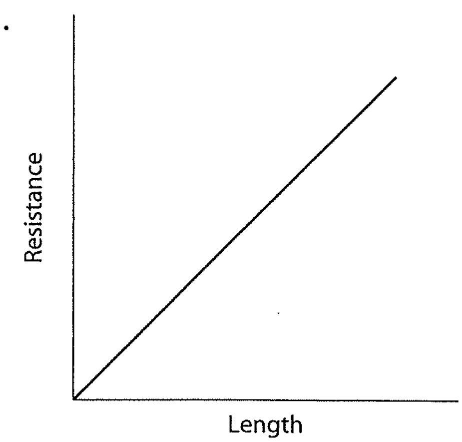
$V = IR = \frac{qR}{t} = \frac{(40.\text{ C})(20.\ \Omega)}{5.0\text{ s}} = 160\text{ V}$

36. 10 Ω

37. $I = \frac{V}{R} = \frac{12\text{ V}}{4.0\ \Omega} = 3.0\text{ A}$

38. 3 **39.** 3 **40.** 4

41.



42. 4 Ω **43.** 2 **44.** 1

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

$\rho = \frac{RA}{L} = \frac{(0.35\ \Omega)(2.00 \times 10^{-6}\text{ m}^2)}{5.00\text{ m}}$

$= 14 \times 10^{-8}\ \Omega\cdot\text{m}$

46. 4 **47.** 1 **48.** 2

49. 2 **50.** 3 **51.** 2

52. 1 **53.** 70 V **54.** 1.0 A

55. 2 **56.** 4 **57.** 2

58. 3 **59.** 4 **60.** 4

61. 2 **62.** 3 A **63.** 33 A

64. 3 **65.** 3 **66.** 4

67. 2 **68.** 3 **69.** 2

70. 4 **71.** 1 **72.** 60. Ω

73. $I = \frac{V}{R} = \frac{120\text{ V}}{60.\ \Omega} = 2.0\text{ A}$

74. $I = I_1 + I_2 = 2.0\text{ A} + 2.0\text{ A} = 4.0\text{ A}$

75. 120 V

76. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{10.\ \Omega} + \frac{1}{15\ \Omega} = \frac{3+2}{30.\ \Omega} = \frac{1}{6.0\ \Omega}$ and

$R_{eq} = 6.0\ \Omega$

77. 12 V

78. $I = \frac{V}{R} = \frac{12\ \text{V}}{10.\ \Omega} = 1.2\ \text{A}$

79. The current in ammeter A_1 is greater than the current in ammeter A_2.

80. If another resistor is added to the circuit in parallel, the equivalent resistance decreases and the total current in the circuit increases.

81. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

$\frac{1}{R_2} = \frac{1}{R_{eq}} - \frac{1}{R_1} = \frac{1}{6.0\ \Omega} - \frac{1}{10.\ \Omega} = \frac{5-3}{30.\ \Omega} = \frac{1}{15\ \Omega}$

$R_2 = 15\ \Omega$

82. $I = \frac{V}{R} = \frac{30.\ \text{V}}{6.0\ \Omega} = 5.0\ \text{A}$

83. $P = \frac{V^2}{R} = \frac{(30.\ \text{V})^2}{10.\ \Omega} = 90.\ \text{W}$

84. The potential difference across the source is equal to the potential difference across R_2, 30. volts.

85. If the resistance of R_2 is increased, the potential difference across it remains 30. volts, but the current through it decreases.

86. 4 **87.** 4 **88.** 3
89. 3 **90.** 2 **91.** 1
92. 3 **93.** 3 **94.** 4

95. $P = \frac{V^2}{R}$

$R = \frac{V^2}{P} = \frac{(120\ \text{V})^2}{4800\ \text{W}} = 3.0\ \Omega$

96. $W = Pt = (4800\ \text{W})(10.0\ \text{s}) = 4.8 \times 10^4\ \text{J}$

97. $P = IV$ and $I = \frac{q}{t}$

$P = \frac{qV}{t}$

$q = \frac{Pt}{V} = \frac{(15\ \text{W})(60.\ \text{s})}{12\ \text{V}} = 75\ \text{C}$

98. 2 **99.** 2 **100.** 2
101. 4 **102.** 1 **103.** 4

104. at least one is a magnet *or* one is a magnet

105. 3

106. S  N

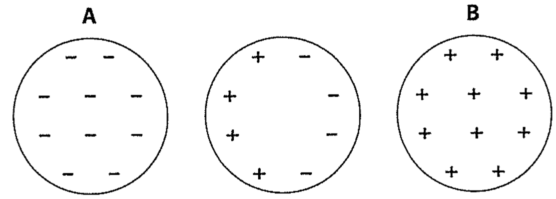
107. 1 **108.** A **109.** C
110. 3 **111.** 4 **112.** 1

Regents Practice Questions

Part A

1. 3 **2.** 3 **3.** 2
4. 2 **5.** 4 **6.** 2
7. 2 **8.** 4 **9.** 4
10. 3 **11.** 3 **12.** 1
13. 4 **14.** 1 **15.** 3
16. 2 **17.** 3 **18.** 2
19. 1 **20.** 2 **21.** 1
22. 2 **23.** 3 **24.** 3
25. 2 **26.** 3 **27.** 4
28. 1 **29.** 2 **30.** 2
31. 4 **32.** 3 **33.** 4
34. 4 **35.** 2 **36.** 4
37. 2 **38.** 1 **39.** 1
40. 3 **41.** 4 **42.** 3
43. 2 **44.** 2

45.



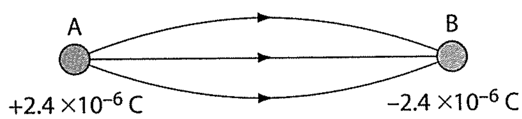
46. $-1.0 \times 10^{-2}\ \text{N}$

47. $\frac{e}{m} = \frac{1.60 \times 10^{-19}\ \text{C}}{9.11 \times 10^{-31}\ \text{kg}} = 1.76 \times 10^{11}\ \text{C/kg}$

48. $q/4$

49.

50.

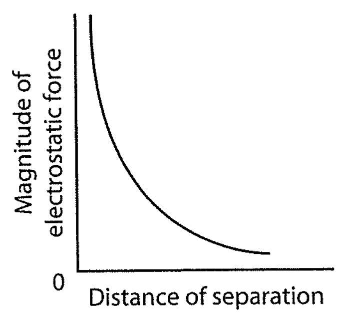


51. $F_e = \frac{kq_1q_2}{r^2}$

$= \frac{(8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2)(2.4 \times 10^{-6}\ \text{C})(2.4 \times 10^{-6}\ \text{C})}{(0.50\ \text{m})^2}$

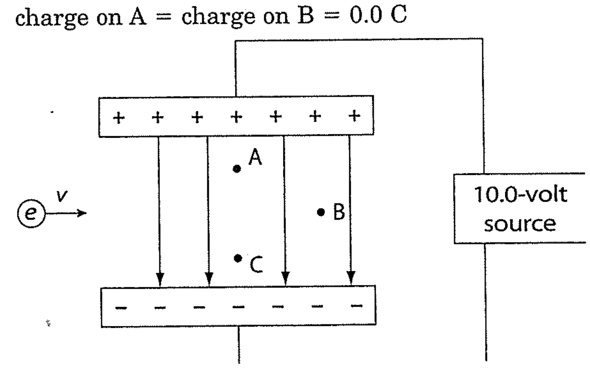
$= 0.21\ \text{N}$

52.



53. charge on A = charge on B = 0.0 C

54.



55. The electron would travel a parabolic path toward the positive plate.

56. The magnitude of the electric field strength at points B and A is the same.

57. $V = \frac{W}{q}$

$W = Vq = (10.0\ \text{V})(-1.60 \times 10^{-19}\ \text{C})$
$= -1.60 \times 10^{-18}\ \text{J}$

58. 1.87×10^{6} m/s

59. 3

60. B

61. D

62. A

63. $R = \frac{V}{I} = \frac{1.5\ \text{V}}{2.0\ \text{A}} = 0.75\ \Omega$

64. $P = VI = (1.5\ \text{V})(2.0\ \text{A}) = 3.0\ \text{W}$

65. 120 V

66. $I = \frac{V}{R} = \frac{120\ \text{V}}{20.\ \Omega} = 6.0\ \text{A}$

67. $P = I^2R = (4.0\ \text{A})^2(30.\ \Omega) = 480\ \text{W}$

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

$V = IR = (0.50\ \text{A})(5.0\ \Omega) = 2.5\ \text{V}$

69. $W = VIt = (15\ \text{V})(0.50\ \text{A})(10.0\ \text{min})(60\ \text{s/min})$
$= 4.5 \times 10^{3}\ \text{J}$

70. 10.0 Ω

71. The 5.0-ohm resistor dissipates less power than the 15.0-ohm resistor.

72. Removing the 5.0-ohm resistor from the circuit increases the potential drop across resistor R and increases the current through the ammeter.

73. 8.0 Ω

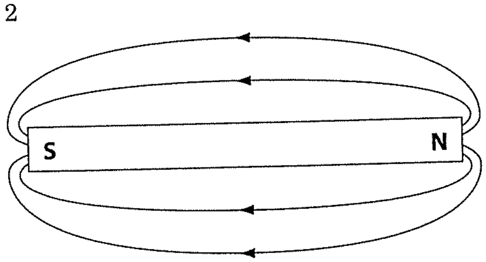
74. $R = \frac{V}{I}$

$I = \frac{V}{R} = \frac{24\ \text{V}}{20.\ \Omega} = 1.2\ \text{A}$

75. 24 Ω

76. 2

77.

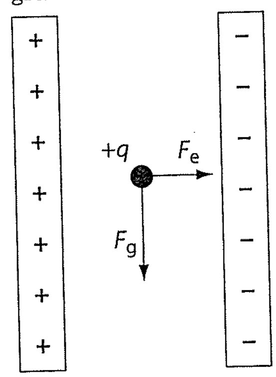


78. A series circuit provides only one current path. Typical electrical devices used in a kitchen include one or more lights, a refrigerator, and a toaster. If these devices were connected in a series circuit, all of the devices would have to be turned on for the refrigerator to operate. If one device was not receiving electricity, none of the other devices would either.

79. Standard incandescent light bulbs are designed to be operated in parallel at 120 volts. The power developed is given by the formula $P = \frac{V^2}{R}$, so power is inversely proportional to resistance. Therefore, the 150-watt bulb has less resistance than the 60-watt bulb. Resistance, $R = \frac{\rho L}{A}$, is directly proportional to length and inversely proportional to cross-sectional area. Thus, a filament of low resistance is relatively thick and short.

80. An electron located between two oppositely charged metal plates experiences an upward electric force that accelerates the electron upward if the upper plate is positively charged and the upward force, exerted by the electric field, is greater than the downward force exerted by the gravitational field.

81.



82. $KE = \frac{1}{2}mv^2$ and $V = \frac{W}{q}$

The maximum speed corresponds to the maximum kinetic energy, which equals the work done on the electron by the field.

$\frac{1}{2}mv^2 = Vq$, but $m = m_e$ and $q = e$

$\frac{1}{2}m_e v^2 = Ve$

$v = \sqrt{\frac{2Ve}{m_e}}$

83. The maximum speed of a proton would be less than that of an electron. Although both particles have the same magnitude of charge e, the proton is more massive than the electron. The maximum speed is inversely proportional to the square root of mass. (See problem 82.)

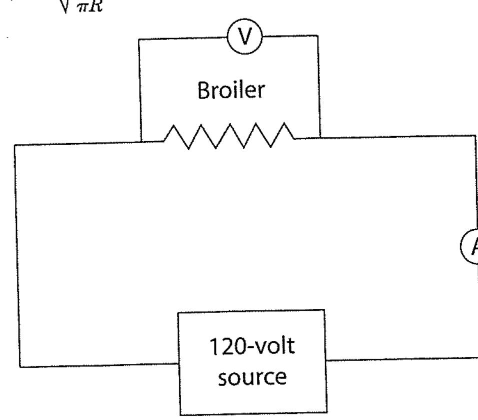
84. $\frac{V}{A} = \frac{\frac{J}{C}}{\frac{C}{s}} = \frac{J \cdot s}{C^2} = \frac{\frac{kg \cdot m^2}{s^2} \cdot s}{C^2} = \frac{\frac{kg \cdot m^2}{s}}{(A \cdot s)^2} = \frac{kg \cdot m^2}{A^2 \cdot s^3}$

85. $R = \frac{\rho L}{A}$ and $A = \pi r^2$

$R = \frac{\rho L}{\pi r^2};\ r^2 = \frac{\rho L}{\pi R}$

$r = \sqrt{\frac{\rho L}{\pi R}}$

86.



87. $P = \frac{V^2}{R}$

$R = \frac{V^2}{P} = \frac{(120\ \text{V})^2}{1440\ \text{W}} = 10.\ \Omega$

88. $W = Pt = (1440\ \text{W})(10.0\ \text{min})(60.\ \text{s/min}) = 8.6 \times 10^5\ \text{J}$

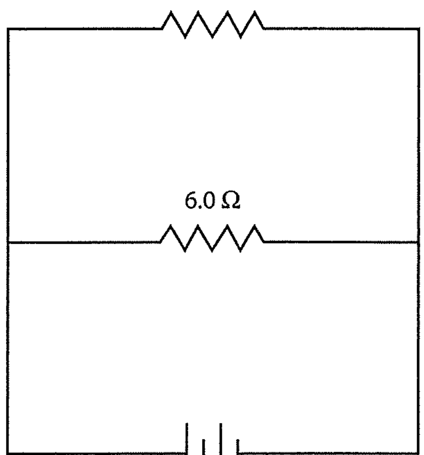
89. $P = VI$

$I = \frac{P}{V} = \frac{1440\ \text{W}}{120\ \text{V}} = 12\ \text{A}$

Because the broiler draws 12 A of current, 3 A additional current can be drawn before the fuse blows.

90. Although the potential drop across the broiler would remain the same, most of the current would go through the short circuit having negligible resistance. Because power is directly proportional to both potential difference and current, the power output of the broiler would decrease.

91.



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

$I = \frac{V}{R} = \frac{12\ \text{V}}{6.0\ \Omega} = 2.0\ \text{A}$

93. 12 V

94. $P = \frac{V^2}{R}$ and $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

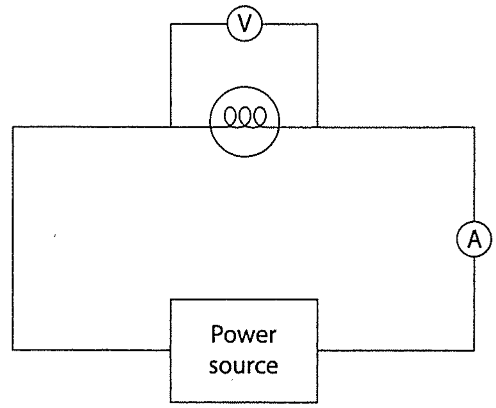
$\frac{1}{R_{eq}} = \frac{1}{3.0\ \Omega} + \frac{1}{6.0\ \Omega} = \frac{2+1}{6.0\ \Omega}$

$P = \frac{(12\ \text{V})^2}{2.0\ \Omega} = 72\ \text{W}$

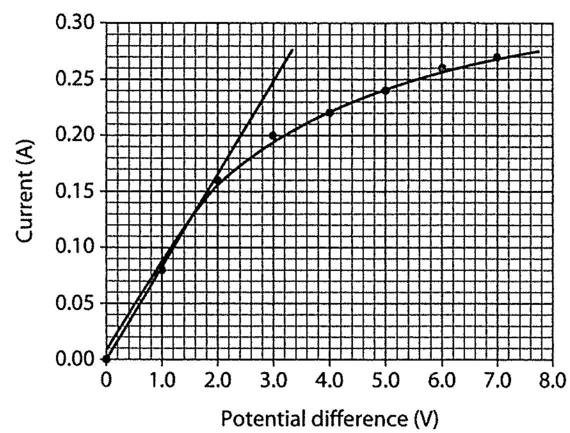
95. Adding an additional 2.0-ohm resistor to the circuit would not change the amount of current drawn by the 6.0-ohm resistor. Only the main line current would increase, as a result of the additional resistor.

96. When connected in parallel, the equivalent resistance is less than the value of either resistor. When connected in series, the equivalent resistance is greater than the value of either resistor.

97.



98.



99. slope $= \frac{\Delta I}{\Delta V} = \frac{0.21\ \text{A} - 0.18\ \text{A}}{3.4\ \text{V} - 2.6\ \text{V}} = 0.038\ \frac{1}{\Omega}$

100. The slope is the reciprocal of the resistance or $\frac{1}{R}$.

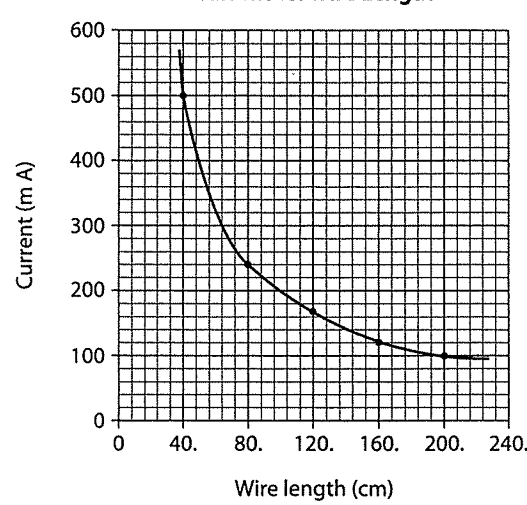
101. The lamp does not obey Ohm's law because the filament gets hot.

102. See answer to question 98.

103. $P = IV = (7.0\ \text{V})(0.27\ \text{A}) = 1.9\ \text{W}$

104. The bulb is not operating at the standard 120 volts.

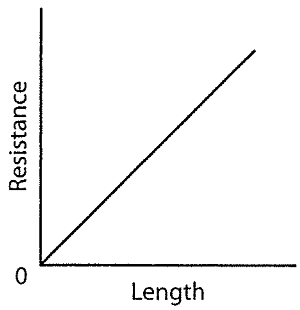
105.



106. The current in the wire is inversely proportional to the wire's length.

107. Ω

108.

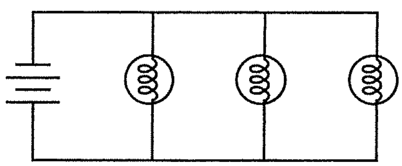


109. $R = \frac{\rho L}{A}$ and $A = \pi r^2$ and $r = d/2$

$$\rho = \frac{RA}{L} = \frac{R\pi r^2}{L} = \frac{(20.\ \Omega)\pi(1.59 \times 10^{-4}\ \text{m})^2}{2.00\ \text{m}}$$

$$= 79 \times 10^{-8}\ \Omega \cdot \text{m}$$

110.



111. 40.1 V

112. $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{89\ \Omega} + \frac{1}{365\ \Omega} + \frac{1}{143\ \Omega}$

$R_{eq} = 48\ \Omega$ *or* $47.7\ \Omega$

or

$I = I_1 + I_2 + I_3 = 0.45\ \text{A} + 0.11\ \text{A} + 0.28\ \text{A} = 0.84\ \text{A}$

$R = \frac{V}{I} = \frac{40.1\ V}{0.84\ A} = 48\ \Omega$ *or* $47.7\ \Omega$

113. 40.1 V

114. 0.11 A

115. The sphere is attracted to both rods.

116. The sphere is repelled by the positive rod (only).

Answers To Topic 5

Review Questions

1. 4	**2.** 4	**3.** 3
4. 3	**5.** 1	**6.** 1
7. $T = 0.50$ s	**8.** 4	**9.** 3
10. 4	**11.** frequency	**12.** 1
13. 1	**14.** 3	**15.** 1
16. 2	**17.** B	**18.** 2 m

19. 2.0 m

20. $v = f\lambda$ and $f = \frac{1}{T}$

$v = \frac{\lambda}{T} = 8.0\ \text{m}/5.0\ \text{s} = 1.6\ \text{m/s}$

21. 170 m	**22.** 1	**23.** A and C

24. A and B *or* C and D

25. A and B *or* C and D

26. 2

27. 2

28. $v = f\lambda$

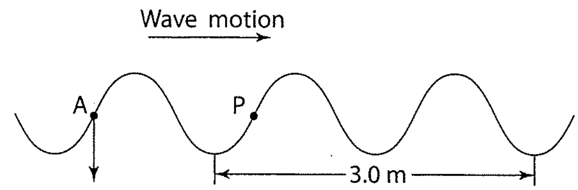
$\lambda = \frac{v}{f} = \frac{331\ \text{m/s}}{250\ \text{Hz}} = 1.3\ \text{m}$

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

$d = \bar{v}t = (331\ \text{m/s})(3.00\ \text{s}) = 993\ \text{m}$

30. longitudinal

31. and **32.**



33. $\lambda = \frac{3.0\ \text{m}}{2} = 1.5\ \text{m}$

$v = f\lambda = (40.\ \text{Hz})(1.5\ \text{m}) = 60.\ \text{m/s}$

34. $T = \frac{1}{f} = \frac{1}{40.\ \text{Hz}} = 0.025\ \text{s}$

35. 0.080 s

36. $f = \frac{1}{T} = \frac{1}{0.080\ \text{s}} = 13\ \text{Hz}$

37. $v = \lambda f = (4.0\ \text{m})\left(\frac{1}{2.5\ \text{s}}\right) = 1.6\ \text{m/s}$

38. $\bar{v} = \frac{s}{t}$

$t = \frac{s}{\bar{v}} = \frac{50.\ \text{m}}{1.6\ \text{m/s}} = 31\ \text{s}$

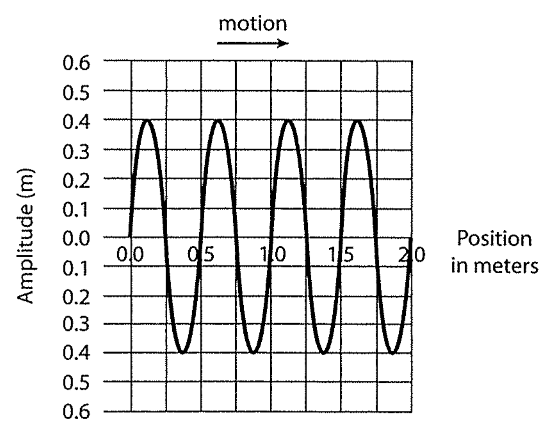
39. 6.4 m

40. $v = \frac{\lambda}{T}$

41. 1

42. 4

43.



44. 150 waves

45. 1	**46.** 3	**47.** 1

48. Doppler effect

49. 3	**50.** 1	**51.** 2
52. 3	**53.** 2	**54.** 1
55. 180°	**56.** 2	**57.** A and C
58. 3	**59.** D	**60.** 1
61. 3	**62.** 2	**63.** 4
64. 4.0 m	**65.** 3	

66. diffraction and interference

67. 2	**68.** 3	**69.** 3
70. 4	**71.** 4	**72.** 3

73. $v = f\lambda$

$\lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{5.3 \times 10^{14}\ \text{Hz}}$

$= 5.7 \times 10^{-7}\ \text{m}\left(\frac{1\ \text{nm}}{10^{-9}\ \text{m}}\right) = 570\ \text{nm}$

74. 2	**75.** 1	**76.** B
77. 2	**78.** C	**79.** 2

80. 0°

81. 1	**82.** 2	**83.** 2
84. 2	**85.** 1	**86.** 3

87. F **88.** 3 **89.** 4

90. $n = \frac{c}{v} = \frac{3.00 \times 10^8\ \text{m/s}}{2.00 \times 10^8\ \text{m/s}} = 1.50$ **91.** 3

92. $\frac{v_1}{v_2} = \frac{n_2}{n_1} = \frac{1.92}{2.42}$

93. diamond

94. 4 **95.** 3 **96.** 1

97. 1 **98.** B **99.** 2

100. 3 **101.** 3 **102.** 3

103. 4 **104.** 4 **105.** 2

106. 3 **107.** green **108.** 10^5 Hz

109. 2 **110.** 3 **111.** 1

112. diamond, crown glass, flint glass, Lucite™, sodium chloride, or zircon

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

$$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2} = \frac{1.00 \sin 45°}{\sin 30.°} = 1.41$$

114. $n = \frac{c}{v}$

$$v = \frac{c}{n} = \frac{3.00 \times 10^8\ \text{m/s}}{1.5} = 2.0 \times 10^8\ \text{m/s}$$

115. The angle of refraction increases.

116. 45° (±2°)

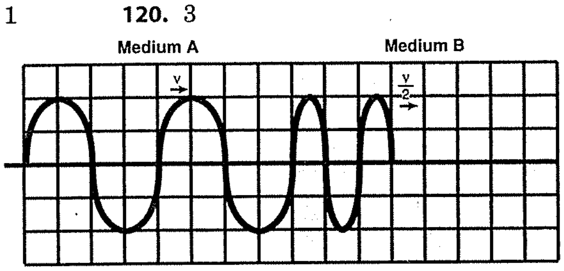
117. 3

118. $n = \frac{c}{v}$

$$v = \frac{c}{n} = \frac{3.00 \times 10^8\ \text{m/s}}{1.4} = 2.1 \times 10^8\ \text{m/s}$$

119. 1 **120.** 3

121.



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

$$\bar{v} = \frac{2(324\ \text{m})}{0.425\ \text{s}}$$

$$\bar{v} = 1520\ \text{m/s}$$

123. $v = f\lambda$

$$\lambda = \frac{v}{f}$$

$$\lambda = \frac{1520\ \text{m/s}}{1.18 \times 10^3\ \text{Hz}}$$

$$\lambda = 1.29\ \text{m}$$

124. 8.47×10^{-4} s

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

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

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

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

126. 0°

127. The frequency of this light in diamond is the same as its frequency in air. The speed of the light in diamond is less than its speed in air.

Regents Practice Questions

1. 2 **2.** 2 **3.** 4

4. 2 **5.** 2 **6.** 1

7. 4 **8.** 1 **9.** 1

10. 3 **11.** 1 **12.** 3

13. 1 **14.** 1 **15.** 3

16. 1 **17.** 3 **18.** 1

19. 3 **20.** 4 **21.** 4

22. 1 **23.** 2 **24.** 3

25. 2 **26.** 1 **27.** 4

28. 4 **29.** 4 **30.** 1

31. 1 **32.** 2 **33.** 4

34. 4 **35.** 1 **36.** 1

37. $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

$$\lambda_2 = \frac{v_2\lambda_1}{v_1} = \frac{(0.15\ \text{m/s})(0.50\ \text{m})}{0.30\ \text{m/s}} = 0.25\ \text{m}$$

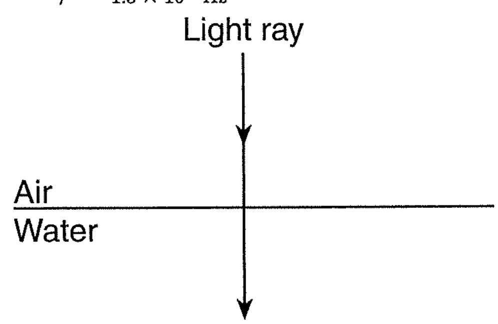
38. 1.41 **39.** 4 **40.** 1

41. 1

42. $v = f\lambda$

$$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{1.5 \times 10^{18}\ \text{Hz}} = 2.0 \times 10^{-10}\ \text{m}$$

43.

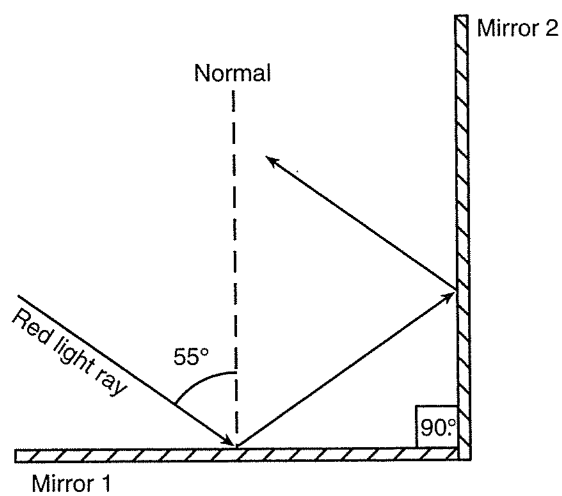


44. $\bar{v} = \frac{s}{t}$

$$t = \frac{s}{\bar{v}} = \frac{1.50 \times 10^{11}\ \text{m}}{3.00 \times 10^8\ \text{m/s}} = 5.00 \times 10^2\ \text{s}$$

45. 35° ± 2°

46.



47. 1.95×10^8 m/s

48. B

49. Doppler effect

50. The observed wave frequency at *B* is higher than that at *D*.

51. The wavelength observed at D increases.
52. 0.2 m
53. 2.0 m
54. 1.5 cycles
55. 2.5 Hz
56. $v = f\lambda = (2.5 \text{ Hz})(2.0 \text{ m}) = 5.0 \text{ m/s}$
57. A and G, *or* C and I, *or* D and J
58. down, towards the bottom of the page
59. $n = \frac{c}{v}$

$v = \frac{c}{n} = \frac{3.00 \times 10^8 \text{ m/s}}{1.33} = 2.26 \times 10^8 \text{ m/s}$

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

$\sin \theta_1 = \frac{n_2 \sin \theta_2}{n_1} = \frac{1.00 \sin 45°}{1.33}$

$\theta_1 = 32°$

61. B
62. The speed of light in water is greater than the speed of light in medium X.
63. 1.33
64. $v = f\lambda$ and $n = \frac{c}{v}$

$\lambda = \frac{v}{f}$ and $v = \frac{c}{n}$

$\lambda = \frac{c}{fn} = \frac{3.00 \times 10^8 \text{ m/s}}{(5.09 \times 10^{14} \text{ Hz})(1.33)} = 4.43 \times 10^{-7} \text{ m}$

65. $v = f\lambda$

$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{4.00 \times 10^{-7} \text{ m}} = 7.50 \times 10^{14} \text{ Hz}$

66. violet
67. $\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$

$\lambda_2 = \frac{n_1 \lambda_1}{n_2} = \frac{1.00(4.00 \times 10^{-7} \text{ m})}{1.50} = 2.67 \times 10^{-7} \text{ m}$

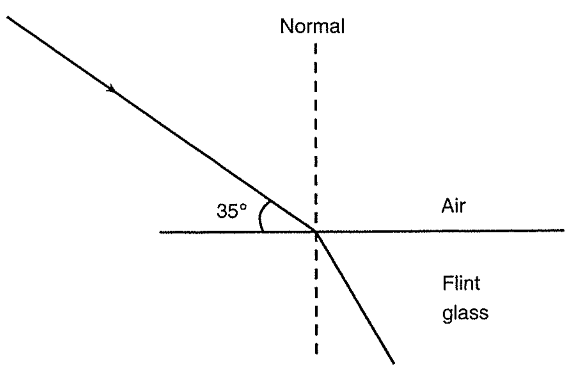
68. The measure of angle A is equal to the measure of angle B.
69. The angle of refraction would increase.
70. 55° (±2°)
71. $n_1 \sin \theta_1 = n_2 \sin \theta_2$

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

$\sin \theta_2 = \frac{(1.00)(\sin 55°)}{1.66}$

$\theta_2 = 29.6°$ *or* 30.°

72. 30.° (±2°)
73.



74. $v = f\lambda$

$\lambda = \frac{v}{f} = \frac{1.5 \times 10^3 \text{ m/s}}{5.0 \times 10^3 \text{ Hz}} = 0.30 \text{ m}$

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

$d = \bar{v}t = (1.5 \times 10^3 \text{ m/s})(2.0 \text{ s}) = 3.0 \times 10^3 \text{ m}$

76. reflection
77. $\bar{v} = \frac{d}{t}$

$t = \frac{d}{\bar{v}} = \frac{20. \text{ m}}{340 \text{ m/s}} = 0.059 \text{ s}$

78. $v = f\lambda$

$\lambda = \frac{v}{f} = \frac{340 \text{ m/s}}{10^3 \text{ Hz}} = 0.34 \text{ m}$

79. 1λ
80. The frequency of the sound observed at point P increases.
81. 22 m
82. The fire engine produces a sound of constant frequency, or pitch. As the engine approaches you, the distance between successive wave fronts that reach you is decreased. Because the speed of sound is constant, a decrease in wavelength produces an observed increase in frequency or pitch.
83. angle of incidence = 45° (±2°)

angle of refraction = 26° (±2°)

84. The angle of reflection in material X is 64° (±2°).
85. longitudinal
86. resonance
87. range = 0.163 m − 0.149 m = 0.014 m
88. 0.038 m
89. 2
90. $\lambda = 4\ell + 1.6d = 4(0.163 \text{ m}) + 1.6(0.032 \text{ m})$

$= 0.703 \text{ m}$

91. $v = 331\sqrt{1 + \frac{T_C}{273}} = 331 \text{ m/s}\sqrt{1 + \frac{21.5}{273}}$

$= 344 \text{ m/s}$

92. Percent Error $= \frac{\text{absolute error}}{\text{accepted value}} \times 100$

$= \frac{6 \text{ m/s}}{343 \text{ m/s}} \times 100 = 2\%$

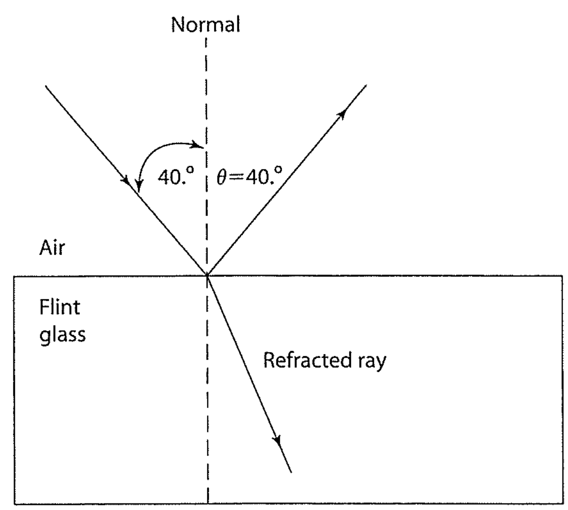
93. $3.75 \times 10^{12} \text{ W}$
94. Heat $= (0.75)(3.75 \times 10^{12} \text{ W})(1.5 \times 10^{-3} \text{ s})$

$= 4.2 \times 10^9 \text{ J}$

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

$t = \frac{d}{\bar{v}} = \frac{3.0 \times 10^4 \text{ m}}{3.31 \times 10^2 \text{ m/s}} = 91 \text{ s}$

96.



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

$\sin\theta_2 = \frac{n_1 \sin\theta_1}{n_2} = \frac{1.00 \sin 40.°}{1.66}$

$\theta_2 = 23°$

98. See question 96.

99. $n = \frac{c}{v}$, so $v = \frac{c}{n}$ and

$v = f\lambda$, so

$f\lambda = \frac{c}{n}$

$\lambda = \frac{c}{nf} = \frac{3.00 \times 10^8\ \text{m/s}}{1.66(5.09 \times 10^{14}\ \text{Hz})} = 3.55 \times 10^{-7}\ \text{m}$

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

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

$\sin\theta_2 = \frac{1.00 \sin 17°}{1.46}$

$\theta_2 = 12°$ *or* $11.6°$

101. The refracted ray makes an angle of 12°(±2°) with the normal.

102. The angles are measured with a protractor.

$\theta_1 = 45°$ and $\theta_2 = 30.°$

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

$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2} = \frac{1.33 \sin 45°}{\sin 30.°} = 1.88$

and $n = \frac{c}{v}$

$v = \frac{c}{n} = \frac{3.00 \times 10^8\ \text{m/s}}{1.88} = 1.60 \times 10^8\ \text{m/s}$

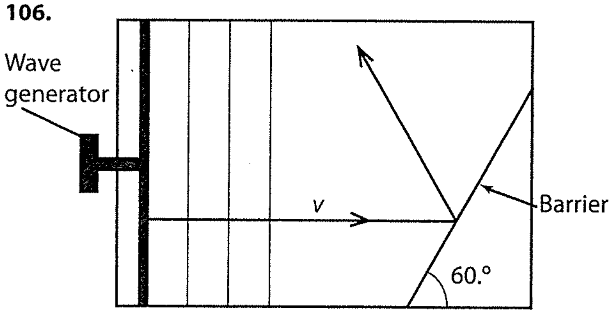
103. $T = \frac{1}{f} = \frac{1}{12\ \text{Hz}} = 0.083\ \text{s}$

104. 0.8 cm *or* 8 mm *or* 0.008 m

105. $v = f\lambda$

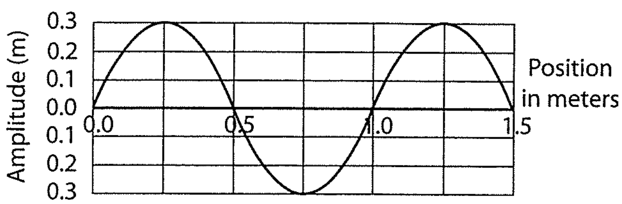
$v = (12\ \text{Hz})(0.8\ \text{cm}) = 10\ \text{cm/s}$

106.



The arrow forms an angle of 60.° ± 2° with the barrier and is directed away from the barrier, as shown.

107.



108. 0.3 m

109. 1.0 m

110. $T = \frac{1}{f}$

$f = \frac{1}{T}$

$f = \frac{1}{5.0\ \text{s}}$

$f = 0.20\ \text{Hz}$

111. $v = f\lambda$ $\qquad$ $\bar{v} = \frac{d}{t}$

$v = (0.20\ \text{Hz})(2.0\ \text{m})$ *or* $\bar{v} = \frac{2.0\ \text{m}}{5.0\ \text{s}}$

$v = 0.40\ \text{m/s}$ $\qquad$ $\bar{v} = 0.40\ \text{m/s}$

Answers To Topic 6

Review Questions

1. 2 **2.** 4 **3.** 3
4. 4 **5.** 1 **6.** 3
7. 4

8. $E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}\ \text{J}\cdot\text{s})(3.00 \times 10^8\ \text{m/s})}{4.00 \times 10^{-7}\ \text{m}}$

$= 4.97 \times 10^{-19}\ \text{J}$

9. 3 **10.** 3 **11.** 3
12. 1 **13.** 1 **14.** 4
15. 3 **16.** 3

17. $1.26 \times 10^{-18}\ \text{J}$

18. bright-line spectrum

19. 3 **20.** 4 **21.** 2
22. 1 **23.** 1

24. $n = 4$ to $n = 2$

25. $4.08 \times 10^{-19}\ \text{J}$

26. $E = hf$

$f = \frac{E}{h} = \frac{4.08 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J}\cdot\text{s}} = 6.15 \times 10^{14}\ \text{Hz}$

27. $E = \frac{hc}{\lambda}$

$E = \frac{(6.63 \times 10^{-34}\ \text{J}\cdot\text{s})(3.00 \times 10^8\ \text{m/s})}{6.58 \times 10^{-7}\ \text{m}}$

$E = 3.02 \times 10^{-19}\ \text{J}$

28. 1.89 eV

29. This value is consistent with the $n = 3$ to $n = 2$ transition of 1.89 eV.

30. $2.34 \times 10^{-18}\ \text{J}$

31. $E = hf$

$f = \frac{E}{h} = \frac{2.34 \times 10^{-18}\ \text{J}}{6.63 \times 10^{-34}\ \text{J}\cdot\text{s}} = 3.53 \times 10^{15}\ \text{Hz}$

32. 4 **33.** 2

34. $E = hf$

$f = \frac{E}{h}$

$= \frac{(-1.51\ \text{eV} - (-3.40\ \text{eV}))(1.60 \times 10^{-19}\ \text{J/eV})}{6.63 \times 10^{-34}\ \text{J}\cdot\text{s}}$

$= 4.56 \times 10^{14}\ \text{Hz}$

35. 3 **36.** 4 **37.** 1
38. 4 **39.** 1 **40.** 3
41. 2

42. $E = mc^2 = (2.50 \times 10^{-3}\ \text{kg})(3.00 \times 10^8\ \text{m/s})^2$
$= 2.25 \times 10^{14}\ \text{J}$

43. 3

44. $E = mc^2$

$m = \frac{E}{c^2} = \frac{9.90 \times 10^{-13}\ \text{J}}{(3.00 \times 10^8\ \text{m/s})^2} = 1.10 \times 10^{-29}\ \text{kg}$

45. 1 46. 1

47. 10^{-3} pm 48. 10^{-9} nm 49. 10^{36}

50. 2

51. The mass of the neutron is greater than the mass of the proton.

52. The charge on the electron antineutrino is zero *or* neutral.

53. 2 54. 3 55. +1e

56. 0e 57. 1 58. 3

59. 1.67×10^{-27} kg

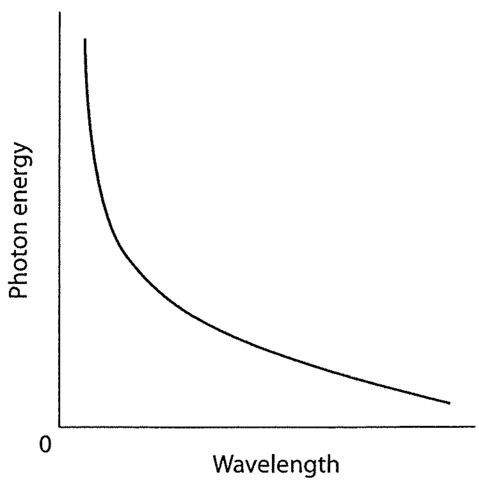
Regents Practice Questions

1. 2 2. 1 3. 3
4. 4 5. 3 6. 1
7. 4 8. 1 9. 3
10. 2 11. 3 12. 2
13. 2 14. 1

15. $\overline{uud}$

16. $E = hf = (6.63 \times 10^{-34}\ \text{J} \cdot \text{s})(5.00 \times 10^{15}\ \text{Hz})$
$= 3.32 \times 10^{-18}\ \text{J}$

17.



18. $v = f\lambda$

$\lambda = \frac{v}{f} = \frac{3.00 \times 10^8\ \text{m/s}}{1.00 \times 10^{18}\ \text{Hz}} = 3.00 \times 10^{-10}\ \text{m}$

19. $\Delta E_{photon} = \frac{hc}{\lambda_f} - \frac{hc}{\lambda_i} = hc\left(\frac{1}{\lambda_f - \lambda_i}\right)$

The energy gained by the electron equals the energy lost by the photon.

20. $E_{\text{photon}} = E_i - E_f = -5.74\ \text{eV} - (-3.71\ \text{eV})$
$= 2.03\ \text{eV}$

21. 3.25×10^{-19} J

22. $E = hf$

$f = \frac{E}{h} = \frac{3.25 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}} = 4.90 \times 10^{14}\ \text{Hz}$

23. Nothing would happen because it is not enough energy to excite the electron to level *b*.

24. 2

25. c^2, the speed of light in a vacuum squared

26. 4

27. $h = 6.63 \times 10^{-34}\ \text{J} \cdot \text{s}$

In fundamental units, 1 joule $= \frac{1\ \text{kilogram} \cdot \text{meter}^2}{\text{second}^2}$,
so 1 joule · second $= \frac{1\ \text{kilogram} \cdot \text{meter}^2}{\text{second}^2} \times$ second
$= \frac{1\ \text{kilogram} \cdot \text{meter}^2}{\text{second}}$

28. $(1.0087\ \text{u})(9.31 \times 10^2\ \text{MeV/u}) = 9.39 \times 10^2\ \text{MeV}$

29. $\Delta m = 3.0170\ \text{u} - [1.0073\ \text{u} + 2(1.0087\ \text{u})]$
$= 0.0077\ \text{u}$

30. $\underline{-1}$ e → $\underline{-1}$ e + $\underline{0}$ e + $\underline{0}$ e

31. 4

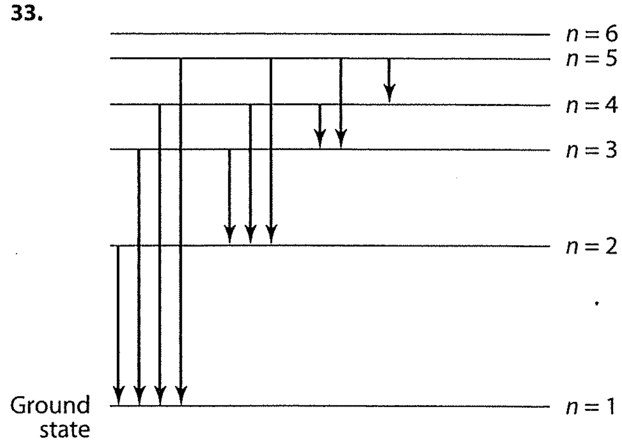
32. $E = mc^2$

$m = \frac{E}{c^2}$

$= \frac{(9.31 \times 10^2\ \text{MeV})(10^6\ \text{eV/MeV})(1.60 \times 10^{-19}\ \text{J/eV})}{(3.00 \times 10^8\ \text{m/s})^2}$

$= 1.66 \times 10^{-27}\ \text{kg}$

33.



34. $\lambda = \frac{h}{mv}$

$\lambda = \frac{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}}{(6.7 \times 10^{-27}\ \text{kg})(2.0 \times 10^6\ \text{m/s})}$

$\lambda = 4.9 \times 10^{-14}\ \text{m}$

35. The wavelength of the particle is of the same order of magnitude of gamma rays.

36. $r_n = \frac{n^2h^2}{4\pi^2 m_e k e^2}$

$= \frac{1^2(6.63 \times 10^{-34}\ \text{J} \cdot \text{s})^2}{4\pi^2(9.11 \times 10^{-31}\ \text{kg})(8.99 \times 10^9\ \text{N} \cdot \text{m}^2/\text{C}^2)(1.60 \times 10^{-19}\ \text{C})^2}$

$= 5.31 \times 10^{-11}\ \text{m}$

37. 5.31×10^{-2} nm

38. $\frac{r_{n=4}}{r_{n=2}} = \frac{\frac{4^2h^2}{4\pi^2 m_e k e^2}}{\frac{2^2h^2}{4\pi^2 m_e k e^2}} = \frac{4^2}{2^2} = \frac{16}{4} = \frac{4}{1}$

39. $E = mc^2 = 2(9.11 \times 10^{-31}\ \text{kg})(3.00 \times 10^8\ \text{m/s})^2$
$= 1.64 \times 10^{-13}\ \text{J}$

40. 5.13×10^5 eV

41. $E = hf$

$f = \frac{E}{h} = \frac{\frac{1}{2}(1.64 \times 10^{-13}\ \text{J})}{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}} = 1.24 \times 10^{20}\ \text{Hz}$

42. gamma ray *or* X-ray

43. $d = 1.67 \times 10^{-6}\ \text{m}$

44. $\sin\theta = \frac{50.4\text{ cm}}{193.9\text{ cm}} = 0.260$

45. $\lambda = d\sin\theta = (1.67 \times 10^{-6}\text{ m})(0.260)$
$= 4.34 \times 10^{-7}\text{ m}$

46. $4.35833 \times 10^{-7}\text{ m}$

47. $\text{Percent Error} = \frac{\text{absolute error}}{\text{accepted value}} \times 100$
$= \frac{0.02 \times 10^{-7}\text{ m}}{4.358\,33 \times 10^{-7}\text{ m}} \times 100 = 0.5\%$

48. $E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}\text{ J}\cdot\text{s})(3.00 \times 10^{8}\text{ m/s})}{4.34 \times 10^{-7}\text{ m}}$

$= 4.58 \times 10^{-19}\text{ J}$

49. 2.86 eV

50. *f* to *c*

51. $19.34 \times 10^{-19}\text{ J}$

or

$1.934 \times 10^{-18}\text{ J}$

52. $E = hf$

$f = \frac{E}{h}$

$f = \frac{19.34 \times 10^{-19}\text{ J}}{6.63 \times 10^{-34}\text{ J}\cdot\text{s}}$

$f = 2.92 \times 10^{15}\text{ Hz}$

or

$f = 2.92 \times 10^{15}\text{ 1/s}$

53. 0.018 63 u

54. 17.3 MeV

PHYSICS—JUNE 2012

Part A

1. 1	**2.** 3	**3.** 3
4. 3	**5.** 1	**6.** 4
7. 3	**8.** 3	**9.** 4
10. 2	**11.** 1	**12.** 1
13. 2	**14.** 4	**15.** 3
16. 4	**17.** 3	**18.** 1
19. 4	**20.** 4	**21.** 2
22. 2	**23.** 2	**24.** 1
25. 1	**26.** 1	**27.** 3
28. 2	**29.** 2	**30.** 2
31. 1	**32.** 4	**33.** 4
34. 2	**35.** 2	

Part B–1

36. 2	**37.** 3	**38.** 3
39. 4	**40.** 3	**41.** 3
42. 4	**43.** 1	**44.** 3
45. 2	**46.** 2	**47.** 1
48. 1	**49.** 4	**50.** 3

Part B–2

51. [1] Allow 1 credit for 20. N/m.

52. [1] Allow 1 credit for the equation and substitutions with units *or* for an answer that is consistent with the student's response to question 51. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 1-credit responses:

$$PE_s = \text{Area} = \frac{1}{2}bh$$

$$PE_s = \frac{1}{2}(0.30\text{ m})(6.00\text{ N})$$

or

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

$$PE_s = \frac{1}{2}(20.\text{ N/m})(0.30\text{ m})^2$$

53. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 52.

Example of a 1-credit response:

$PE_s = 0.90$ J

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 52–53.

54. [1] Allow 1 credit for the equation and substitutions with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 1-credit responses:

$$F_{net}\,t = \Delta p$$

$$t = \frac{\Delta p}{F_{net}}$$

$$t = \frac{(1200.\text{ kg})(-10.\text{ m/s})}{-6000.\text{ N}}$$

or

$$F = ma$$

$$a = \frac{F}{m}$$

$$a = \frac{6000.\text{ N}}{1200\text{ kg}}$$

$$a = 5\text{ m/s}^2$$

$$a = \frac{\Delta v}{t}$$

$$t = \frac{\Delta v}{a}$$

$$t = \frac{10\text{ m/s}}{5\text{ m/s}^2}$$

Note: Δp, F_{net}, and Δv must be in the same sign.

55. Allow 1 credit for the correet answer with units *or* for an answer that is consistent with the student's response to question 54.

Example of a 1-credit response:

$t = 2.0$ s

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 54–55.

56. [1] Allow 1 credit for stating that the total horizontal distance would decrease.

57. [1] Allow 1 credit for stating that the time in the air would increase.

58. [1] Allow 1 credit for the equation and substitutions with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of 1-credit response:

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

$$F_g = \frac{(6.67\times10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2)(5.98\times10^{24}\,\text{kg})(7.35\times10^{22}\,\text{kg})}{(3.84\times10^{8}\,\text{m})^2}$$

59. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 58.

Example of a 1-credit response:

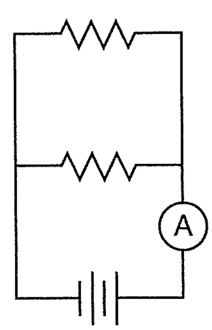
$F_g = 1.99 \times 10^{20}$ N

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 58–59.

60. [1] Allow 1 credit for drawing a parallel circuit containing two resistors *or* lamps and a battery *or* a cell.

61. [1] Allow 1 credit for correct placement of the ammeter.

Example of a 2-credit response for questions 60–61:



62. [1] Allow 1 credit for the equation and substitutions with units *or* for an answer that is consistent with the student's response to question 60. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{15\ \Omega} + \frac{1}{20.\ \Omega}$$

63. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 62.

Example of a 1-credit response:

$R_{eq} = 8.6\ \Omega$

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 62–63.

64. [1] Allow 1 credit for 3.2 m.

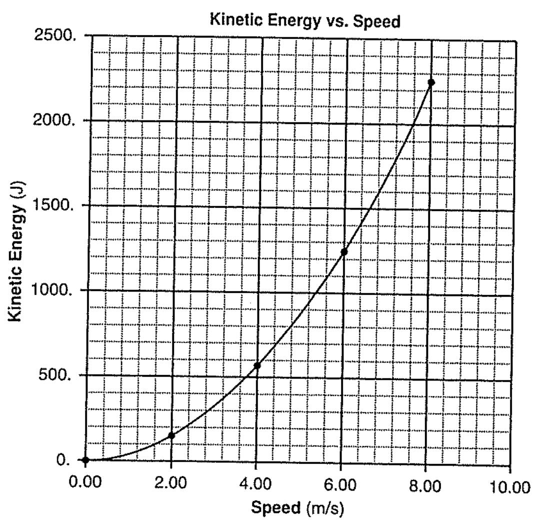
65. [1] Allow 1 credit for 0.60 m.

Part C

66. [1] Allow 1 credit for correctly plotting all points ± 0.3 grid space.

67. [1] Allow 1 credit for drawing the line or curve of best fit.

Example of a 2-credit graph for questions 66 and 67:



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

68. [1] Allow 1 credit for the equation and substitutions with units *or* for an answer that is consistent with the student's response to question 67. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$KE = \frac{1}{2}mv^2$$

$$m = \frac{2\,KE}{v^2}$$

$$m = \frac{2(140.\ \text{J})}{(2.00\ \text{m/s})^2}$$

69. [1] Allow 1 credit for the correct answer with units *or* for an answer consistent with the student's response to question 67 and/or 68.

Example of a 1-credit response:

70.0 kg

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 68–69.

70. [1] Allow 1 credit for indicating that the less massive soccer player has less kinetic energy.

71. [1] Allow 1 credit for the equation and substitutions with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

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

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

$$t = \frac{75\ \text{m}}{3.0\ \text{m/s}}$$

72. [1] Allow 1 credit for the correct answer with units *or* for an answer consistent with the student's response to question 71.

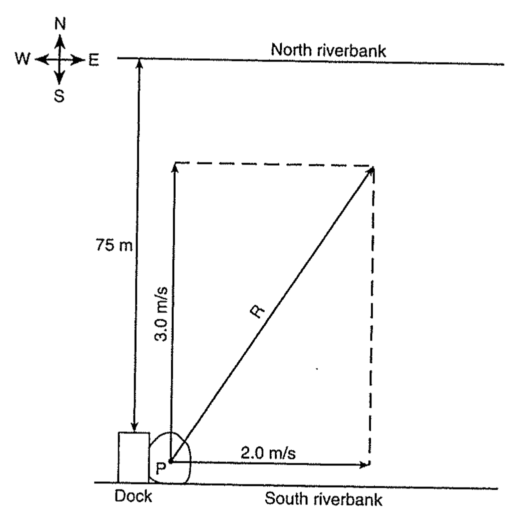
Example of a 1-credit response:

$t = 25$ s

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 71–72.

73. [1] Allow 1 credit for a vector 4.0 cm ± 0.2 cm long, directed to the east. Do *not* allow credit if the arrowhead is missing *or* if the arrowhead is pointing in the wrong direction.

Example of a 1-credit response for question 73 and a 1-credit response for question 74:



Note: Allow credit even if the vector does *not* start at point *P*.

The graphical solution for the resultant, *R*, shown above, represents the graphical response to question 74.

74. [1] Allow 1 credit for the equation and substitutions with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of a 1-credit responses:

$c^2 = a^2 + b^2$

$c^2 = (3.0\,\text{m/s})^2 + (2.0\,\text{m/s})^2$

or

$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

$$\tan\theta = \frac{3.0\text{ m/s}}{2.0\text{ m/s}}$$

$$\theta = 56°$$

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\text{hypotenuse} = \frac{3.0\text{ m/s}}{\sin 56°}$$

or

For a graphic response, allow 1 credit for constructing a vector diagram in the student answer space for question 73, with a resultant vector 7.2 cm ± 0.2 cm long *or* for an answer that is consistent with the student's response to question 73. To receive this credit, the arrowheads must be correctly drawn.

75. [1] Allow 1 credit for the eorrect answer with units *or* for an answer that is consistent with the student's response to question 73 and/or 74.

Examples of a 1-credit responses:

$c = 3.6$ m/s *or* hypotenuse = 3.6 m/s *or* $R = 3.6$ m/s

or

For a graphic response, allow 1 credit for 3.6 m/s ± 0.1 m/s.

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 74–75.

76. [1] Allow 1 credit for 37° ± 2°.

77. [1] Allow 1 credit for the equation and substitutions with units *or* for an answer that is consistent with the student's response to question 76. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

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

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

$$\sin\theta_1 = \frac{1.66 \sin 37°}{1.33}$$

78. [1] Allow 1 credit for the correct answer with units *or* for an answer consistent with the student's response to question 77.

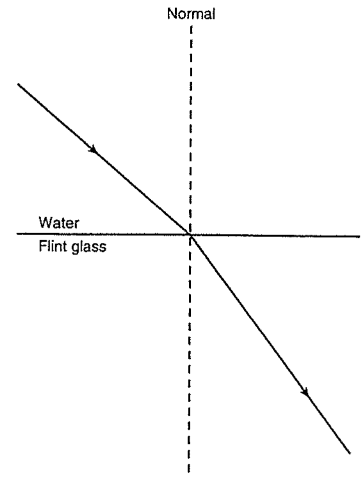
Example of a 1-credit response:

$\theta_1 = 49°$

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 77–78.

79. [1] Allow 1 credit for drawing the incident ray at an angle of incidence of 49° ± 2°.

Example of a 1-credit response:



Note: Allow credit for an answer that is consistent with the student's response to question 78.

80. [1] Allow 1 credit. Acceptable responses include, but are not limited to:
- — reflection
- — absorption
- — The speed of the wave decreases upon entering the flint glass.
- — wavelength decreases

81. [1] Allow 1 credit for udd *or* up, down, down.

82. [1] Allow 1 credit for $-1e$. Do *not* allow credit if the negative sign is missing.

83. [1] Allow 1 credit for 1.60×10^{-7} J.

84. [1] Allow 1 credit for the equation and substitutions with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of a 1-credit responses:

$$E = mc^2$$

$$m = \frac{E}{c^2}$$

$$m = \frac{2(1.60 \times 10^{-7}\text{ J})}{(3.00 \times 10^8\text{ m/s})^2}$$

or

$E = mc^2$ (m_p) mass of proton

$m = \frac{E}{c^2}$ ($m_{\bar{p}}$) mass of antiproton

$$m_{total} = m + m_p + m_{\bar{p}}$$

$$m_{total} = \frac{E}{c^2} + m_p + m_{\bar{p}}$$

$$m_{total} = \frac{2(1.60 \times 10^{-7}\text{ J})}{(3.00 \times 10^8\text{ m/s})^2} + 1.67 \times 10^{-27}\text{ kg} + 1.67 \times 10^{-27}\text{ kg}$$

85. [1] Allow 1 credit for the correct answer with units *or* for an answer consistent with the student's response to question 84.

Examples of a 1-credit responses:

$m = 3.56 \times 10^{-24}$ kg *or* $m_{total} = 3.56 \times 10^{-24}$ kg

Note: Do *not* penalize the student more than 1 credit for errors in units in questions 84–85.

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Part A

1. 1	**2.** 2	**3.** 1
4. 4	**5.** 3	**6.** 1
7. 1	**8.** 4	**9.** 3
10. 4	**11.** 2	**12.** 4
13. 2	**14.** 3	**15.** 2
16. 3	**17.** 1	**18.** 4
19. 2	**20.** 2	**21.** 1
22. 3	**23.** 3	**24.** 1
25. 1	**26.** 4	**27.** 3
28. 2	**29.** 2	**30.** 1
31. 3	**32.** 2	**33.** 3
34. 4	**35.** 4	

Part B–1

36. 2	**37.** 1	**38.** 3
39. 3	**40.** 3	**41.** 2
42. 2	**43.** 4	**44.** 4
45. 1	**46.** 2	**47.** 4
48. 3	**49.** 3	**50.** 1

Part B–2

51. [1] Allow 1 credit for the equation and substitution with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$a = \frac{F_{net}}{m}$$

$$F_{net} = ma$$

$$F_{net} = (0.50\text{ kg})(3.0\text{ m/s}^2)$$

52. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 51.

Example of a 1-credit response:

$F_{net} = 1.5\text{ N}$

53. [1] Allow 1 credit for 850 N.

54. [1] Allow 1 credit for the equation and substitution with units *or* for an answer that is consistent with the student's response to question 53. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$F_f = \mu F_N$

$F_f = (0.05)(850\text{ N})$

55. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 54.

Example of a 1-credit response:

$F_f = 40\text{ N}$

56. [1] Allow 1 credit for the equation and substitution with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2}(3.34 \times 10^{-27}\text{ kg})(2.89 \times 10^5\text{m/s})^2$$

57. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 56.

Example of a 1-credit response:

$KE = 1.39 \times 10^{-16}\text{ J}$

58. [1] Allow 1 credit for 20. Ω.

59. [1] Allow 1 credit. Acceptable responses include, but are not limited to:

— power

— the rate at which work is done

Note: Do *not* allow credit for a linear relationship.

60. [1] Allow 1 credit for the equation and substitution with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$P = \frac{V^2}{R}$$

$$P = \frac{(12\text{V})^2}{1.2\Omega}$$

61. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 60.

Example of a 1-credit response:

$P = 120\text{ W}$

62. [1] Allow 1 credit for the equation and substitution with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

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

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

$$\lambda_2 = \frac{1.00(5.89 \times 10^{-7}\text{m})}{1.47}$$

63. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 62.

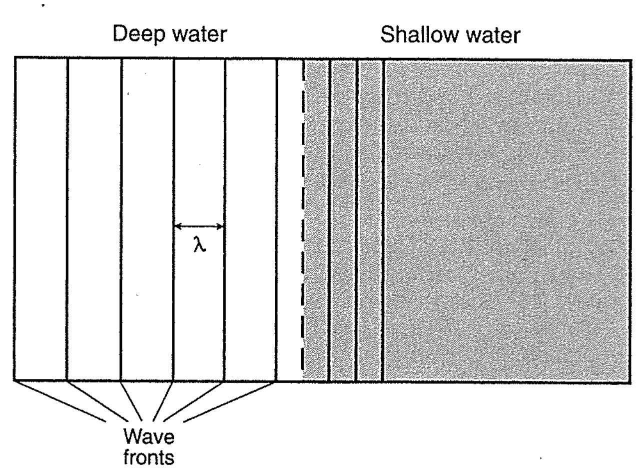
Example of a 1-credit response:

$\lambda_2 = 4.01 \times 10^{-7}\text{m}$

64. [1] Allow 1 credit for 4.22×10^{-2} u.

65. [1] Allow 1 credit for a minimum of *three* wave fronts, approximately evenly spaced, drawn parallel to each other and to the original wave fronts, *and* spaced closer together than the original wave fronts.

Example of a 1-credit response:



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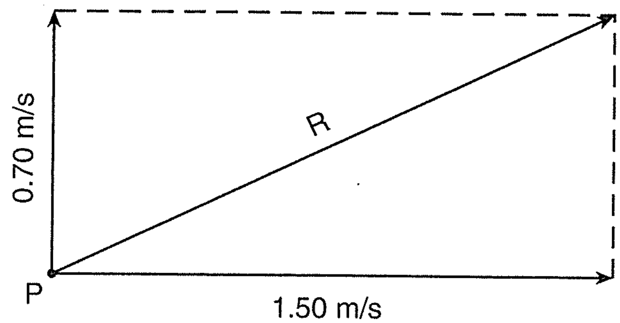
Part C

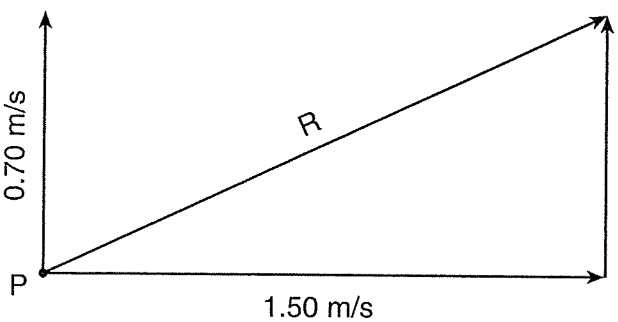
66. [1] Allow 1 credit for 1.0 cm = 0.20 m/s ± 0.04 m/s.

67. [1] Allow 1 credit for constructing the resultant 8.3 cm ± 0.2 cm long at an angle of 65° ± 2° east of north.

Examples of 1-credit responses:



or



Note: The resultant vector need *not* be labeled to receive this credit.

68. [1] Allow 1 credit for 1.7 m/s *or* an answer that is consistent with the student's response to questions 66 and 67.

69. [1] Allow 1 credit for 65° ± 2° *or* an answer that is consistent with the student's response to questions 67 and/or 68.

70. [1] Allow 1 credit for the equation and substitution with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$F_s = kx$$
$$x = \frac{F_s}{k} = \frac{\text{mg}}{k}$$
$$x = \frac{(2.00\ \text{kg})(9.81\ \text{m/s}^2)}{150.\ \text{N/m}}$$

71. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 70.

Example of a 1-credit response:

$$x = 0.131\ \text{m}$$

72. [1] Allow 1 credit for the equation and substitution with units, *or* for an answer that is consistent with the student's response to question 71. Refer to *Scoring Criteria for Calculations* in this rating guide.

$$PE_s = \frac{1}{2}kx^2$$
$$PE_s = \frac{1}{2}(150.\ \text{N/m})(0.131\ \text{m})^2$$

73. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 72.

Example of a 1-credit response:

$$PE_s = 1.29\ \text{J}$$

74. [1] Allow 1 credit for 6.00 Ω.

75. [1] Allow 1 credit for the equation and substitution with units, *or* for an answer that is consistent with the student's response to question 74. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$R = \frac{\rho L}{A}$$
$$A = \frac{\rho L}{R}$$
$$A = \frac{(150. \times 10^{-8}\Omega \cdot \text{m})(0.100\text{m})}{6.00\Omega}$$

76. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 75.

Example of a 1-credit response:

$$A = 2.50 \times 10^{-8}\text{m}^2$$

77. [1] Allow 1 credit for equation and substitution with units. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$E_{photon} = \frac{hc}{\lambda}$$
$$E_{photon} = \frac{(6.63 \times 10^{-34}\text{J} \cdot \text{s})(3.00 \times 10^8\text{m/s})}{2.29 \times 10^{-7}\text{m}}$$

78. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 77.

Example of a 1-credit response:

$$E_{photon} = 8.69 \times 10^{-19}\ \text{J}$$

79. [1] Allow 1 credit for 5.43 eV *or* an answer that is consistent with the student's response to question 78.

80. [1] Allow 1 credit for indicating that the photon can be absorbed and explaining that the energy of the photon is exactly equal to the energy-level difference between the ground state and level *d*.

Note: Allow credit for an answer that is consistent with the student's response to question 79.

81. [1] Allow 1 credit for 41° ± 2°.

82. [1] Allow 1 credit for equation and substitution with units, *or* for an answer that is consistent with the student's response to question 81. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2}$$
$$n_2 = \frac{(1.00)(\sin 41°)}{\sin 20.°}$$

83. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 82.

Example of a 1-credit response:

$$n_2 = 1.9$$

84. [1] Allow 1 credit for equation and substitution with units, *or* for an answer that is consistent with the student's response to question 82 and/ or 83. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 1-credit response:

$$n = \frac{c}{v} \qquad \frac{n_2}{n_1} = \frac{v_1}{v_2}$$

$$v = \frac{c}{n} \qquad \textit{or} \qquad v_2 = \frac{n_1 v_1}{n_2}$$

$$v = \frac{3.00 \times 10^8 \text{ m/s}}{1.9} \qquad v_2 = \frac{(1.00)(3.00 \times 10^8 \text{ m/s})}{1.9}$$

85. [1] Allow 1 credit for the correct answer with units *or* for an answer that is consistent with the student's response to question 84.

Example of a 1-credit response:

$v = 1.6 \times 10^8$ m/s

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Chart for Converting Total Test Raw Scores to
Final Examination Scores (Scale Scores)

Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score
85	100	63	81	41	58	19	30
84	99	62	80	40	56	18	28
83	98	61	79	39	55	17	27
82	98	60	78	38	54	16	26
81	97	59	77	37	53	15	24
80	96	58	76	36	52	14	23
79	95	57	75	35	51	13	21
78	94	56	74	34	49	12	20
77	93	55	73	33	48	11	18
76	93	54	72	32	47	10	17
75	92	53	71	31	46	9	15
74	91	52	70	30	44	8	14
73	90	51	69	29	43	7	12
72	89	50	67	28	42	6	10
71	88	49	66	27	41	5	9
70	87	48	65	26	39	4	7
69	86	47	64	25	38	3	5
68	85	46	63	24	37	2	4
67	84	45	62	23	35	1	2
66	83	44	61	22	34	0	0
65	83	43	60	21	33		
64	82	42	59	20	31		

Part A

1. 2	**2.** 3	**3.** 3
4. 4	**5.** 4	**6.** 1
7. 2	**8.** 1	**9.** 4
10. 4	**11.** 3	**12.** 3
13. 2	**14.** 4	**15.** 3
16. 3	**17.** 2	**18.** 2
19. 1	**20.** 2	**21.** 3
22. 2	**23.** 3	**24.** 4
25. 2	**26.** 1	**27.** 4
28. 3	**29.** 1	**30.** 1
31. 3	**32.** 4	**33.** 1
34. 3	**35.** 2	

Part B–1

36. 2	**37.** 4	**38.** 2
39. 4	**40.** 3	**41.** 2
42. 4	**43.** 3	**44.** 3
45. 1	**46.** 4	**47.** 1
48. 3	**49.** 1	**50.** 3

For each question requiring the student to *determine* the answer, apply the following scoring criteria:

- Allow credit if the answer is not expressed with the correct number of significant figures.
- Do not penalize a student for a rounding error or if the answer is truncated.

For each question requiring the student to *show all calculations, including the equation and substitution with units*, apply the following scoring criteria:

Scoring Criteria for Parts Calculations

- Allow 1 credit for the equation and substitution of values with units. If the equation and/or substitution with units is not shown, do *not* allow this credit. Allow credit if the student has listed the values with units and written a correct equation.
- Allow 1 credit for the correct answer (number and unit). If the number is given without the unit, allow credit if the credit for units was previously deducted for this calculation problem.
- Penalize a student only once per calculation problem for incorrect or omitted units.
- Allow credit if the answer is not expressed with the correct number of significant figures.
- Do not penalize a student for a rounding error or if the answer is truncated.

Part B–2

51. [1] Allow 1 credit for 25 m/s ± 1 m/s.

52. [1] Allow 1 credit for 39° ± 2°.

Note: Allow credit for an answer that is consistent with the student's response to question 51.

53. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

$$v_{ix} = v_i \cos\theta$$

$$v_{ix} = (40.\text{ m/s})\cos 39°$$

$$v_{ix} = 31\text{ m/s}$$

or

$$v_{ix}{}^2 + v_{iy}{}^2 = v_i{}^2$$

$$v_{ix} = \sqrt{v_i^2 - v_{iy}{}^2}$$

$$v_{ix} = \sqrt{(40.\text{ m/s})^2 - (25\text{ m/s})^2}$$

$$v_{ix} = 31\text{ m/s}$$

Note: Allow credit for an answer that is consistent with the student's response to question 51 or 52.

54. [1] Allow 1 credit. Acceptable responses include, but are not limited to:

— friction

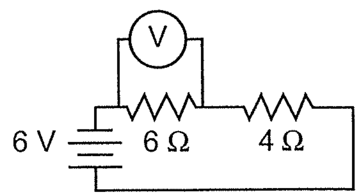
— Some of the gravitational energy of the mass was converted into internal energy. Therefore, it could not return to its original height.

— air resistance

55. [2] Allow a maximum of 2 credits, allocated as follows:

- Allow 1 credit for drawing a series circuit containing two resistors and a battery.
- Allow 1 credit for correct placement of the voltmeter.

Example of a 2-credit response:



Note: Allow credit even if the student draws a cell instead of a battery and/or labels only one resistor with its value.

56. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$$k = \frac{2PE_s}{x^2}$$

$$k = \frac{2(1.25 \times 10^{-2}\text{ J})}{(2.50 \times 10^{-2}\text{ m})^2}$$

$$k = 40.0\text{ N/m}$$

57. [1] Allow 1 credit for 6.25×10^{-2} Ω.

58. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$$\rho = \frac{RA}{L}$$

$$\rho = \frac{(6.25 \times 10^{-2}\ \Omega)(3.14 \times 10^{-6}\text{ m}^2)}{3.50\text{ m}}$$

$$\rho = 5.61 \times 10^{-8}\ \Omega \cdot \text{m}$$

Note: Allow credit for an answer that is consistent with the student's response to question 57.

59. [1] Allow 1 credit for 6.3 m/s.

60. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$F_c = ma_c \qquad a_c = \frac{v^2}{r}$

$F_c = \frac{mv^2}{r}$

$F_c = \frac{(0.028 \text{ kg})(6.3 \text{ m/s})^2}{1.0 \text{ m}}$

$F_c = 1.1 \text{ N}$

Note: Allow credit for an answer that is consistent with the student's response to question 59.

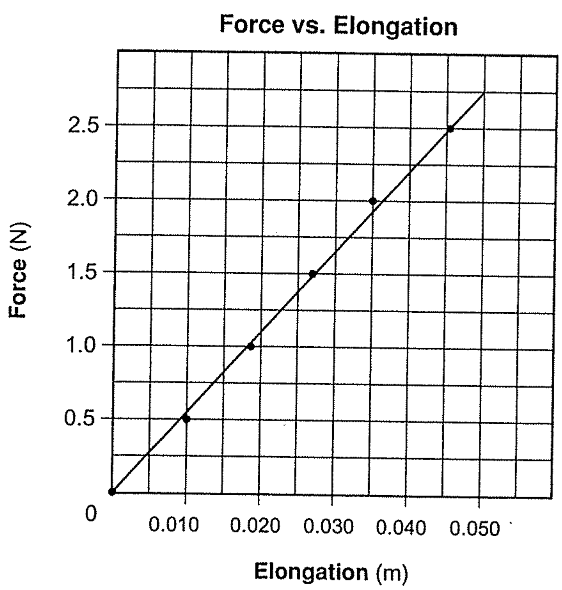
Part C

61. [1] Allow 1 credit for an appropriate linear scale.

62. [1] Allow 1 credit for plotting all points accurately ± 0.3 grid space.

63. [1] Allow 1 credit for drawing the best-fit line or curve consistent with the student's responses to questions 61 and 62.

Example of a 3-credit graph for questions 61–63:



64. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

$k = \frac{\Delta F}{\Delta x}$

$k = \frac{2.5 \text{ N}}{0.046\ m}$

$k = 54 \text{ N/m}$

or

$\text{slope} = \frac{\Delta y}{\Delta x}$

$\text{slope} = \frac{2.5 \text{ N} - 0.8 \text{ N}}{0.046 \text{ m} - 0.015 \text{ m}}$

$\text{slope} = 55 \text{ N/m}$

Note: Allow credit for an answer that is consistent with the student's graph. The slope may be determined by substitution of values from the data table only if the data points are on the best-fit line *or* if the student failed to draw a best-fit line.

65. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$a = \frac{F_{net}}{m}$

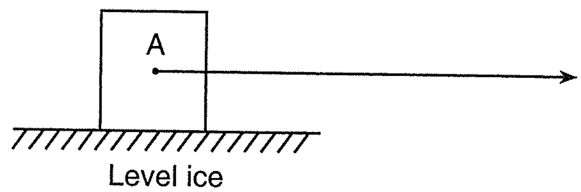
$F_{net} = ma$

$F_{net} = (20.\text{ kg})(1.4 \text{ m/s}^2)$

$F_{net} = 28 \text{ N}$

66. [1] Allow 1 credit for a vector 5.6 cm ± 0.2 cm long parallel to the surface of the ice and pointing to the right.

Example of a 1-credit response:



Note: Allow credit for an answer that is consistent with the student's response to question 65. The vector need *not* start at point *A* to receive this credit.

67. [1] Allow 1 credit for 2.0×10^2 N *or* 196 N.

68. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$F_f = \mu F_N$

$F_f = (0.28)(2.0 \times 10^2 \text{ N})$

$F_f = 56 \text{ N}$

Note: Allow credit for an answer that is consistent with the student's response to question 67.

69. [1] Allow 1 credit for 50.° ± 2°.

70. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

$\sin \theta_2 = \frac{1.00 (\sin 50.°)}{1.50}$

$\theta_2 = 31°$

Note: Allow credit for an answer that is consistent with the student's response to question 69.

71. [1] Allow 1 credit for 50.°.

Note: Allow credit for an answer that is consistent with the student's response to question 69 or 70.

72. [1] Allow 1 credit for 1.24 eV.

73. [1] Allow 1 credit for 1.98×10^{-19} J *or* an answer that is consistent with the student's response to question 72.

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74. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$E_{photon} = hf$

$f = \frac{E_{photon}}{h}$

$f = \frac{1.98 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}}$

$f = 2.99 \times 10^{14}\ \text{Hz}$

Note: Allow credit for an answer that is consistent with the student's response to question 73.

75. [1] Allow 1 credit for infrared *or* an answer that is consistent with the student's response to question 74.

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Chart for Converting Total Test Raw Scores to Final Examination Scores (Scale Scores)

Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score
85	100	63	80	41	59	19	32
84	99	62	79	40	58	18	31
83	98	61	78	39	57	17	30
82	97	60	77	38	56	16	28
81	96	59	76	37	55	15	27
80	95	58	75	36	54	14	25
79	94	57	74	35	52	13	23
78	93	56	73	34	51	12	22
77	92	55	72	33	50	11	20
76	92	54	72	32	49	10	19
75	91	53	71	31	48	9	17
74	90	52	70	30	47	8	15
73	89	51	69	29	45	7	14
72	88	50	68	28	44	6	12
71	87	49	67	27	43	5	10
70	86	48	66	26	42	4	8
69	85	47	65	25	40	3	6
68	84	46	64	24	39	2	4
67	83	45	63	23	38	1	2
66	82	44	62	22	37	0	0
65	82	43	61	21	35		
64	81	42	60	20	34		

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Allow 1 credit for each correct response.

Part A

1. 3	**2.** 4	**3.** 1
4. 4	**5.** 3	**6.** 2
7. 2	**8.** 3	**9.** 4
10. 2	**11.** 3	**12.** 4
13. 2	**14.** 3	**15.** 3
16. 1	**17.** 1	**18.** 3
19. 2	**20.** 3	**21.** 4
22. 1	**23.** 2	**24.** 1
25. 2	**26.** 2	**27.** 3
28. 4	**29.** 2	**30.** 1
31. 4	**32.** 4	**33.** 2
34. 4	**35.** 1	

Part B–1

36. 1	**37.** 1	**38.** 3
39. 2	**40.** 4	**41.** 3
42. 3	**43.** 1	**44.** 4
45. 1	**46.** 4	**47.** 3

Scoring Criteria for Calculations

For each question requiring the student to show *all calculations, including the equation and substitution with units,* apply the following scoring criteria:

- Allow 1 credit for the equation and substitution of values with units. If the equation and/or substitution with units is not shown, do *not* allow this credit.
- Allow 1 credit for the correct answer (number and unit). If the number is given without the unit, do *not* allow this credit.
- Penalize a student only once per equation for omitting units.
- Allow full credit even if the answer is not expressed with the correct number of significant figures.

Part B–2

48. [1] Allow 1 credit for 5.66 m.

49. [1] Allow 1 credit for 50 N.

50. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

$p_{before} = p_{after}$

$m_1v_1 + m_2v_2 = 0$

$v_1 = \frac{-m_2v_2}{m_1}$

$v_1 = \frac{-(2.5 \times 10^3 \text{ kg})(8.0 \text{ m/s})}{1.1 \times 10^3 \text{ kg}}$

$v_1 = -18$ m/s *or* 18 m/s

or

$m_1v_1 = m_2v_2$

$(1.1 \times 10^3 \text{ kg})v_1 = (2.5 \times 10^3 \text{ kg})(8.0 \text{ m/s})$

$v_1 = 18$ m/s

51. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$F_c = \frac{mv^2}{r}$

$v = \sqrt{\frac{F_cr}{m}}$

$v = \sqrt{\frac{(36 \text{ N})(5.0 \text{ m})}{20. \text{ kg}}}$

$v = 3.0$ m/s

52. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$F_s = kx$

$k = \frac{F_s}{x}$

$k = \frac{10. \text{ N}}{0.25 \text{ m}}$

$k = 40.$ N/m

53. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

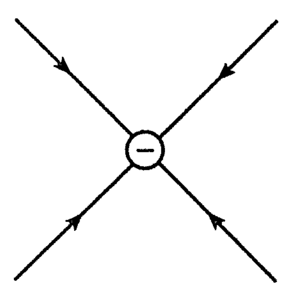
$E = \frac{F_e}{q}$

$E = \frac{3.60 \times 10^{-15} \text{ N}}{1.60 \times 10^{-19} \text{ C}}$

$E = 2.25 \times 10^4$ N/C

54. [1] Allow 1 credit for *at least four* straight lines drawn perpendicular to the surface of the sphere with each line having an arrowhead directed toward the sphere and ending within 0.2 cm of the sphere.

Example of a 1-credit response:

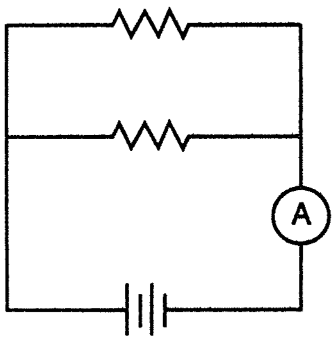


Note: Allow credit even if the lines are *not* drawn symmetrically.

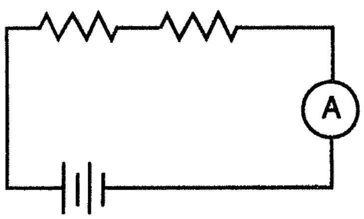
55. [2] Allow a maximum of 2 credits, allocated as follows:

- Allow 1 credit for two resistors connected in parallel with the battery (or cell) in a complete circuit.
- Allow 1 credit for an ammeter connected in the circuit to measure the total current.

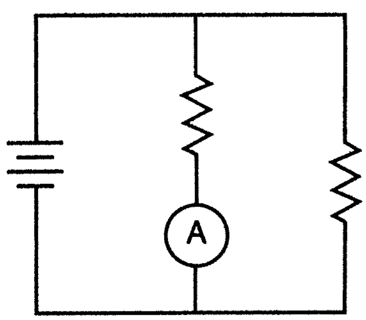
Example of a 2-credit response:



Examples of 1-credit responses:



or



Note: Allow credit for lines *not* touching the battery if the distance from the lines to the battery is ≤ the distance between the battery symbol lines.

56. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P}$$

$$R = \frac{(120\text{ V})^2}{900.\text{ W}}$$

$$R = 16\ \Omega$$

57. [1] Allow 1 credit. Acceptable responses include, but are not limited to:

— north and south
— up and down
— perpendicular to spring
— left and right

Note: Do *not* allow credit for back and forth or east and west.

58. [1] Allow 1 credit for 1.5 m.

59. [1] Allow 1 credit for indicating that the wavelength is shorter while the speaker is moving *or* for an answer that is consistent with the student's response to question 58.

Part C

60. [1] Allow 1 credit for 16 m/s.

61. [1] Allow 1 credit for 4.9 m/s.

62. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$$d_y = (4.9\text{ m/s})(0.50\text{ s}) + \frac{1}{2}(9.81\text{ m/s}^2)(0.50\text{ s})^2$$

$$d_y = 3.7\text{ m}$$

Note: Allow credit for an answer that is consistent with the student's response to question 61.

63. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

$$\Delta h = \frac{3.13 \times 10^5\text{ J}}{(290.\text{ kg})(9.81\text{ m/s}^2)}$$

$$\Delta h = 110.\text{ m}$$

64. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$KE = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2KE}{m}}$$

$$v = \sqrt{\frac{2(3.13 \times 10^5\text{ J})}{290.\text{ kg}}}$$

$$v = 46.5\text{ m/s}$$

65. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$a = \frac{\Delta v}{t}$$

$$a = \frac{46.5\text{ m/s}}{5.3\text{ s}}$$

$$a = 8.8\text{ m/s}^2$$

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

66. [1] Allow 1 credit for 3.0 m *or* 3 m.

67. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$v = f\lambda$

$v = (20.0 \text{ Hz})(3.0 \text{ m})$

$v = 60. \text{ m/s}$

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

68. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

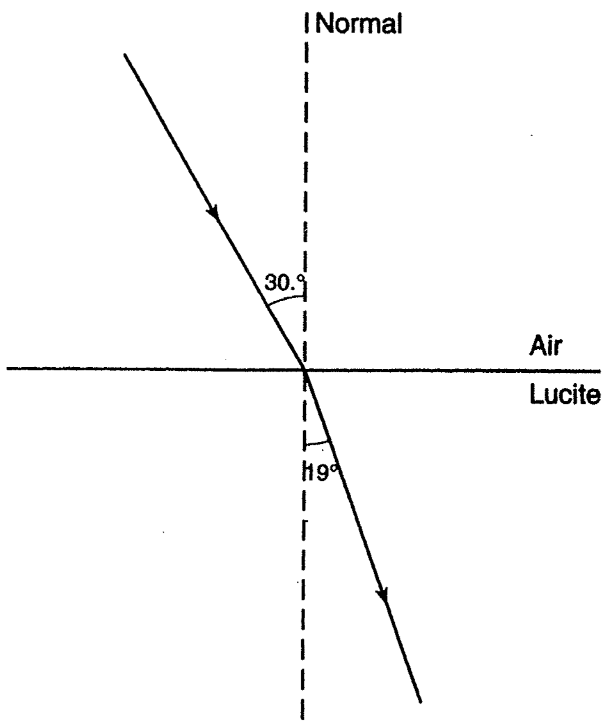
$$\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2}$$

$$\sin \theta_2 = \frac{(1.00)(\sin 30.°)}{1.50}$$

$\theta_2 = 19°$

69. [1] Allow 1 credit for a response correctly showing the refracted ray at 19° ± 2° to the normal.

Example of a 1-credit response:



Note: Allow credit even if the arrowhead is missing.

Allow credit for an answer that is consistent with the student's response to question 68.

70. [1] Allow 1 credit for green.

71. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in the rating guide.

Example of a 2-credit response:

$E_{photon} = hf$

$E_{photon} = (6.63 \times 10^{-34} \text{ J} \cdot \text{s})(5.48 \times 10^{14} \text{ Hz})$

$E_{photon} = 3.63 \times 10^{-19} \text{ J}$

72. [1] Allow 1 credit for 2.27 eV.

Note: Allow credit for an answer that is consistent with the student's response to question 71.

Regents Examination in Physical Setting / Physics
June 2009

Chart for Converting Total Test Raw Scores to Final Examination Scores (Scale Scores)

Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score
85	100	63	79	41	58	19	32
84	99	62	78	40	57	18	31
83	98	61	77	39	56	17	29
82	97	60	76	38	54	16	28
81	96	59	75	37	53	15	26
80	95	58	74	36	52	14	25
79	94	57	73	35	51	13	23
78	93	56	72	34	50	12	22
77	92	55	71	33	49	11	20
76	91	54	70	32	48	10	19
75	90	53	69	31	47	9	17
74	89	52	68	30	46	8	15
73	88	51	67	29	44	7	14
72	87	50	66	28	43	6	12
71	86	49	65	27	42	5	10
70	85	48	64	26	41	4	8
69	84	47	64	25	40	3	6
68	83	46	63	24	39	2	4
67	82	45	62	23	37	1	2
66	81	44	61	22	36	0	0
65	80	43	60	21	35		
64	79	42	59	20	33		

PHYSICS–JANUARY 2009

Allow 1 credit for each correct response.

Part A

1. 4	**2.** 2	**3.** 3
4. 1	**5.** 3	**6.** 3
7. 4	**8.** 3	**9.** 2
10. 4	**11.** 1	**12.** 1
13. 3	**14.** 4	**15.** 1
16. 2	**17.** 2	**18.** 2
19. 1	**20.** 1	**21.** 3
22. 1	**23.** 4	**24.** 2
25. 3	**26.** 2	**27.** 3
28. 1	**29.** 4	**30.** 4
31. 1	**32.** 1	**33.** 3
34. 2	**35.** 3	

Part B–1

36. 2	**37.** 3	**38.** 1
39. 1	**40.** 2	**41.** 1
42. 1	**43.** 4	**44.** 4
45. 3	**46.** 1	

Part B–2

47. [2] Allow a maximum of 2 credits, allocated as follows:

- Allow 1 credit for a magnitude of 120. m.
- Allow 1 credit for a direction of east.

48. [2] Allow a maximum of 2 credits, allocated as follows:

- Allow 1 credit for a magnitude of 8.0×10^3 m/s^2.
- Allow 1 credit for a direction of east.

49. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

$$a = \frac{F_{net}}{m}$$

$$F_{net} = ma$$

$$F_{net} = (0.14 \text{ kg})(8.0 \times 10^3 \text{ m/s}^2)$$

$$F_{net} = 1.1 \times 10^3 \text{ N}$$

or

$$J = F_{net}t = \Delta p$$

$$F_{net} = \frac{m\Delta v}{t}$$

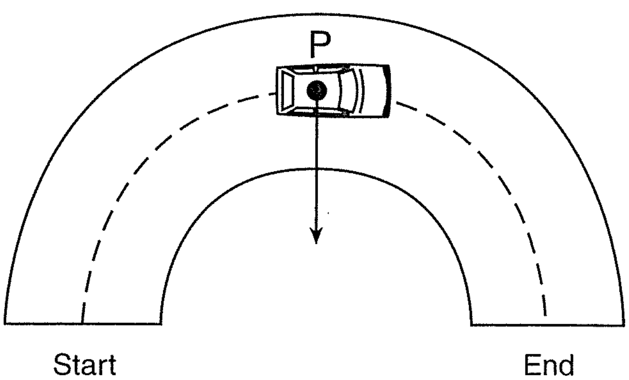
$$F_{net} = \frac{(0.14 \text{ kg})(80 \text{ m/s})}{1.0 \times 10^{-2} \text{ s}}$$

$$F_{net} = 1.1 \times 10^3 \text{ N}$$

Note: Allow credit for an answer that is consistent with the student's response to question 48.

50. [1] Allow 1 credit for an arrow at *P* directed toward the center of curvature.

Example of a 1-credit response:



51. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$J = \Delta p = m\Delta v$$

$$J = (0.75 \text{ kg})(1.50 \text{ m/s})$$

$$J = 1.1 \text{ N•s}$$

52. [1] Allow 1 credit for indicating that the magnitude of the force on each electron is the same.

53. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$R = \left(\frac{\rho L}{A}\right)_{copper} = \left(\frac{\rho L}{A}\right)_{silver}$$

$$R = \frac{\rho_{copper} L_{copper}}{A} = \frac{\rho_{silver} L_{silver}}{A}$$

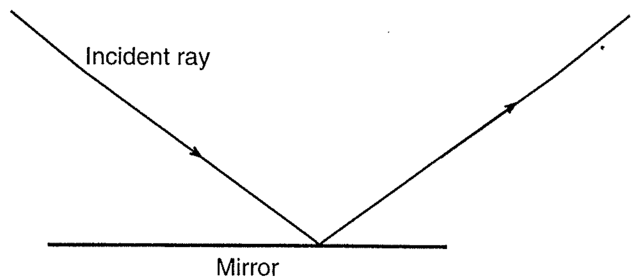
$$L_{copper} = \frac{\rho_{silver} L_{silver}}{\rho_{copper}}$$

$$L_{copper} = \frac{((1.59 \times 10^{-8}\,\Omega \bullet m)(1.00\,m))}{1.72 \times 10^{-8}\,\Omega \bullet m}$$

$$L_{copper} = 0.924 \text{ m}$$

54. [1] Allow 1 credit for a reflected ray at 36° ± 2° to the mirror.

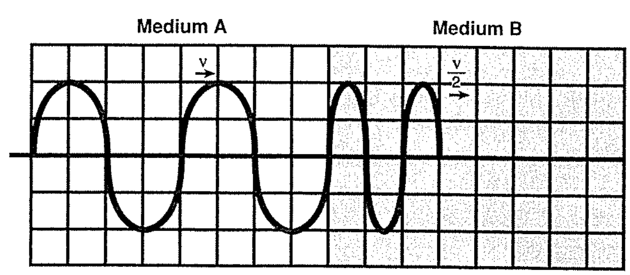
Example of a 1-credit response:



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

55. [1] Allow 1 credit for *at least one* full wave with a wavelength one-half as great. If the wavelength is *not* constant, do *not* allow credit.

Example of a 1-credit response:



Note: Allow this credit even if the amplitude is *not* the same as the original wave.

56. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

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

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

57. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$E_{photon} = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E_{photon}}$$

$$\lambda = \frac{(6.63 \times 10^{-34}\ \text{J} \bullet \text{s})(3.00 \times 10^{8}\ \text{m/s})}{3.26 \times 10^{-19}\ \text{J}}$$

$$\lambda = 6.10 \times 10^{-7}\ \text{m}$$

58. [1] Allow 1 credit for 736 J.

Part C

59. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

$$p_{before} = p_{after}$$

$$(m_1 v_1 = m_2 v_2)_{before} = (m_1 + m_2) v_{after}$$

$$v_{after} = \frac{(m_1 v_1 + m_2 v_2)_{before}}{(m_1 + m_2)}$$

$$v_{after} = \frac{(1200\ \text{kg})(12\ \text{m/s}) + (2300\ \text{kg})(0\ \text{m/s})}{1200\ \text{kg} + 2300\ \text{kg}}$$

$$v_{after} = 4.1\ \text{m/s}$$

or

$$p_{before} = p_{after}$$

$$(1200\ \text{kg})(12\ \text{m/s}) = (3500\ \text{kg})v$$

$$v = 4.1\ \text{m/s}$$

60. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$F_f = \mu F_N \qquad F_N = mg$$

$$F_f = \mu mg$$

$$F_f = (0.67)(1200\ \text{kg} + 2300\ \text{kg})(9.81\ \text{m/s}^2)$$

$$F_f = 2.3 \times 10^4\ \text{N}$$

61. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

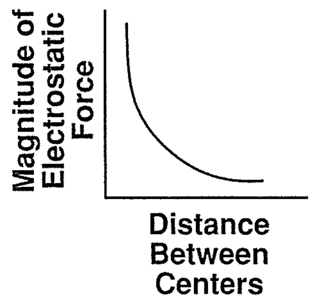
$$F = \frac{kq_1 q_2}{r^2}$$

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

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

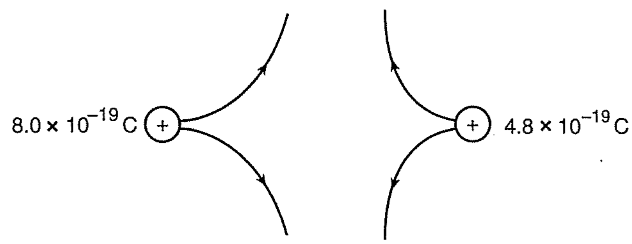
62. [1] Allow 1 credit for a graph showing an inverse square relationship.

Example of a 1-credit response:



63. [1] Allow 1 credit.

Example of a 1-credit response:



Note: Allow credit even if the lines are drawn symmetrically.

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

Example of a 2-credit response:

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

$$\bar{v} = \frac{2(324\ \text{m})}{0.425\ \text{s}}$$

$$\bar{v} = 1520\ \text{m/s}$$

65. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$$v = f\lambda$$

$$\lambda = \frac{v}{f}$$

$$\lambda = \frac{1520\ \text{m/s}}{1.18 \times 10^3\ \text{Hz}}$$

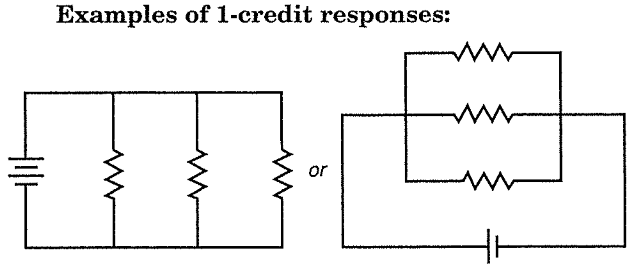
$$\lambda = 1.29\ \text{m}$$

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

66. [1] Allow 1 credit for 8.47×10^{-4} s.

67. [1] Allow 1 credit.

Examples of 1-credit responses:



Note: Allow credit even if the student uses the symbol for a cell in place of the symbol for a battery.

68. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

$W = I^2Rt$
$W = (2.4\text{ A})^2(5.0\ \Omega)(120\text{ s})$
$W = 3.5 \times 10^3\text{ J}$

or

$W = VIt$
$W = (12\text{ V})(2.4\text{ A})(120\text{ s})$
$W = 3500\text{ J}$

69. [1] Allow 1 credit for indicating that the energy expended in the 5.0-ohm resistor remains the same.

Note: Allow credit for an answer that is consistent with the student's circuit diagram in question 67.

70. [1] Allow 1 credit for meson *or* hadron.

71. [1] Allow 1 credit for +1e *or* 1e.

72. [1] Allow 1 credit. Acceptable responses include, but are not limited to:

— The particles have enough (kinetic) energy to be converted to that much mass.

— Energy is converted to mass.

Regents Examination in Physical Setting / Physics
January 2009

Chart for Converting Total Test Raw Scores to Final Examination Scores (Scale Scores)

Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score
85	100	63	81	41	60	19	32
84	99	62	80	40	59	18	31
83	98	61	79	39	58	17	30
82	97	60	79	38	57	16	28
81	97	59	78	37	56	15	27
80	96	58	77	36	55	14	25
79	95	57	76	35	53	13	23
78	94	56	75	34	52	12	22
77	93	55	74	33	51	11	20
76	92	54	73	32	50	10	19
75	91	53	72	31	48	9	17
74	91	52	71	30	47	8	15
73	90	51	70	29	46	7	14
72	89	50	69	28	45	6	12
71	88	49	68	27	43	5	10
70	87	48	67	26	42	4	8
69	86	47	66	25	41	3	6
68	86	46	65	24	39	2	4
67	85	45	64	23	38	1	2
66	84	44	63	22	37	0	0
65	83	43	62	21	35		
64	82	42	61	20	34		

PHYSICS—JUNE 2008

Part A

1. 1	13. 3	25. 2
2. 1	14. 2	26. 3
3. 4	15. 3	27. 2
4. 3	16. 3	28. 4
5. 3	17. 1	29. 4
6. 1	18. 2	30. 4
7. 3	19. 4	31. 2
8. 3	20. 1	32. 4
9. 2	21. 1	33. 2
10. 2	22. 1	34. 4
11. 2	23. 4	35. 4
12. 3	24. 1	

Part B–1

36. 3	44. 4
37. 4	45. 1
38. 3	46. 3
39. 2	47. 1
40. 1	48. 2
41. 3	49. 3
42. 2	50. 4
43. 4	51. 2

Part B–2

52. [1] Allow 1 credit for 50. m.

53. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$KE = (65 \text{ kg})(9.81 \text{ m/s}^2)(5.5 \text{ m})$

$KE = 3.5 \times 10^3 \text{ J}$

54. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$KE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2KE}{m}}$

$v = \sqrt{\frac{2(3.5 \times 10^3 \text{ J})}{65 \text{ kg}}}$

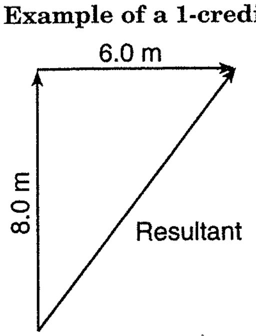
$v = 10. \text{ m/s}$

Note: Allow credit for an answer that is consistent with the student's response to question 53.

55. [1] Allow 1 credit for 1.0 cm = 2.0 m ± 0.2 m.

56. [1] Allow 1 credit for drawing a vector 5.0 cm ± 0.2 cm long, including an arrowhead at the end directed away from the starting point.

Example of a 1-credit response:



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

57. [1] Allow 1 credit for 10. m ± 0.4 m.

Note: Allow credit for an answer that is consistent with the student's response to questions 55 and/or 56.

58. [2] Allow a maximum of 2 credits. Refer to the *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$F_e = \frac{(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2)(2.0 \times 10^{-6} \text{ C})(2.0 \times 10^{-6} \text{ C})}{(2.0 \times 10^{-1} \text{ m})^2}$

$F_e = 9.0 \times 10^{-1} \text{ N}$

59. [1] Allow 1 credit for $3.1 \times 10^{-6} \text{ m}^2$.

60. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

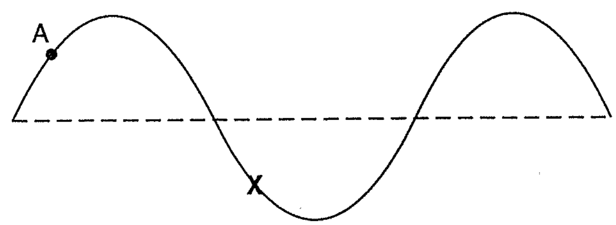
$R = \frac{(1.72 \times 10^{-8}\ \Omega\cdot\text{m})(10.0 \text{ m})}{3.1 \times 10^{-6} \text{ m}^2}$

$R = 5.5 \times 10^{-2}\ \Omega$

Note: Allow credit for an answer that is consistent with the student's response to question 59.

61. [1] Allow 1 credit for marking an **X** 180° out of phase with point *A*.

Example of a 1-credit response:



Part C

62. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

$A_y = A \sin \theta$

$v_{iy} = (25 \text{ m/s})(\sin 40.°)$

$v_{iy} = 16 \text{ m/s}$

63. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

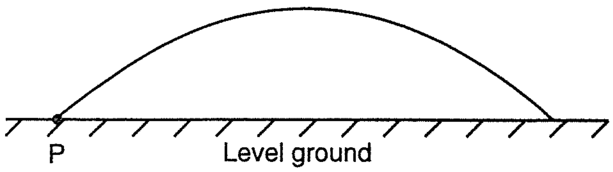
$d = \frac{(16 \text{ m/s})^2}{2(9.81 \text{ m/s}^2)}$

$d = 13 \text{ m}$

Note: Allow credit for an answer that is consistent with the student's response to question 62.

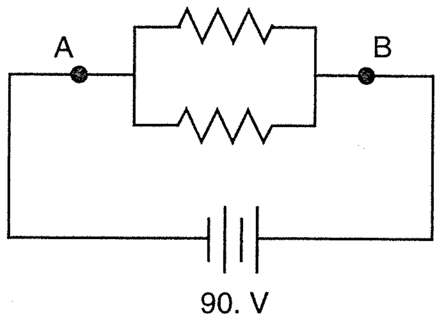
64. [1] Allow 1 credit for drawing a generally parabolic path.

Example of a 1-credit response:



65. [1] Allow 1 credit for drawing two resistors in parallel, completing the circuit.

Example of a 1-credit response:



66. [1] Allow 1 credit for 90. V.

Note: Allow credit for an answer that is consistent with the student's response to question 65.

67. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

$$I = \frac{90.\text{ V}}{15\text{ W}}$$

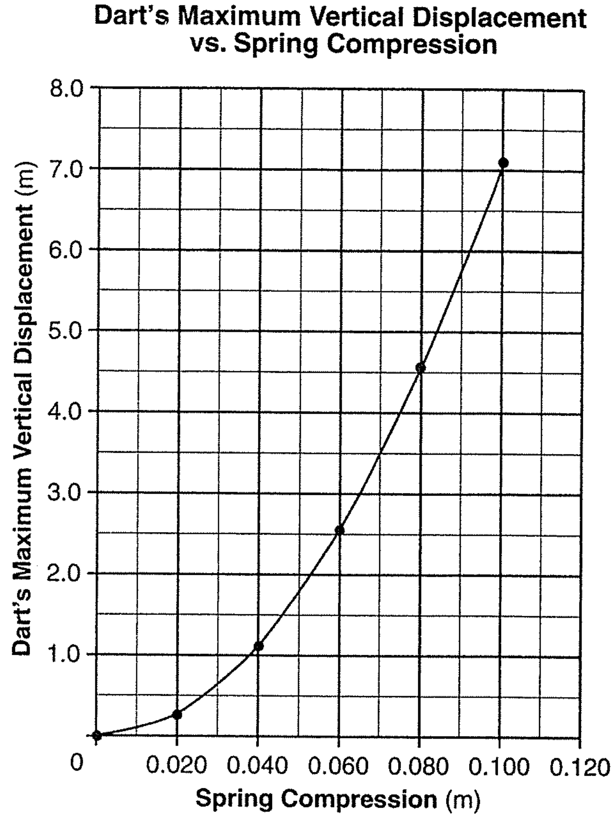
$$I = 6.0\text{ A}$$

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

68. [1] Allow 1 credit for correctly plotting all data points ± 0.3 grid space.

69. [1] Allow 1 credit for drawing a line or curve of best fit.

Example of a 2-credit response for questions 68 and 69:



70. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

$$PE_s = \frac{1}{2}(140\text{ N/m})\,(0.070\text{ m})^2$$

$$PE_s = 0.34\text{ J}$$

Note: Allow credit for an answer that is consistent with the student's graph.

71. [1] Allow 1 credit for 5.6 N.

72. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

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

$$\theta_2 = 23°$$

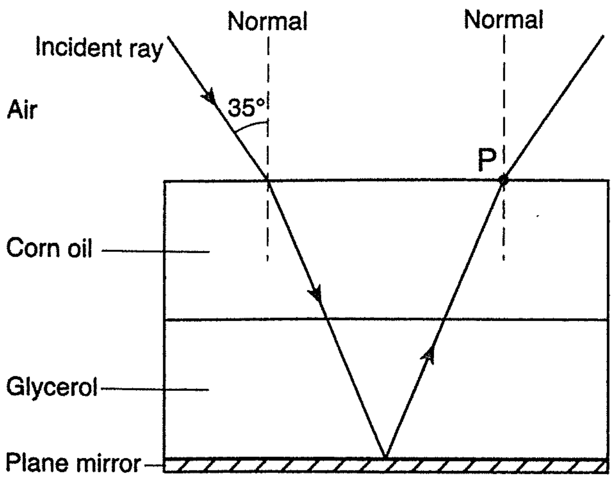
73. [1] Allow 1 credit. Acceptable responses include, but are not limited to:

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

—The absolute indices of refraction are the same.

74. [1] Allow 1 credit for drawing the refracted ray at an angle of 35° ± 2° to the normal.

Example of a 1-credit response:



75. [1] Allow 1 credit for 0.018 63 u.

76. [1] Allow 1 credit for 17.3 MeV.

Note: Allow credit for an answer that is consistent with the student's response to question 75.

Regents Examination in Physical Setting / Physics
June 2008

Chart for Converting Total Test Raw Scores to Final Examination Scores (Scale Scores)

Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score
85	100	63	80	41	58	19	30
84	99	62	79	40	57	18	29
83	98	61	78	39	56	17	28
82	97	60	77	38	55	16	26
81	96	59	76	37	54	15	25
80	95	58	75	36	52	14	23
79	94	57	74	35	51	13	22
78	94	56	73	34	50	12	20
77	93	55	72	33	49	11	19
76	92	54	71	32	48	10	17
75	91	53	71	31	46	9	15
74	90	52	70	30	45	8	14
73	89	51	68	29	44	7	12
72	88	50	68	28	43	6	11
71	87	49	67	27	41	5	9
70	86	48	65	26	40	4	7
69	86	47	64	25	39	3	5
68	85	46	63	24	37	2	4
67	84	45	62	23	36	1	2
66	83	44	61	22	35	0	0
65	82	43	60	21	33		
64	81	42	59	20	32		

Acknowledgments

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