ANSWER KEY

Reviewing Physics: The Physical Setting

THIRD EDITION

Amsco School Publications, Inc.
315 Hudson Street / New York, N.Y. 10013

N 7310 CD

Manufactured in the United States of America
1 2 3 4 5 6 7 8 9 10 12 11 10 09 08 07

CHAPTER 1

Mechanics

PART A: Pages 9–10

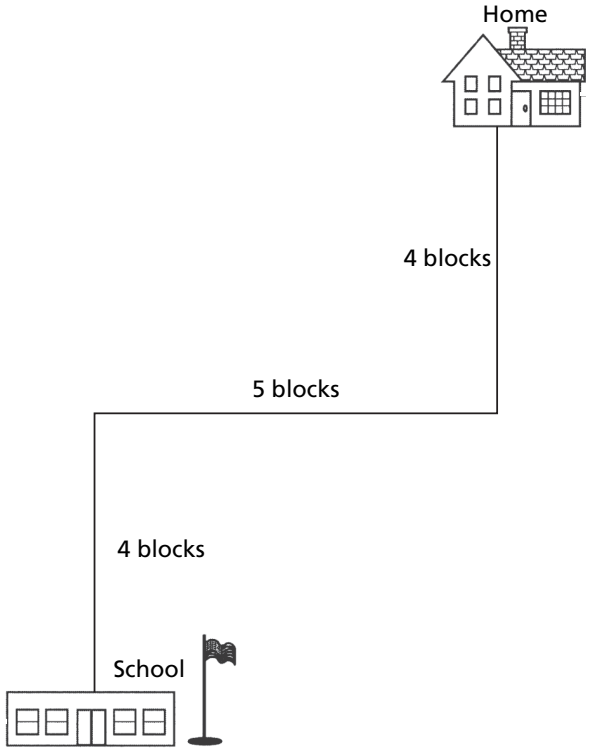
1. A girl leaves a history classroom and walks 10. meters north to a drinking fountain. Then she turns and walks 30. meters south to an art classroom. What is the girl's total displacement from the history classroom to the art classroom?

ANSWER: (1) 20. m south

2. A projectile is fired with an initial velocity of 120. meters per second at an angle, θ, above the horizontal. If the projectile's initial horizontal speed is 55 meters per second, then angle θ measures approximately

ANSWER: (3) 63°

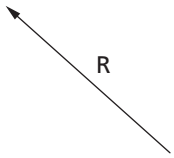
3. A student on her way to school walks four blocks south, five blocks west, and another four blocks south, as shown in the diagram.



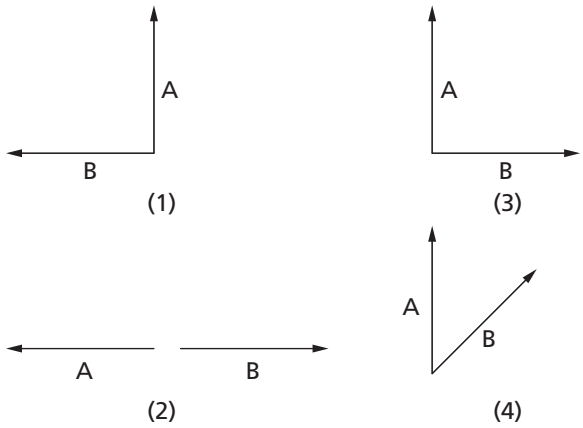
Compared to the distance she walks the magnitude of her displacement from home to school is

ANSWER: (1) less

4. The diagram below shows a resultant vector, **R**.



Which diagram best represents a pair of component vectors, **A** and **B**, that would combine to form resultant vector **R**?



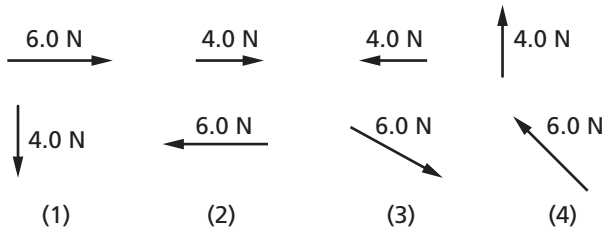
ANSWER: (1)

5. A vector makes an angle, θ, with the horizontal. The horizontal and vertical components of the vector will be equal in magnitude if the angle is

ANSWER: (2) 45°

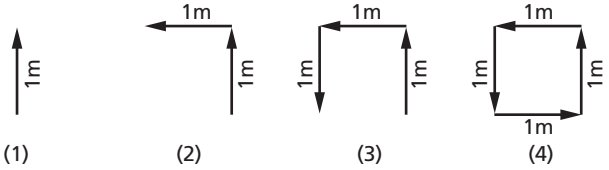
PART B-1: Page 10

6. Which pair of forces acting concurrently on an object will produce the resultant of greatest magnitude?



ANSWER: (4)

7. Which vector diagram represents the greatest magnitude of displacement for an object?



ANSWER: (2)

PART A: Pages 15–16

8. A car travels 90. meters due north in 15 seconds. Then the car turns around and travels 40. meters due south in 5.0 seconds. What is the magnitude of the average velocity of the car during this 20-second interval?

ANSWER: (1) 2.5 m/s

9. A skater increases her speed uniformly from 2.0 meters per second to 7.0 meters per second over a distance of 12 meters. The magnitude of her acceleration as she travels this 12 meters is

ANSWER: (1) 1.9 m/s^2

10. In a 4.0-kilometer race, a runner completes the first kilometer in 5.9 minutes, the second kilometer in 6.2 minutes, the third kilometer in 6.3 minutes, and the final kilometer in 6.0 minutes. The average speed of the runner for the race is approximately

ANSWER: (1) 0.16 km/min

11. A golf ball is hit with an initial velocity of 15 meters per second at an angle of 35 degrees above the horizontal. What is the vertical component of the golf ball's initial velocity?

ANSWER: (1) 8.6 m/s

12. The speed of a wagon increases from 2.5 meters per second to 9.0 meters per second in 3.0 seconds as it accelerates uniformly down a hill. What is the magnitude of the acceleration of the wagon during this 3.0-second interval?

ANSWER: (2) 2.2 m/s^2

13. An object with an initial speed of 4.0 meters per second accelerates uniformly at 2.0 meters per second2 in the direction of its motion for a distance of 5.0 meters. What is the final speed of the object?

ANSWER: (1) 6.0 m/s

14. An astronaut drops a hammer from 2.0 meters above the surface of the moon. If the acceleration due to gravity on the moon is 1.62 meters per second^2, how long will it take for the hammer to fall to the moon's surface?

ANSWER: (3) 1.6 s

15. The average speed of a runner in a 400.-meter race is 8.0 meters per second. How long did it take the runner to complete the race?

ANSWER: (2) 50. s

16. Which statement about the movement of an object with zero acceleration is true?

ANSWER: (4) The object may be in motion.

17. An object travels for 8.00 seconds with an average speed of 160. meters per second. The distance traveled by the object is

ANSWER: (3) 1280 m

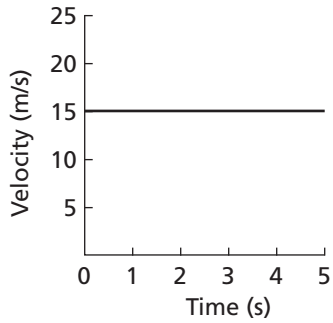
18. An object is displaced 12 meters to the right and then 16 meters upward. The magnitude of the resultant displacement is

ANSWER: (3) 20 m

19. An object moves a distance of 10 meters in 5 seconds. The average speed of the object is

ANSWER: (2) 2.0 m/s

20. The graph following represents the relationship between velocity and time for an object moving in a straight line.



What is the acceleration of the object?

ANSWER: (1) 0 m/s^2

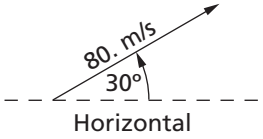
21. Acceleration is a vector quantity that represents the time-rate of change in

ANSWER: (2) velocity

22. A moving body must undergo a change of

ANSWER: (3) position

23. What is the magnitude of the vertical component of the velocity vector shown below?



ANSWER: (4) 40. m/s

24. The maximum number of components that a single force may be resolved into is

ANSWER: (4) unlimited

25. Which quantity has both magnitude and direction?

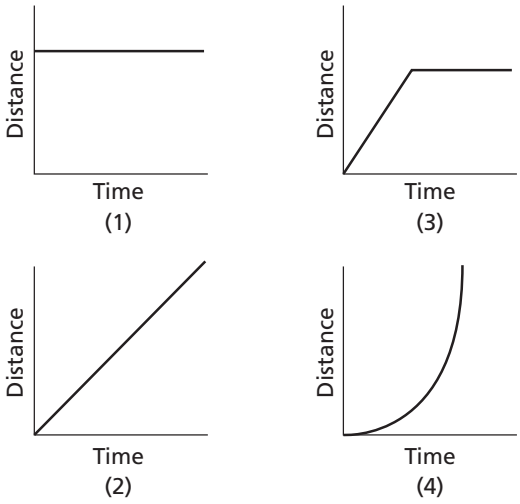
ANSWER: (4) velocity

26. If a man walks 17 meters east then 17 meters south, the magnitude of the man's displacement is

ANSWER: (2) 24 m

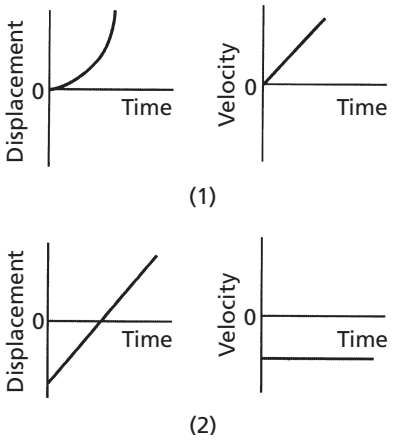
PART B-1: Pages 16–18

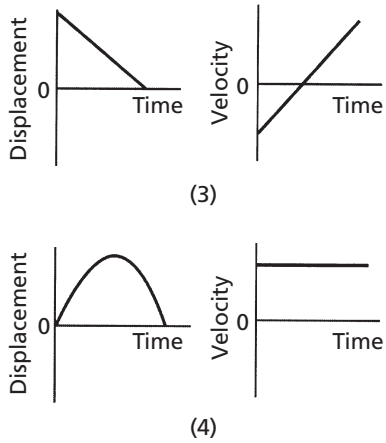
27. Which graph best represents the motion of a block accelerating uniformly down an inclined plane?



ANSWER: (4)

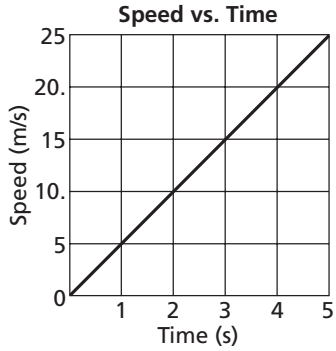
28. Which pair of graphs represents the same motion of an object?





ANSWER: (1)

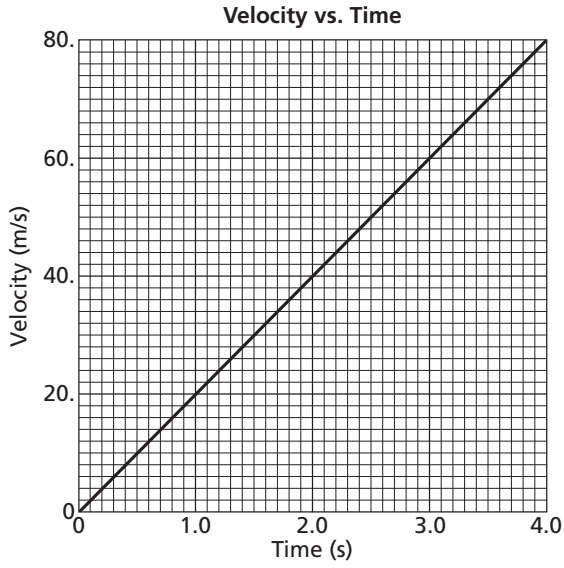
29. The graph below represents the relationship between speed and time for an object moving along a straight line.



What is the total distance traveled by the object during the first 4 seconds?

ANSWER: (3) 40 m

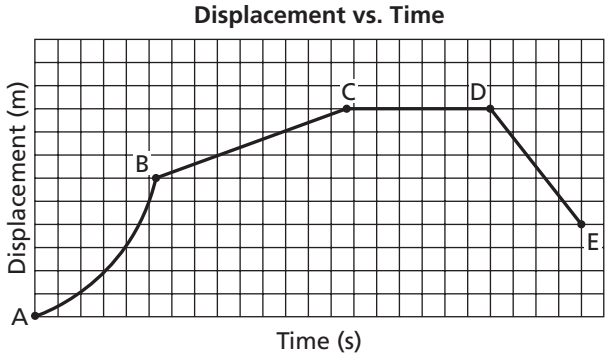
30. The graph below shows the velocity of a race car moving along a straight line as a function of time.



What is the magnitude of the displacement of the car from $t = 2.0$ seconds to $t = 4$ seconds?

ANSWER: (3) 120 m

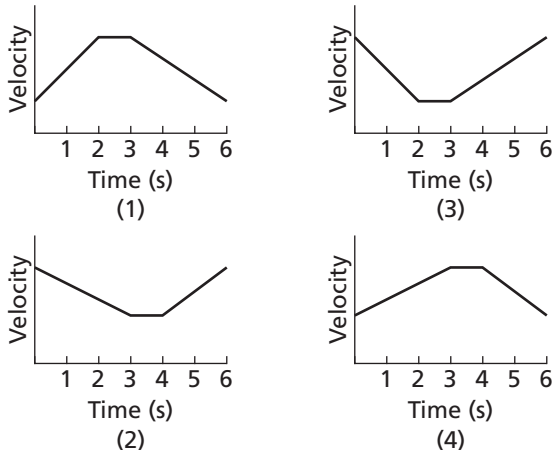
31. The displacement-time graph below represents the motion of a cart initially moving forward along a straight line.



During which interval is the cart moving forward at constant speed?

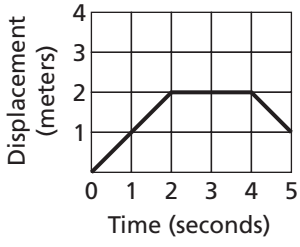
ANSWER: (2) BC

32. Which graph best represents the relationship between velocity and time for an object that accelerates uniformly for 2 seconds, then moves at a constant velocity for 1 second, and finally decelerates for 3 seconds?



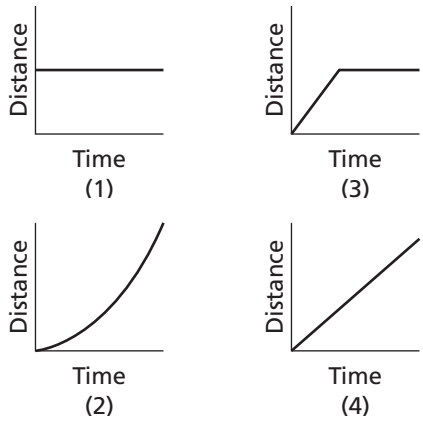
ANSWER: (1)

33. The graph below represents the motion of an object traveling in a straight line as a function of time. What is the average speed of the object during the first 4 seconds?



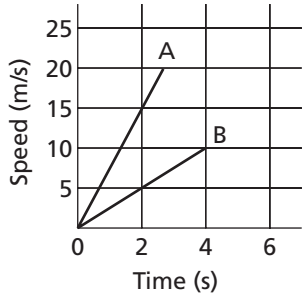
ANSWER: (3) 0.5 m/s

34. Which graph represents an object moving at a constant speed for the entire time interval?



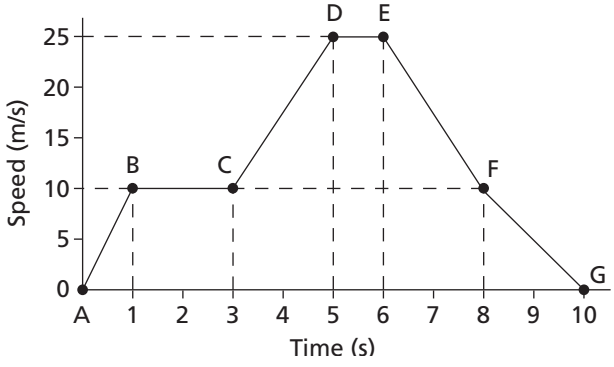
ANSWER: (4)

35. The graph shows the relationship between speed and time for two objects, *A* and *B*. Compared with the acceleration of object *B*, the acceleration of object *A* is



ANSWER: (3) three times as great

Base your answers to questions 36 through 41 on the graph below, which represents the relationship between speed and time for an object in motion along a straight line.



36. What is the acceleration of the object during the time interval $t = 3$ s to $t = 5$ s?

ANSWER: (2) 7.5 m/s^2

37. What is the average speed of the object during the time interval $t = 6$ s to $t = 8$ s

ANSWER: (4) 17.5 m/s

38. What is the total distance traveled by the object during the first 3 seconds?

ANSWER: (3) 25 m

39. During which interval is the object's acceleration the greatest?

ANSWER: (1) AB

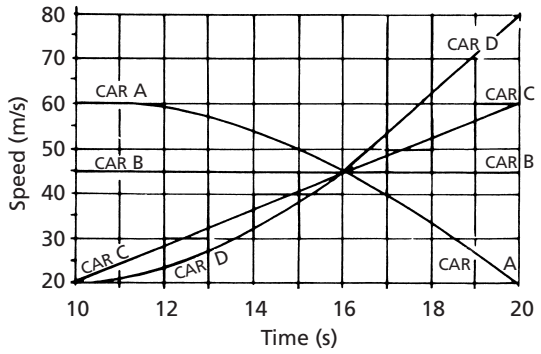
40. During the interval $t = 8$ s to $t = 10$ s, the speed of the object is

ANSWER: (3) decreasing

41. What is the maximum speed reached by the object during the 10 seconds of travel?

ANSWER: (2) 25 m/s

Base your answers to questions 42 through 46 on the accompanying graph, which represents the motions of four cars on a straight road.



42. The speed of car *C* at time $t = 20$ s is closest to

ANSWER: (1) 60 m/s

43. Which car has zero acceleration?

ANSWER: (2) *B*

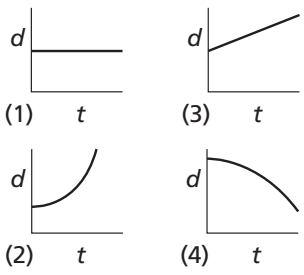
44. Which car is decelerating?

ANSWER: (1) *A*

45. Which car moves the greatest distance in the time interval $t = 10$ s to $t = 16$ s?

ANSWER: (1) *A*

46. Which graph best represents the relationship between distance and time for car *C*?



ANSWER: (2)

PART A: Pages 20–21

47. The diagram below shows a worker using a rope to pull a cart.

The worker's pull on the handle of the cart can best be described as a force having

ANSWER: (3) both magnitude and direction

48. Which is a vector quantity?

ANSWER: (4) force

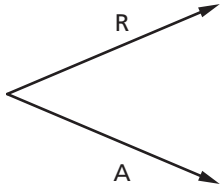
49. A 5.0-newton force and a 7.0-newton force act concurrently on a point. As the angle between the forces is increased from 0° to 180°, the magnitude of the resultant of the two forces changes from

ANSWER: (3) 12.0 N to 2.0 N

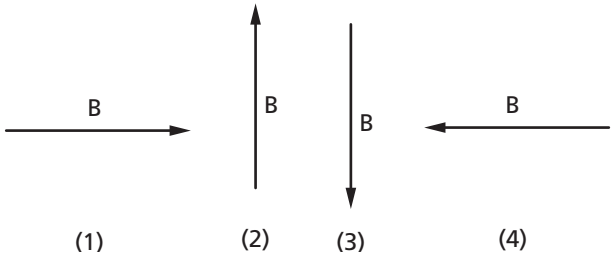
50. A 5.0-newton force could have perpendicular components of

ANSWER: (3) 3.0 N and 4.0 N

51. Forces **A** and **B** have a resultant **R**. Force **A** and resultant **R** are represented in the following diagram.



Which vector best represents force B?



ANSWER: (2)

52. Two 10.0-newton forces act concurrently on a point at an angle of 180° to each other. The magnitude of the resultant of the two forces is

ANSWER: (1) 0.00 N

53. A force of 3 newtons and a force of 5 newtons act concurrently to produce a resultant of 8 newtons. The angle between the forces may be

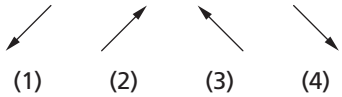
ANSWER: (1) 0°

54. A table exerts a 2.0-newton force on a book lying on the table. The force exerted by the book on the table is

ANSWER: (2) 2.0 N

55. The diagram represents two concurrent forces acting on a point.

Which vector best represents their resultant?



ANSWER: (4)

56. The resultant of two forces acting on the same point at the same time will be greatest when the angle between the forces is

ANSWER: (1) 0°

57. What is the magnitude of the vector sum of the two concurrent forces represented in the diagram?

ANSWER: (2) 2.5 N

58. The resultant of two concurrent forces is minimum when the angle between them is

ANSWER: (4) 180°

59. As the angle between two concurrent forces of 10 newtons and 12 newtons changes from 180° to 0°, the magnitude of their resultant changes from

ANSWER: (2) 2.0 N to 22

60. Two concurrent forces act at right angles to each other. If one of the forces is 40 newtons and the resultant of the two forces is 50 newtons, the magnitude of the other force must be

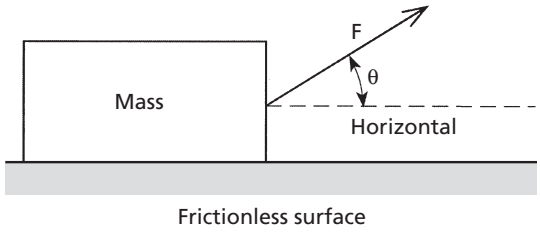
ANSWER: (3) 30 N

61. If two 10.-newton concurrent forces have a resultant of zero, the angle between the forces must be

ANSWER: (4) 180°

PART B-1: Pages 21–22

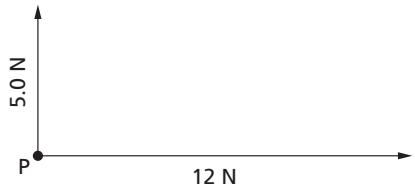
62. The diagram below shows a force of magnitude F applied to a mass at angle θ relative to a horizontal frictionless surface.



As the angle is increased, the horizontal acceleration of the mass

ANSWER: (1) decreases

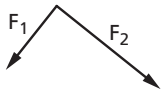
63. The diagram below represents a 5.0-newton force and a 12-newton force acting on point *P*.



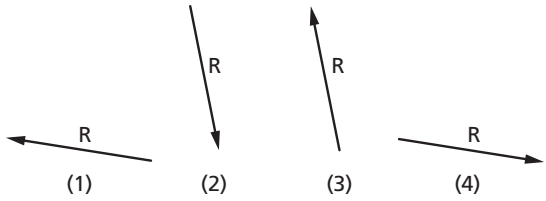
The resultant of the two forces has a magnitude of

ANSWER: (4) 13 N

64. The vector diagram below represents two forces, $\mathbf{F_1}$ and $\mathbf{F_2}$, simultaneously acting on an object.

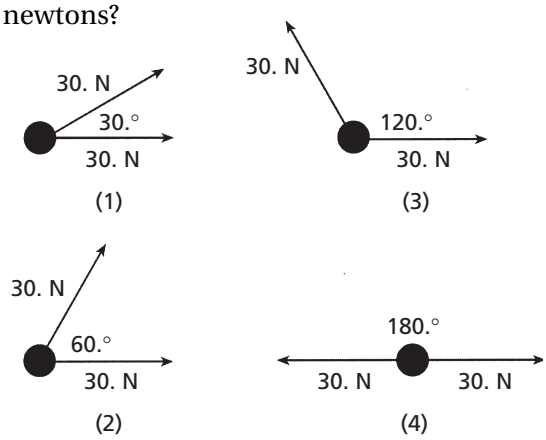


Which vector best represents the resultant of the two forces?



ANSWER: (2)

65. Two 30.-newton forces act concurrently on an object. In which diagram would the forces produce a resultant with a magnitude of 30. newtons?



ANSWER: (3)

PART A: Pages 26–29

66. How far will a brick starting from rest fall freely in 3 seconds?

ANSWER: (3) 44 m

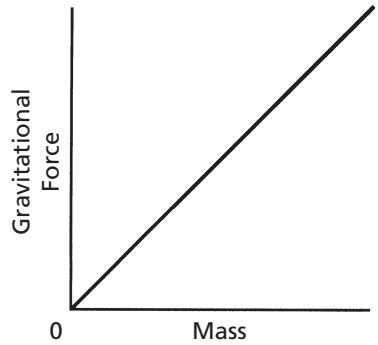
67. If the sum of all the forces acting on a moving object is zero, the object will

ANSWER: (4) continue moving with constant velocity

68. A net force of 10. newtons accelerates an object at 5.0 meters per second^2. What net force would be required to accelerate the same object at 1 meter per second^2?

ANSWER: (2) 2.0 N

69. The graph below represents the relationship between gravitational force and mass for objects near the surface of Earth.



The slope of the graph represents the

ANSWER: (1) acceleration due to gravity

70. A 1200-kilogram car traveling at 10. meters per second hits a tree and is brought to rest in 0.10 second. What is the magnitude of the average force acting on the car to bring it to rest?

ANSWER: (4) 1.2×10^5 N

71. A spring scale reads 20. newtons as it pulls a 5.0-kilogram mass across a table. What is the magnitude of the force exerted by the mass on the spring scale?

ANSWER: (2) 20. N

72. An object weighs 100. newtons on Earth's surface. When it is moved to a point one Earth radius above Earth's surface, it will weigh

ANSWER: (1) 25.0 N

73. A ball thrown vertically upward reaches a maximum height of 30. meters above the surface of Earth. At its maximum height, the speed of the ball is

ANSWER: (1) 0.0 m/s

74. Which object has the most inertia?

ANSWER: (4) a 10.-kilogram sled at rest

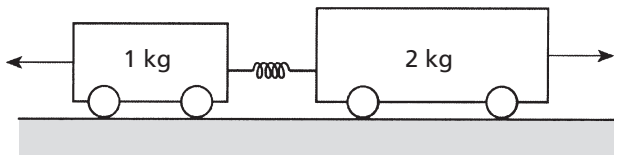
75. A 40.-kilogram mass is moving across a horizontal surface at 5.0 meters per second. What is the magnitude of the net force required to bring the mass to a stop in 8.0 seconds?

ANSWER: (3) 25 N

76. A ball dropped from rest falls freely until it hits the ground with a speed of 20 meters per second. The time during which the ball is in free fall is approximately

ANSWER: (2) 2 s

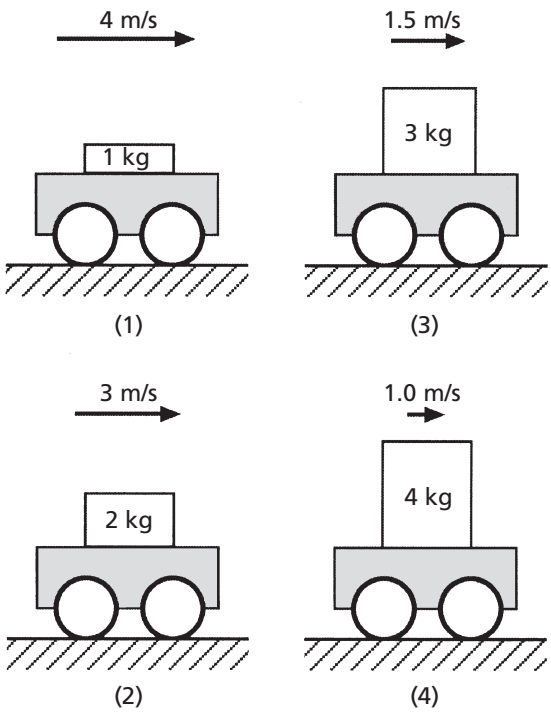
77. Two carts are pushed apart by an expanding spring, as shown in the diagram below.



If the average force on the 1-kilogram cart is 1 newton, what is the average force on the 2-kilogram cart?

ANSWER: (1) 1 N

78. A lab cart is loaded with different masses and moved at various velocities. Which diagram shows the cart-mass system with the greatest inertia?



ANSWER: (4)

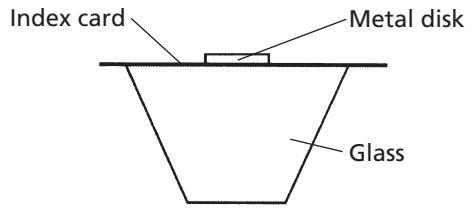
79. A 1.0-kilogram ball is dropped from the roof of a building 40. meters tall. What is the approximate time of fall? [Neglect air resistance.]

ANSWER: (1) 2.9 s

80. 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 will be the cart's velocity after a 6.0-newton westward force acts on it for 2.0 seconds?

ANSWER: (2) 2.0 m/s west

Base your answers to questions 81 and 82 on the diagram below, which shows a 1.0-newton metal disk resting on an index card that is balanced on top of a glass.



81. What is the net force acting on the disk?

ANSWER: (3) 0 N

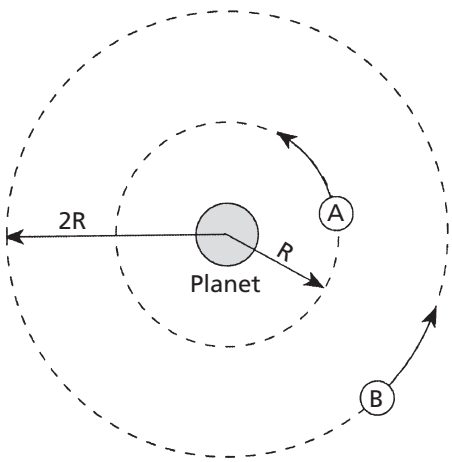
82. When the index card is quickly pulled away from the glass in a horizontal direction, the disk falls straight down into the glass. This action is a result of the disk's

ANSWER: (1) inertia

83. A 400-newton girl standing on a dock exerts a force of 100 newtons on a 10,000-newton sailboat as she pushes it away from the dock. How much force does the sailboat exert on the girl?

ANSWER: (2) 100 N

84. The diagram below represents two satellites of equal mass, *A* and *B*, in circular orbits around a planet.



Compared to the magnitude of the gravitational force of attraction between satellite *A* and the planet, the magnitude of the gravitational force of attraction between satellite *B* and the planet is

ANSWER: (3) one-fourth as great

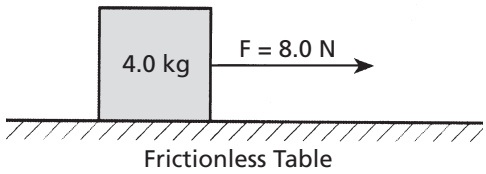
85. After a model rocket reached its maximum height, it then took 5.0 seconds to return to the launch site. What is the approximate maximum height reached by the rocket? [Neglect air resistance.]

ANSWER: (3) 120 m

86. A 70.-kilogram astronaut has a weight of 560 newtons on the surface of planet Alpha. What is the acceleration due to gravity on planet Alpha?

ANSWER: (2) 8.0 m/s^2

87. The diagram below shows a horizontal 8.0-newton force applied to a 4.0-kilogram block on a frictionless table.



What is the magnitude of the block's acceleration?

ANSWER: (2) 2.0 m/s^2

88. An object is dropped from rest and falls freely 20. meters to Earth. When is the speed of the object 9.8 meters per second?

ANSWER: (2) at the end of its first second of fall

89. Which cart has the greatest inertia?

ANSWER: (4) a 4-kilogram cart traveling at a speed of 1 m/s

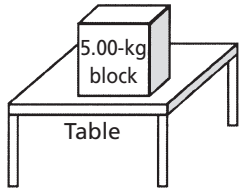
90. A container of rocks with a mass of 65.0 kilograms is brought back from the Moon's surface where the acceleration due to gravity is 1.62 meters per second^2. What is the weight of the container of rocks on Earth's surface?

ANSWER: (1) 638 N

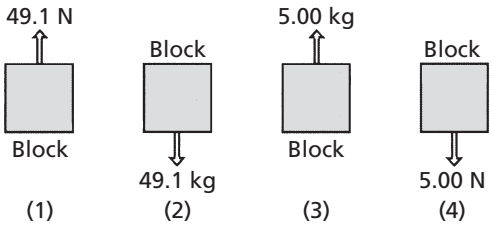
91. A satellite weighs 200 newtons on the surface of Earth. What is its weight at a distance of one Earth radius above the surface of Earth?

ANSWER: (1) 50 N

92. The diagram below shows a 5.00-kilogram block at rest on a horizontal, frictionless table.



Which diagram best represents the force exerted on the block by the table?



ANSWER: (1)

93. A person is standing on a bathroom scale in an elevator car. If the scale reads a value greater than the weight of the person at rest, the elevator car could be moving

ANSWER: (4) upward at increasing speed

94. The acceleration due to gravity on the surface of planet *X* is 19.6 meters per second^2. If an object on the surface of this planet weighs 980. newtons, the mass of the object is

ANSWER: (1) 50.0 kg

95. A basketball player jumped straight up to grab a rebound. If she was in the air for 0.80 second, how high did she jump?

ANSWER: (4) 3.1 m

96. A man is pushing a baby stroller. Compared to the magnitude, or amount, of force exerted on the stroller by the man, the magnitude of the force exerted on the man by the stroller is

ANSWER: (4) the same

97. A man standing on a scale in an elevator notices that the scale reads 30 newtons greater than his normal weight. Which type of movement of the elevator could cause this greater-than-normal reading?

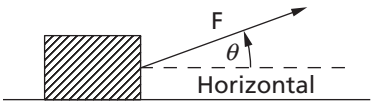
ANSWER: (1) accelerating upward

98. An object with a mass of 2 kilograms is accelerated at 5 meters per second^2. The net force acting on the mass is

ANSWER: (3) 10 N

99. The diagram below represents a constant force *F* acting on a box located on a frictionless horizontal surface. As the angle θ between the force and the horizontal increases, the acceleration of the box will

ANSWER: (1) decrease



100. An object accelerates at 2.5 meters per second^2 when an unbalanced force of 10. newtons acts on it. What is the mass of the object?

ANSWER: (4) 4.0 kg

101. An unbalanced force of 10.0 newtons causes an object to accelerate at 2.0 m/s^2. What is the mass of the object?

ANSWER: (2) 5.0 kg

102. An unbalanced force of 10 newtons acts on a 20-kilogram mass for 5 seconds. The acceleration of the mass is

ANSWER: (1) 0.5 m/s^2

103. Two objects of equal mass are a fixed distance apart. If the mass of each object could be tripled, the gravitational force between the objects would

ANSWER: (4) increase 9 times

104. Which two quantities are measured in the same units?

ANSWER: (2) weight and force

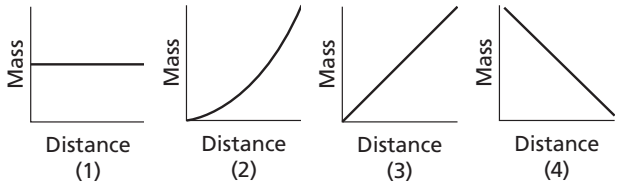
105. What is the weight of a 5.0-kilogram object at Earth's surface?

ANSWER: (3) 49 N

106. What is the gravitational acceleration on a planet where a 2-kilogram mass has a weight of 16 newtons on the planet's surface?

ANSWER: (2) 8 m/s^2

107. Which graph represents the relationship between the mass of an object and its distance from Earth's surface?

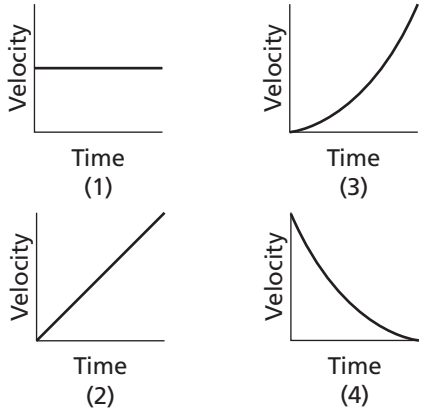


ANSWER: (1)

108. Which is constant for a freely falling object?

ANSWER: (4) acceleration

109. An object starting from rest falls freely near Earth's surface. Which graph best represents the motion of the object?



ANSWER: (2)

110. Starting from rest, an object rolls freely down an incline that is 10 meters long in 2 seconds. The acceleration of the object is approximately

ANSWER: (2) 5 m/sec^2

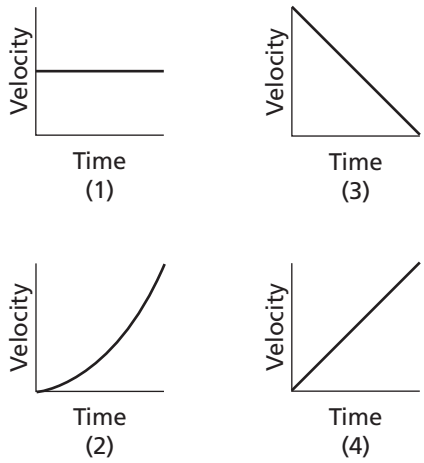
111. An object, initially at rest, falls freely near Earth's surface. How long does it take the object to attain a speed of 98 meters per second?

ANSWER: (2) 10 s

112. Starting from rest, object *A* falls freely for 2.0 seconds, and object *B* falls freely for 4.0 seconds. Compared with object *A*, object *B* falls

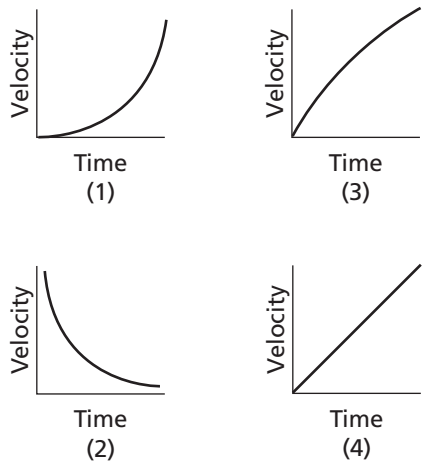
ANSWER: (4) four times as far

113. An object is thrown vertically upward from Earth's surface. Which graph best shows the relationship between velocity and time as the object rises?



ANSWER: (3)

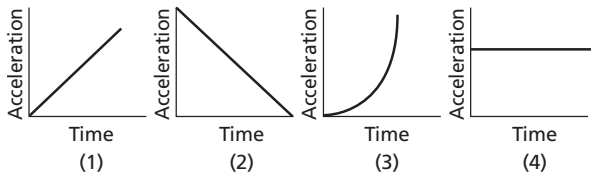
114. An astronaut drops a stone near the surface of the Moon. Which graph best represents the motion of the stone as it falls toward the Moon's surface?



ANSWER: (4)

PART B-1: Pages 29–30

115. A constant unbalanced force is applied to an object for a period of time. Which graph best represents the acceleration of the object as a function of elapsed time?



ANSWER: (4)

Base your answers to questions 116 and 117 on the information and table below.

The weight of an object was determined at five different distances from the center of Earth. The results are shown in the table below. Position A represents results for the object at the surface of Earth.

Position	Distance from Earth's Center (m)	Weight (N)
A	6.37×10^6	1.0×10^3
B	1.27×10^7	2.5×10^2
C	1.91×10^7	1.1×10^2
D	2.55×10^7	6.3×10^1
E	3.19×10^7	4.0×10^1

116. The approximate mass of the object is

ANSWER: (3) 100 kg

117. At what distance from the center of Earth is the weight of the object approximately 28 newtons?

ANSWER: (2) 3.8×10^7 m

Base your answers to questions 118 through 122 on the following information.

A 10.-kilogram object, starting from rest, slides down a frictionless incline with a constant acceleration of 2.0 m/s^2 for 4.0 seconds.

118. What is the velocity of the object at the end of the 4.0 seconds?

ANSWER: (2) 8.0 m/s

119. During the 4.0 seconds, the object moves a total distance of

ANSWER: (2) 16 m

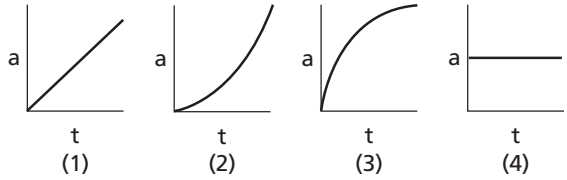
120. To produce this acceleration, what is the force on the object?

ANSWER: (2) 2.0×10^1 N

121. What is the approximate weight of the object?

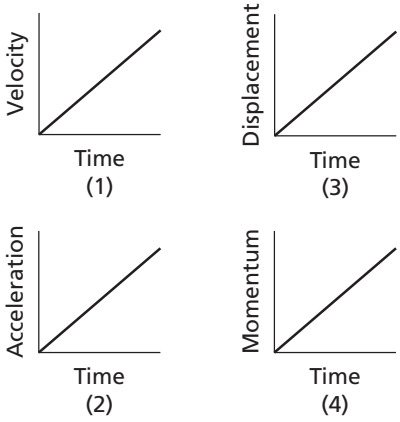
ANSWER: (3) 100 N

122. Which graph best represents the relationship between acceleration (a) and time (t) for the object?



ANSWER: (4)

123. Which graph could represent the motion of an object with no unbalanced forced acting on it?

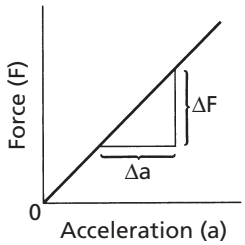


ANSWER: (3)

124. Two frictionless blocks having masses of 8.0 kilograms and 2.0 kilograms rest on a horizontal surface. If a force applied to the 8.0-kilogram block gives it an acceleration of 5.0 m/s^2, then the same force will give the 2.0-kilogram block an acceleration of

ANSWER: (4) 20. m/s^2

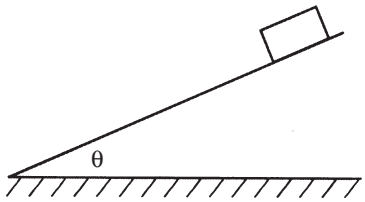
125. The graph below shows the relationship between the acceleration of an object and the unbalanced force producing the acceleration. The ratio ($\Delta F/\Delta a$) of the graph represents the object's



ANSWER: (1) mass

PART A: Pages 31–33

126. The diagram below shows a block sliding down a plane inclined at angle with the horizontal.



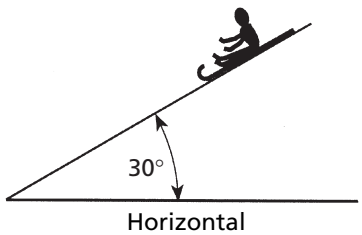
As angle θ is increased, the coefficient of kinetic friction between the bottom surface of the block and the surface of the incline will

ANSWER: (3) remain the same

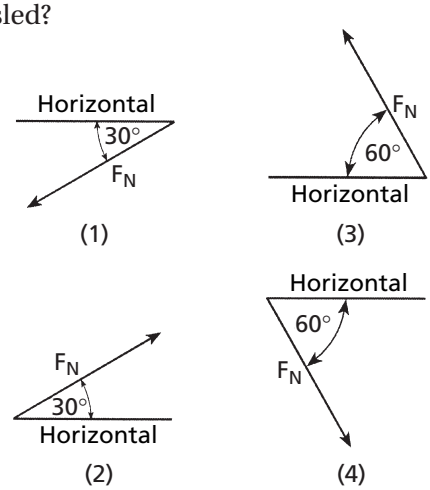
127. A box is pushed toward the right across a class room floor. The force of friction on the box is directed toward the

ANSWER: (1) left

128. The diagram below shows a sled and rider sliding down a snow-covered hill that makes an angle of 30.° with the horizontal.



Which vector best represents the direction of the normal force, F_N, exerted by the hill on the sled?

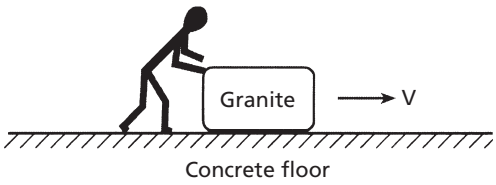


ANSWER: (3)

129. Compared to the force needed to start sliding a crate across a rough level floor, the force needed to keep it sliding once it is moving is

ANSWER: (1) less

130. The diagram below shows a granite block being slid at constant speed across a horizontal concrete floor by a force parallel to the floor.



Which pair of quantities could be used to determine the coefficient of friction for the granite on the concrete?

ANSWER: (4) frictional force and normal force on the block

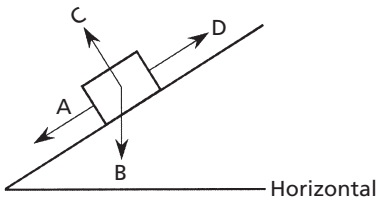
131. The force required to start an object sliding across a uniform horizontal surface is larger than the force required to keep the object sliding at a constant velocity. The magnitudes of the required forces are different in these situations because the force of kinetic friction

ANSWER: (2) is less than the force of static friction

132. When a 12-newton horizontal force is applied to a box on a horizontal tabletop, the box remains at rest. The force of static friction acting on the box is

ANSWER: (3) 12 N

133. In the diagram below, a box is at rest on an inclined plane.



Which vector best represents the direction of the normal force acting on the box?

ANSWER: (3) C

134. The strongest frictional force between two surfaces is

ANSWER: (1) static friction

135. A 40.-N object requires 5.0 N to start moving over a horizontal surface. The coefficient of static friction is

ANSWER: (1) 0.13

136. A 12-N cart is moving on a horizontal surface with a coefficient of kinetic friction of 0.10. What force of friction must be overcome to keep the object moving at constant speed?

ANSWER: (2) 1.2 N

137. The coefficient of friction between two dry sliding surfaces is 0.05. What value is possible if these surfaces are lubricated?

ANSWER: (2) 0.02

138. If the normal force between two surfaces is doubled, the static friction force will

ANSWER: (3) be doubled

139. If the normal force between two surfaces is doubled, the coefficient of static friction will

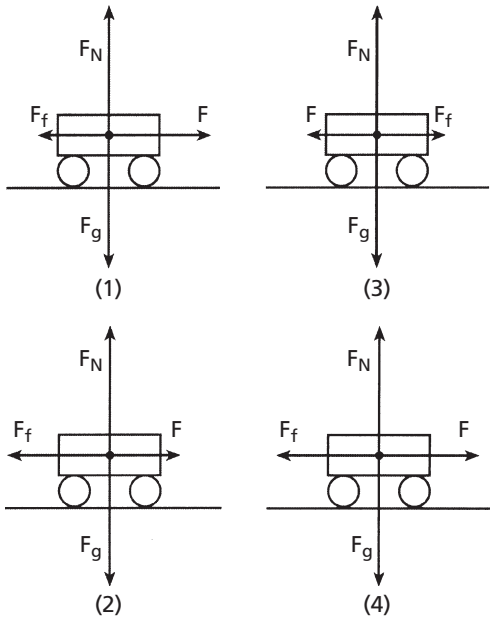
ANSWER: (2) remain the same

140. In which situation is fluid friction not involved?

ANSWER: (4) Climbing up a pole

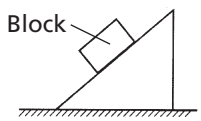
PART B-1: Page 33

141. Which vector diagram best represents a cart slowing down as it travels to the right on a horizontal surface?

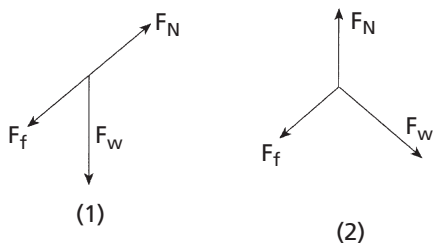


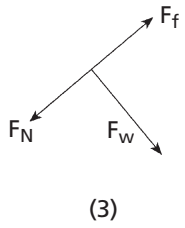
ANSWER: (2)

142. The diagram at the right represents a block at rest on an incline.

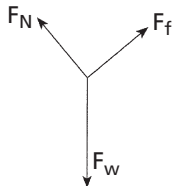


Which diagram best represents the forces acting on the block? (F_f = frictional force, F_N = normal force, and F_w = weight.)





(3)



(4)

ANSWER: (4)

Questions 143–149 relate to this situation: A 6.0-N block is moving to the right on a horizontal surface. The friction force during the motion is found to be 1.0 N.

143. In which direction does the friction force act on the block?

ANSWER: (2) to the left

144. What is the magnitude of the normal force on the block?

ANSWER: (2) 6.0 N

145. What is the coefficient of friction in this example?

ANSWER: (2) 0.17

146. If the block is at rest, how much force will be needed to get it moving?

ANSWER: (3) more than 1.0 N

147. If a weight is placed on top of the block, the force of friction will

ANSWER: (2) increase

148. If the same block slides on the surface at greater speed, the force of friction will be

ANSWER: (1) the same

149. If the block is turned so that it slides on a side whose surface is smaller, the force of friction will

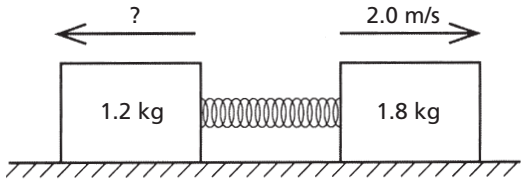
ANSWER: (2) remain the same

150. A constant unbalanced force of friction acts on a 15.0-kilogram mass moving along a horizontal surface at 10.0 meters per second. If the mass is brought to rest in 1.50 seconds, what is the magnitude of the force of friction?

ANSWER: (2) 100. N

PART A: Pages 36–37

151. A 1.2-kilogram block and a 1.8-kilogram block are initially at rest on a frictionless, horizontal surface. When a compressed spring between the blocks is released, the 1.8-kilogram block moves to the right at 2.0 meters per second, as shown.



What is the speed of the 1.2-kilogram block after the spring is released?

ANSWER: (3) 3.0 m/s

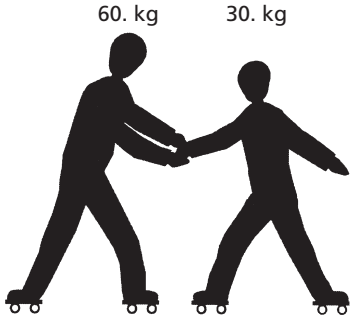
152. One car travels 40. meters due east in 5.0 seconds, and a second car travels 64 meters due west in 8.0 seconds. During their periods of travel, the cars definitely had the same

ANSWER: (4) average speed

153. What is the speed of a 1.0×10^3-kilogram car that has a momentum of 2.0×10^4 kilogram • meters per second east?

ANSWER: (2) 2.0×10^1 m/s

154. In the diagram below, a 60.-kilogram roller skater exerts a 10.-newton force on a 30.-kilogram roller skater for 0.20 second.



What is the magnitude of the impulse applied to the 30.-kilogram roller skater?

ANSWER: (2) 2.0 N • s

155. A 2.0-kilogram body is initially traveling at a velocity of 40. meters per second east. If a constant force of 10. newtons due east is applied to the body for 5.0 seconds, the final speed of the body is

ANSWER: (3) 65 m/s

156. Which is a scalar quantity?

ANSWER: (3) speed

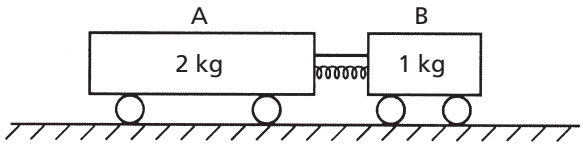
157. A 0.10-kilogram model rocket's engine is designed to deliver an impulse of 6.0 newton-seconds. If the rocket engine burns for 0.75 second, what average force does it produce?

ANSWER: (2) 8.0 N

Base your answers to questions 158 and 159 on the information and diagram below.

The diagram shows a compressed spring between two carts initially at rest on a horizon-

tal frictionless surface. Cart *A* has a mass of 2 kilograms and cart *B* has a mass of 1 kilogram. A string holds the carts together.



158. What occurs when the string is cut and the carts move apart?

ANSWER: (1) The magnitude of the acceleration of cart A is one-half the magnitude of the acceleration of cart B.

159. After the string is cut and the two carts move apart, the magnitude of which quantity is the same for both carts?

ANSWER: (1) momentum

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

ANSWER: (3) 3.0 m/s

161. Velocity is to speed as displacement is to

ANSWER: (4) distance

162. A 50.-kilogram student threw a 0.40-kilogram ball with a speed of 20. meters per second. What was the magnitude of the impulse that the student exerted on the ball?

ANSWER: (1) 8.0 N • s

163. Ball *A* of mass 5.0 kilograms moving at 20. meters per second collides with ball *B* of unknown mass moving at 10. meters per second in the same direction. After the collision, ball *A* moves at 10. meters per second and ball *B* at 15 meters per second, both still in the same direction. What is the mass of ball *B*?

ANSWER: (3) 10. kg

164. Which is an acceptable unit for impulse?

ANSWER: (4) kg • m/s

165. A 20-kilogram mass moving at a speed of 3.0 meters per second is stopped by a constant force of 15 newtons. How many seconds must the force act on the mass to stop it?

ANSWER: (3) 4.0 s

166. An object traveling at 4.0 meters per second has a momentum of 16 kilogram-meters per second. What is the mass of the object?

ANSWER: (4) 4.0 kg

167. Two carts resting on a frictionless surface are forced apart by a spring. One cart has a mass of 2 kilograms and moves to the left at a speed of 3 meters per second. If the second cart has a mass of 3 kilograms, it will move to the right at a speed of

ANSWER: (2) 2 m/s

168. A 15-newton force acts on an object in a direction due east for 3.0 seconds. What will be the change in momentum of the object?

ANSWER: (1) 45 kg-m/s due east

169. A 5.0-kilogram cart moving with a velocity of 4.0 meters per second is brought to a stop in 2.0 seconds. The magnitude of the average force used to stop the cart is

ANSWER: (3) 10. N

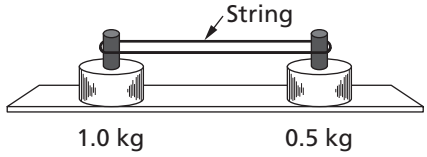
170. A 5.0-newton force imparts an impulse of 15 newton-seconds to an object. The force acted on the object for a period of

ANSWER: (3) 3.0 s

171. A net force of 12 newtons acting north on an object for 4.0 seconds will produce an impulse of

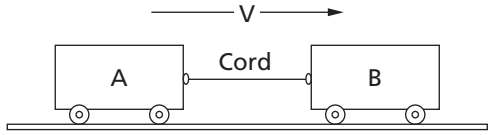
ANSWER: (1) 48 kg-m/s north

172. Two disk magnets are arranged at rest on a frictionless horizontal surface as shown in the diagram. When the string holding them together is cut, they move apart under a magnetic force of repulsion. When the 1.0-kilogram disk reaches a speed of 3.0 meters per second, what is the speed of the 0.5-kilogram disk?



ANSWER: (4) 6.0 m/s

173. The diagram represents two identical carts, attached by a cord moving to the right at speed *V*. If the cord is cut, what would be the speed of cart *A*?



ANSWER: (3) *V*

174. If a 3.0-kilogram object moves 10. meters in 2.0 seconds, its average momentum is

ANSWER: (3) 15 kg-m/s

175. An impulse of 30.0 newton-seconds is applied to a 5.00-kilogram mass. If the mass had a speed of 100. meters per second before the impulse, its speed after the impulse could be

ANSWER: (2) 106 m/s

176. Two carts of masses of 5.0 kilograms and 1.0 kilogram are pushed apart by a compressed spring. If the 5.0-kilogram cart moves westward at 2.0 meters per second, the magnitude of the velocity of the 1.0-kilogram cart will be

ANSWER: (4) 10. m/s

177. The direction of an object's momentum is always the same as the direction of the object's

ANSWER: (3) velocity

178. An unbalanced force of 20 newtons is applied to an object for 10 seconds. The change in the momentum of the object will be

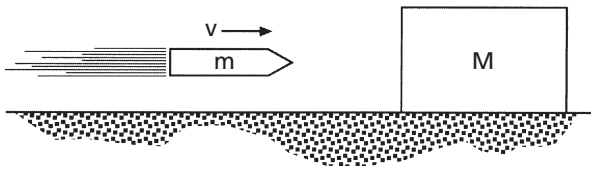
ANSWER: (1) 200 kg • m/s

PART B-1: Page 38

179. A 4.0-kilogram mass is moving at 3.0 meters per second toward the right and a 6.0-kilogram mass is moving at 2.0 meters per second toward the left on a horizontal frictionless table. If the two masses collide and remain together after the collision, their final momentum is

ANSWER: (4) 0 kg-m/s

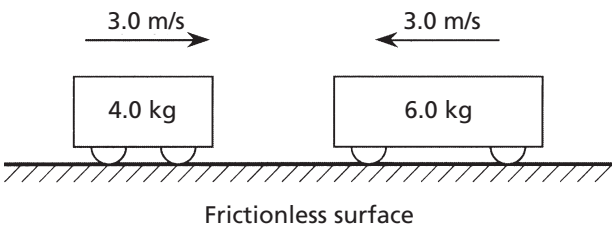
180. In the diagram below, a block of mass M initially at rest on a frictionless horizontal surface is struck by a bullet of mass m moving with horizontal velocity v.



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

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

181. The diagram below shows a 4.0-kilogram cart moving to the right and a 6.0-kilogram cart moving to the left on a horizontal frictionless surface.



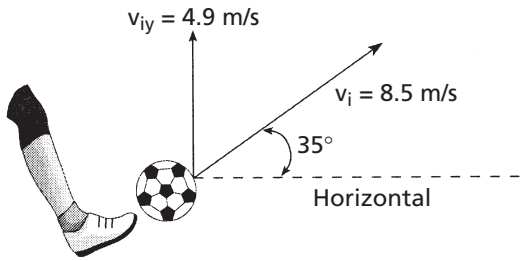
When the two carts collide they lock together. The magnitude of the total momentum of the two-cart system after the collision is

ANSWER: (2) 6.0 kg m/s

PART A: Pages 41–43

Base your answers to questions 182 and 183 on the information and diagram below.

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



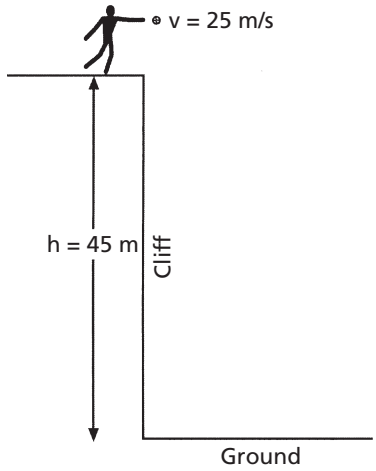
182. The horizontal component of the ball's initial velocity is approximately

ANSWER: (3) 7.0 m/s

183. The maximum height reached by the ball is approximately

ANSWER: (1) 1.2 m

184. The diagram below shows a student throwing a baseball horizontally at 25 meters per second from a cliff 45 meters above the level ground.



Approximately how far from the base of the cliff does the ball hit the ground? [Neglect air resistance.]

ANSWER: (2) 75 m

185. A projectile is fired from a gun near the surface of Earth. The initial velocity of the pro-

jectile has a vertical component of 98 meters per second and a horizontal component of 49 meters per second. How long will it take the projectile to reach the highest point in its path?

ANSWER: (2) 10. s

186. A golf ball is hit at an angle of 45° above the horizontal. What is the acceleration of the golf ball at the highest point in its trajectory? [Neglect friction.]

ANSWER: (2) 9.8 m/s^2 downward

187. A ball is thrown horizontally at a speed of 24 meters per second from the top of a cliff. If the ball hits the ground 4.0 seconds later, approximately how high is the cliff?

ANSWER: (3) 78 m

188. A 0.2-kilogram red ball is thrown horizontally at a speed of 4 meters per second from a height of 3 meters. A 0.4-kilogram green ball is thrown horizontally from the same height at a speed of 8 meters per second. Compared to the time it takes the red ball to reach the ground, the time it takes the green ball to reach the ground is

ANSWER: (3) the same

189. A ball is thrown at an angle of 38° to the horizontal. What happens to the magnitude of the ball's vertical acceleration during the total time interval that the ball is in the air?

ANSWER: (4) It remains the same.

Base your answers to questions 190 and 191 on the information below.

Projectile *A* is launched horizontally at a speed of 20. meters per second from the top of a cliff and strikes a level surface below, 3.0 seconds later. Projectile *B* is launched horizontally from the same location at a speed of 30. meters per second.

190. The time it takes projectile *B* to reach the level surface is

ANSWER: (3) 3.0 s

191. Approximately how high is the cliff?

ANSWER: (2) 44 m

Base your answers to questions 192 and 193 on the information below.

A 2.0 $\times$ 10^3-kilogram car travels at a constant speed of 12 meters per second around a circular curve of radius 30. meters.

192. What is the magnitude of the centripetal acceleration of the car as it goes around the curve?

ANSWER: (2) 4.8 m/s^2

193. As the car goes around the curve, the centripetal force is directed

ANSWER: (1) toward the center of the circular curve

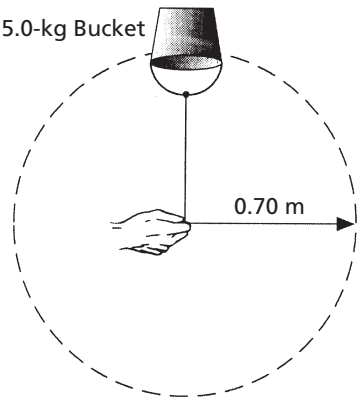
194. What is the magnitude of the centripetal force on a 2.0 $\times$ 10^3-kilogram car as it goes around a 25-meter curve with an acceleration of 5 m/s^2?

ANSWER: (3) 1.0 $\times$ 10^4 N

195. A ball of mass *M* at the end of a string is swung in a horizontal circular path of radius *R* at constant speed *V*. Which combination of changes would require the greatest increase in the centripetal force acting on the ball?

ANSWER: (2) doubling *V* and halving *R*

196. The following diagram shows a 5.0-kilogram bucket of water being swung in a horizontal circle of 0.70-meter radius at a constant speed of 2.0 meters per second.

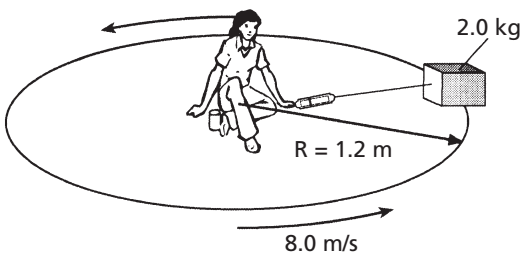


The magnitude of the centripetal force on the bucket of water is approximately

ANSWER: (3) 29 N

Base your answers to questions 197 and 198 on the diagram and information below.

The diagram shows a student seated on a rotating circular platform, holding a 2.0-kilogram block with a spring scale. The block is 1.2 meters from the center of the platform. The block has a constant speed of 8.0 meters per second. [Frictional forces on the block are negligible.]



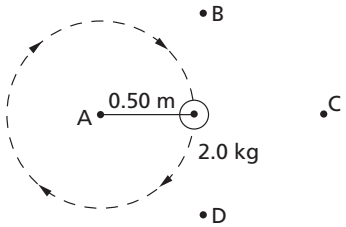
197. Which statement best describes the block's movement as the platform rotates?

ANSWER: (1) Its velocity is directed tangent to the circular path, with an inward acceleration.

198. The reading on the spring scale is approximately

ANSWER: (3) 110 N

Base your answers to questions 199 through 202 on the following diagram, which represents a 2.0-kilogram mass moving in a circular path on the end of a string 0.50 meter long. The mass moves in a horizontal plane at a constant speed of 4.0 meters per second.



199. The force exerted on the mass by the string is

ANSWER: (4) 64 N

200. In the position shown in the diagram, the momentum of the mass is directed toward point

ANSWER: (4) *D*

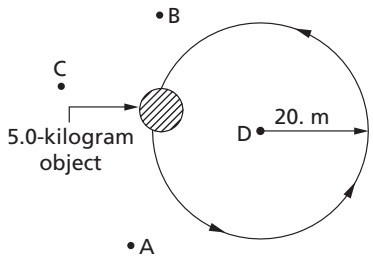
201. The centripetal force acting on the mass is directed toward point

ANSWER: (1) *A*

202. The speed of the mass is changed to 2.0 meters per second. Compared to the centripetal acceleration of the mass when moving at 4.0 meters per second, its centripetal acceleration when moving at 2.0 meters per second would be

ANSWER: (3) one-fourth as great

Base your answers to questions 203 through 207 on the diagram below, which represents a 5.0-kilogram object revolving around a circular track in a horizontal plane at a constant speed. The radius of the track is 20. meters and the centripetal force on the object is 4.0×10^2 newtons.



203. In the position shown, the object's centripetal acceleration is directed toward point

ANSWER: (4) *D*

204. In the position shown, the object's velocity is directed toward point

ANSWER: (1) *A*

205. The object's centripetal acceleration is

ANSWER: (3) 80. m/s^2

206. The object's speed is

ANSWER: (2) 40. m/s

207. If the radius of the track is increased, the centripetal force necessary to keep the object revolving at the same speed would

ANSWER: (1) decrease

PART B-1: Page 44

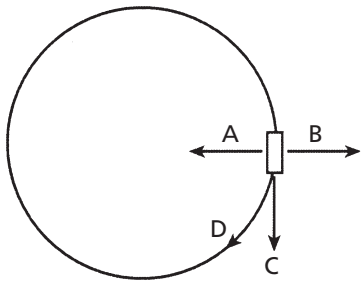
208. At what angle from the horizontal must a projectile be launched in order to achieve the greatest range?

ANSWER: (3) 45°

209. At the same moment that a baseball is thrown horizontally by a pitcher, a ring drops vertically off his hand. Which statement about the baseball and the ring is correct, neglecting air resistance?

ANSWER: (3) They both hit the ground at the same time.

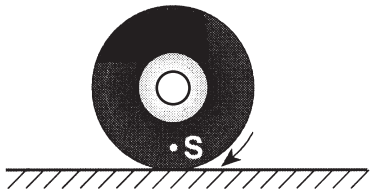
210. In the diagram below, a cart travels clockwise at constant speed in a horizontal circle.



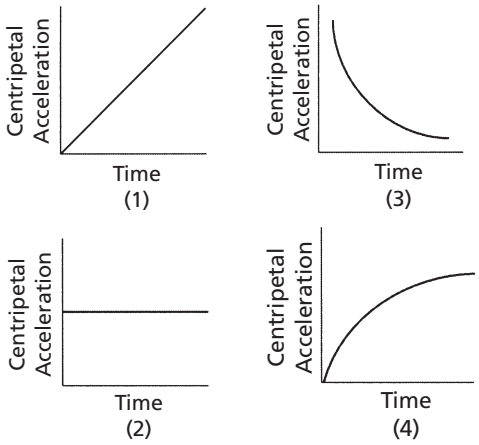
At the position shown in the diagram, which arrow indicates the direction of the centripetal acceleration of the cart?

ANSWER: (1) A

211. In the diagram below, *S* is a point on a car tire rotating at a constant rate.

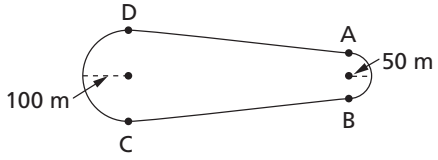


Which graph best represents the magnitude of the centripetal acceleration of point *S* as a function of time?



ANSWER: (2)

Base your answers to questions 212 through 216 on the diagram below, which represents a flat racetrack as viewed from above, with the radii of its two curves indicated. A *car with a mass of 1000 kilograms moves counterclockwise around the track at a constant speed of 20 meters per second.*



212. The net force acting on the car while it is moving from *A* to *D* is

ANSWER: (1) 0 N

213. The net force acting on the car while it is moving from *D* to *C* is

ANSWER: (3) 4000 N

214. If the car moved from *C* to *B* in 20 seconds, the distance *CB* is

ANSWER: (4) 400 m

215. Compared with the centripetal acceleration of the car while moving from *B* to *A*, the centripetal acceleration of the car while moving from *D* to *C* is

ANSWER: (3) one-half as great

216. Compared with the speed of the car while moving from *A* to *D*, the speed of the car while moving from *D* to *C* is

ANSWER: (3) the same

PHYSICS IN YOUR LIFE—Free Fall

Page 45

1. Under what conditions is an object in free fall?

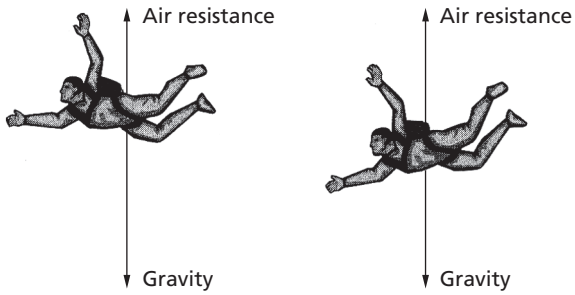
When the only force acting on the object is that of gravity.

2. What is air resistance?

It is a force of friction exerted by the air on an object as the object passes through the air.

3. Describe the force(s) acting on a skydiver before and after terminal velocity is reached. Include diagrams in your description.

The forces are gravity acting downward and air resistance opposing the downward motion and thus acting upward. Before terminal velocity is reached, the force of gravity is stronger and the diver accelerates downward. As his speed increases, the force of air resistance increases until it becomes equal to gravity. The net force on the diver now is zero, the diver no longer accelerates and continues to move downward at constant (terminal) velocity.



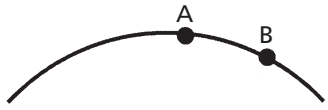
4. How is a skydiver's parachute related to the motion of the skydiver? How does a parachute affect the motion of a skydiver?

The open parachute increases air resistance, thereby lowering the terminal velocity. This allows the diver to descend at a slower rate.

Chapter Review Questions

PART A: Pages 45–46

1. The diagram below represents the path of an object after it was thrown.



What happens to the object's acceleration as it travels from *A* to *B*? [Neglect friction.]

ANSWER: (3) It remains the same.

2. The speed of a car is increased uniformly from 20. meters per second to 30. meters per sec-

ond in 4.0 seconds. The magnitude of the car's average acceleration in this 4.0-second interval is

ANSWER: (2) 2.5 m/s^2

3. A roller coaster car, traveling with an initial speed of 15 meters per second, decelerates uniformly at -7.0 meters per second^2 to a full stop. Approximately how far does the roller coaster car travel during its deceleration?

ANSWER: (3) 16 m

4. If the magnitude of the gravitational force of Earth on the Moon is F, the magnitude of the gravitational force of the Moon on Earth is

ANSWER: (3) equal to F

5. Which term represents a scalar quantity?

ANSWER: (1) distance

6. The centers of two 15.0-kilogram spheres are separated by 3.00 meters. The magnitude of the gravitational force between the two spheres is approximately

ANSWER: (3) 1.67×10^{-9} N

7. During a collision, an 84-kilogram driver of a car moving at 24 meters per second is brought to rest by an inflating air bag in 1.2 seconds. The magnitude of the force exerted on the driver by the air bag is approximately

ANSWER: (3) 1.7×10^3 N

8. An apple weighing 1 newton on the surface of Earth has a mass of approximately

ANSWER: (1) 1×10^{-1} kg

9. A car initially traveling at a speed of 16 meters per second accelerates uniformly to a speed of 20. meters per second over a distance of 36 meters. What is the magnitude of the car's acceleration?

ANSWER: (2) 2.0 m/s^2

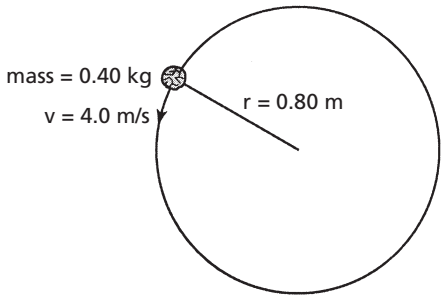
10. A net force of 25 newtons is applied horizontally to a 10.-kilogram block resting on a table. What is the magnitude of the acceleration of the block?

ANSWER: (4) 2.5 m/s^2

11. A child is riding on a merry-go-round. As the speed of the merry-go-round is doubled, the magnitude of the centripetal force acting on the child

ANSWER: (4) is quadrupled

12. The diagram below represents a 0.40-kilogram stone attached to a string. The stone is moving at a constant speed of 4.0 meters per second in a horizontal circle having a radius of 0.80 meter.



The magnitude of the centripetal acceleration of the stone is

ANSWER: (4) 20. ms/^{2}

13. In which situation is the net force on the object equal to zero?

ANSWER: (3) a bicycle moving at constant speed on a straight, level road

14. A 60-kilogram skydiver is falling at a constant speed near the surface of Earth. The magnitude of the force of air friction acting on the skydiver is approximately

ANSWER: (4) 600 N

15. An astronaut weighs 8.00×10^2 newtons on the surface of Earth. What is the weight of the astronaut 6.37×10^6 meters above the surface of Earth?

ANSWER: (2) 2.00×10^2 N

16. A 1.5-kilogram lab cart is accelerated uniformly from rest to a speed of 2.0 meters per second in 0.50 second. What is the magnitude of the force producing this acceleration?

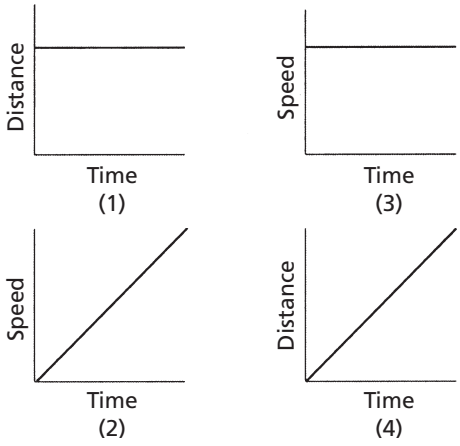
ANSWER: (4) 6.0 N

17. Which person has the greatest inertia?

ANSWER: (1) a 110-kg wrestler resting on a mat

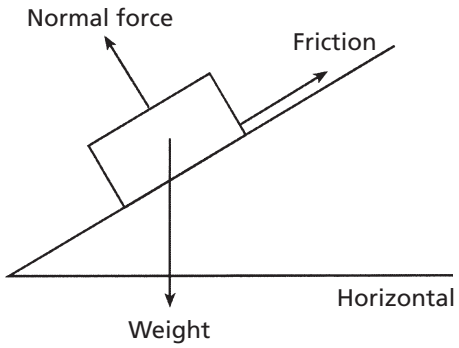
PART B-1: Pages 46–48

18. Which graph best represents the motion of an object that is not in equilibrium as it travels along a straight line?



ANSWER: (2)

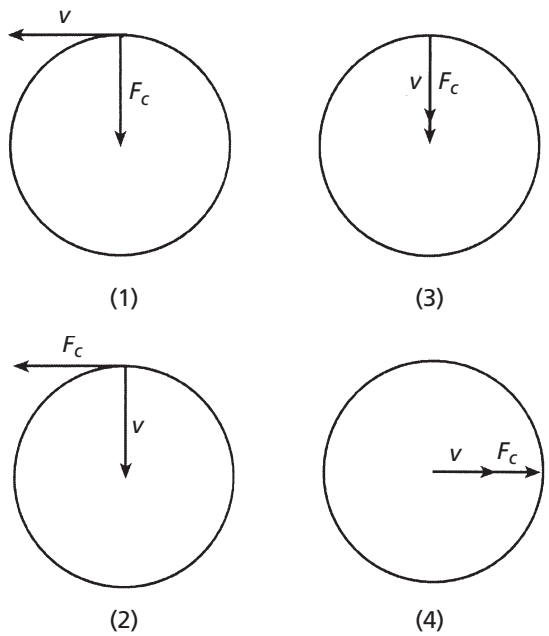
19. Three forces act on a box on an inclined plane as shown in the diagram below. [Vectors are not drawn to scale.]



If the box is at rest, the net force acting on it is equal to

ANSWER: (4) zero

20. A 1.0×10^3-kilogram car travels at a constant speed of 20. meters per second around a horizontal circular track. Which diagram correctly 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?

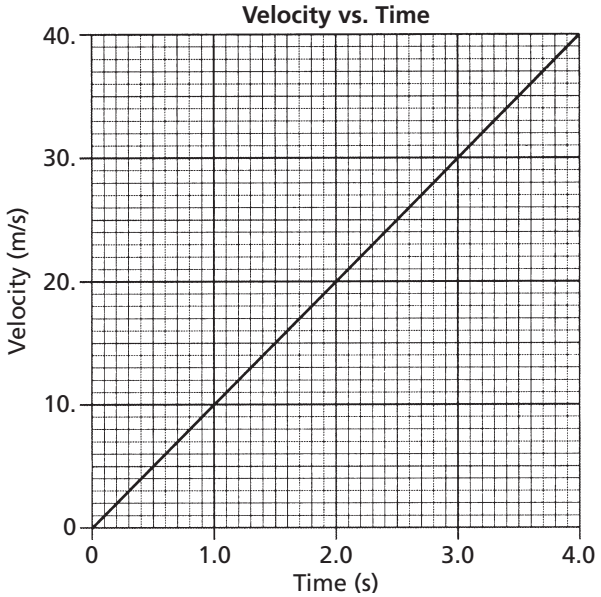


ANSWER: (1)

21. An archer uses a bow to fire two similar arrows with the same string force. One arrow is fired at an angle of 60.° with the horizontal, and the other is fired at an angle of 45° with the horizontal. Compared to the arrow fired at 60.°, the arrow fired at 45° has a

ANSWER: (3) shorter flight time and longer horizontal range

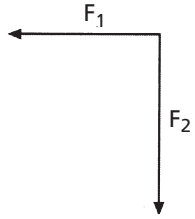
22. The graph below shows the velocity of a race car moving along a straight line as a function of time.



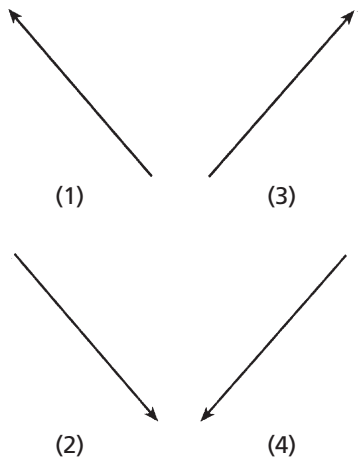
What is the magnitude of the displacement of the car from t = 2.0 seconds to t = 4.0 seconds?

ANSWER: (3) 60. m

23. A force vector was resolved into two perpendicular components, F_1 and F_2, as shown in the diagram at the right.

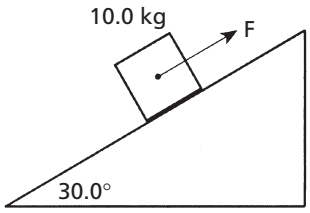


Which vector best represents the original force?



ANSWER: (4)

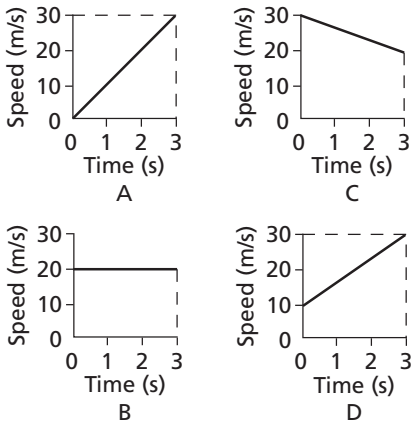
24. The diagram below shows a 10.0-kilogram mass held at rest on a frictionless 30.0° incline by force F.



What is the approximate magnitude of force F?

ANSWER: (2) 49.1 N

Base your answers to questions 25 through 29 on the four graphs below, which represent the relationship between speed and time of four different objects, A, B, C, and D.



25. Which object was slowing?

ANSWER: (3) *C*

26. Which object was neither accelerating nor decelerating?

ANSWER: (2) *B*

27. Which object traveled the greatest distance in the 3.0-second interval?

ANSWER: (3) *C*

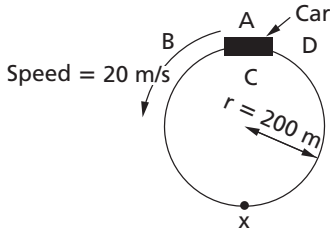
28. Which object had the greatest acceleration?

ANSWER: (1) *A*

29. Compared with the average velocity of object *A*, the average velocity of object *D* is

ANSWER: (2) greater

Base your answers to questions 30 through 33 on the following diagram, which represents a car of mass 1000 kilograms traveling around a horizontal circular track of radius 200 meters at a constant speed of 20 meters per second.



30. When the car is in the position shown, the direction of its centripetal acceleration is toward

ANSWER: (3) C

31. The magnitude of the centripetal force acting on the car is closest to

ANSWER: (3) 2000 N

32. If the speed of the car were doubled, the centripetal acceleration of the car would be

ANSWER: (4) 4 times as great

33. If additional passengers were riding in the car, at the original speed, the car's centripetal acceleration would be

ANSWER: (3) the same

PART B-2: Pages 46–50

Base your answers to questions 34 and 35 on the information below.

An outfielder throws a baseball to the first baseman at a speed of 19.6 meters per second and an angle of 30.° above the horizontal.

34. Which pair represents the initial horizontal velocity (v_x) and initial vertical velocity (v_y) of the baseball?

ANSWER: (1) $v_x = 17.0$ m/s, $v_y = 9.80$ m/s

35. If the ball is caught at the same height from which it was thrown, calculate the amount of time the ball was in the air. Show all work, including the equation and substitution with units.

ANSWER:

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

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

$$t = \frac{9.80 \text{ m/s}}{9.81 \text{ m/s}^2} \quad \text{or} \quad t = \frac{(-9.80 \text{ m/s}) - (9.80 \text{ m/s})}{-9.81 \text{ m/s}^2}$$

$$t = 1\text{s} \qquad t = \frac{-19.6 \text{ m/s}}{-9.81 \text{ m/s}^2}$$

$$t = 2.00 \text{ s} \qquad t = 2.00 \text{ s}$$

Base your answers to questions 36 and 37 on the information below.

A soccer player accelerates a 0.50-kilogram soccer ball by kicking it with a net force of 5.0 newtons.

36. Calculate the magnitude of the acceleration of the ball. Show all work, including the equation and substitution with units.

ANSWER:

$$a = \frac{F_{net}}{m}$$

$$a = \frac{5.0\ \text{N}}{0.50\ \text{kg}}$$

$$a = \frac{5.0\ \text{kg-m/s}^2}{0.50\ \text{kg}}$$

$$a = 10.\ \text{m/s}^2 \text{ or } 10.\ \text{N/kg}$$

37. What is the magnitude of the force of the soccer ball on the player's foot?

ANSWER: 5.0 N or −5.0 N

38. State the two general characteristics that are used to define a vector quantity.

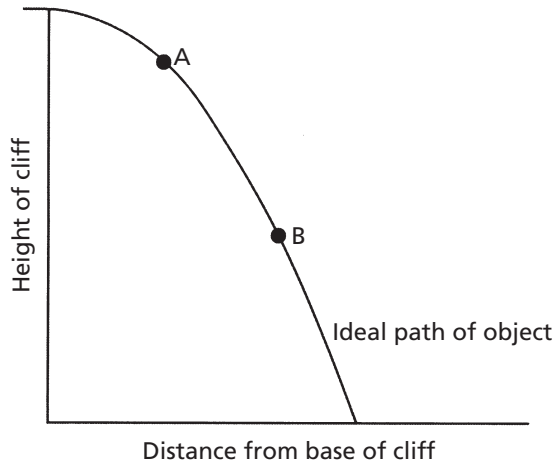
ANSWER: magnitude and direction

39. An airplane is moving with a constant velocity in level flight. Compare the magnitude of the forward force provided by the engines to the magnitude of the backward frictional drag force.

ANSWER: The force of the engines is equal in magnitude to the frictional drag force.

Base your answers to questions 40 through 42 on the information and diagram below.

An object was projected horizontally from a tall cliff. The diagram below represents the path of the object, neglecting friction.



40. How does the magnitude of the horizontal component of the object's velocity at point *A* compare with the magnitude of the horizontal component of the object's velocity at point *B*?

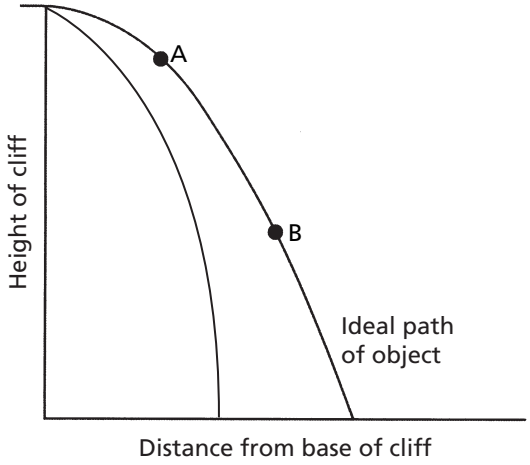
ANSWER: The horizontal velocities at *A* and *B* are the same.

41. How does the magnitude of the vertical component of the object's velocity at point *A* compare with the magnitude of the vertical component of the object's velocity at point *B*?

ANSWER: The vertical velocity at *A* is less than at *B*.

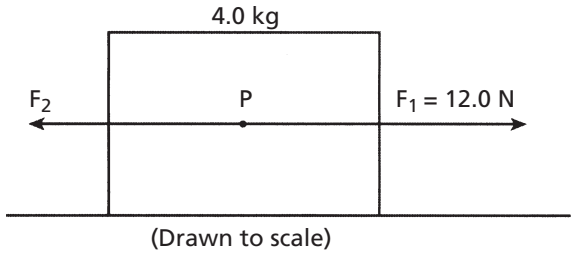
42. Sketch a likely path of the horizontally projected object, assuming that it was subject to air resistance.

ANSWER:



Base your answers to questions 43 through 45 on the information and diagram below.

In the scaled diagram, two forces, F_1 and F_2, act on a 4.0-kilogram block at point *P*. Force F_1 has a magnitude of 12.0 newtons, and is directed toward the right.



43. Using a ruler and the scaled diagram, determine the magnitude of F_2 in newtons.

ANSWER: 9.0 N

44. Determine the magnitude of the net force acting on the block.

ANSWER: 3.0 N

45. Calculate the magnitude of the acceleration of the block. Show all work, including the equation and substitution with units.

ANSWER:

$$a = \frac{F_{net}}{m} \qquad a = \frac{F_1 - F_2}{m}$$

$$a = \frac{3.0\text{ N}}{4.0\text{ kg}} \quad \text{or} \quad a = \frac{12.0\text{ N} - 9.0\text{ N}}{4.0\text{ kg}}$$

$$a = 0.75\text{ m/s}^2 \qquad a = 0.75\text{ m / s}^2$$

46. The coefficient of kinetic friction between a 780.-newton crate and a level warehouse floor is 0.200. Calculate the magnitude of the horizontal force required to move the crate across the floor at constant speed. Show all work, including the equation and substitution with units.

ANSWER:

$$F_f = \mu F_N$$

$$F_f = (0.200)\ (780.\text{ N})$$

$$F_f = 156\text{ N}$$

47. Objects in free fall near the surface of Earth accelerate downward at 9.81 meters per second^2. Explain why a feather does not accelerate at this rate when dropped near the surface of Earth.

ANSWER: Air friction acts on the feather. The feather is not in free fall.

48. A skier on waxed skis is pulled at constant speed across level snow by a horizontal force of 39 newtons. Calculate the normal force exerted on the skier. Show all work, including the equation and substitution with units.

ANSWER:

$$F_f = \mu F_N$$

$$F_N = \frac{F_f}{\mu}$$

$$F_N = \frac{39\text{ N}}{0.05}$$

$$F_N = 780\text{ N}$$

49. A 1000-kilogram car traveling due east at 15 meters per second is hit from behind and receives a forward impulse of 6000 newton-seconds. Determine the magnitude of the car's change in momentum due to this impulse.

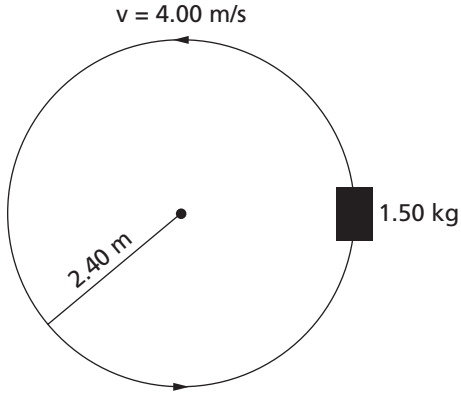
ANSWER: $6000\,\frac{\text{kg} \cdot \text{m}}{\text{s}}$

50. Using dimensional analysis, show that the expression v^2/d has the same units as acceleration. Show all the steps used to arrive at your answer.

ANSWER: $\frac{v^2}{d} = \frac{\left(\frac{\text{m}}{\text{s}}\right)^2}{\text{m}} = \frac{\frac{\text{m}^2}{\text{s}^2}}{\text{m}} = \frac{\text{m}}{\text{s}^2}$

Base your answers to questions 51 through 53 on the information and diagram below.

A 1.50-kilogram cart travels in a horizontal circle of radius 2.40 meters at a constant speed of 4.00 meters per second.



51. Calculate the time required for the cart to make one complete revolution. Show all work, including the equation and substitution with units.

ANSWER:

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

$$t = \frac{d}{v} \qquad 4.00\text{ m/s} = \frac{15.08\text{ m}}{t}$$

$$t = \frac{2\pi r}{v} \qquad t = 3.77\text{ s}$$

or

$$t = \frac{2\pi(2.40\text{ m})}{4.00\text{ m/s}}$$

$$t = 3.77\text{ s}$$

52. Describe a change that would quadruple the magnitude of the centripetal force.

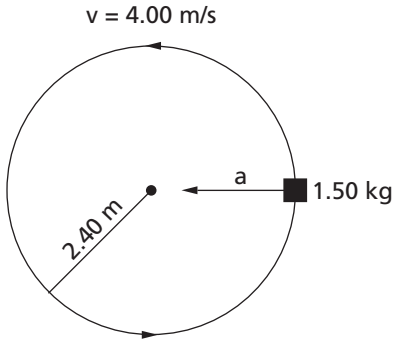
Examples of acceptable responses include, but are not limited to:

- double the speed of the car
- reduce the radius to 0.60 m
- quadruple the mass
- double the mass of the cart and halve the radius

- increase the speed of the cart to 5.66 m/s and double the mass of the cart
- increase the speed of the cart to 5.66 m/s and halve the radius

53. Copy the diagram, then, draw an arrow to represent the direction of the acceleration of the cart in the position shown. Label the arrow a.

ANSWER:



Base your answers to questions 54 and 55 on the information below.

A car traveling at a speed of 13 meters per second accelerates uniformly to a speed of 25 meters per second in 5.0 seconds.

54. Calculate the magnitude of the acceleration of the car during this 5.0-second time interval. Show all work, including the equation and substitution with units.

ANSWER:

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

$$a = \frac{25 \text{ m/s} - 13 \text{ m/s}}{5 \text{ s}}$$

$$a = 2.4 \text{ m/s}^2$$

55. A truck traveling at a constant speed covers the same total distance as the car in the same 5.0-second time interval. Determine the speed of the truck.

ANSWER: 19 m/s.

56. The gravitational force of attraction between Earth and the Sun is 3.52×10^{22} newtons. Calculate the mass of the Sun. Show all work, including the equation and substitution with units.

ANSWER:

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

$$m_2 = \frac{F_g r^2}{Gm_1}$$

$$m_2 = \frac{(3.52 \times 10^{22} \text{ N})(1.50 \times 10^{11} \text{ m})^2}{(6.67 \times 10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2)\,(5.98 \times 10^{24} \text{ kg})}$$

$$m_2 = 1.99 \times 10^{30} \text{ kg}$$

Base your answers to questions 57 through 59 on the information below.

The combined mass of a race car and its driver is 600. kilograms. Traveling at constant speed, the car completes one lap around a circular track of radius 160 meters in 36 seconds.

57. Calculate the speed of the car. Show all work, including the equation and substitution with units.

ANSWER:

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

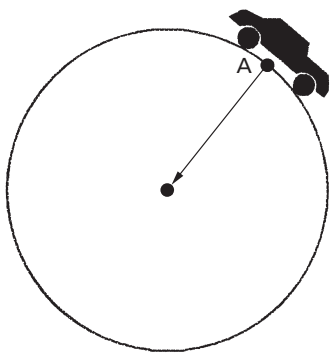
$$\bar{v} = \frac{2\pi r}{t}$$

$$\bar{v} = \frac{2\pi 160 \text{ m}}{36 \text{ s}}$$

$$\bar{v} = 27.9 \text{ s} \text{ or } 28 \text{ s}$$

58. Copy the figure below, then draw an arrow to represent the direction of the net force acting on the car when it is in position *A*.

ANSWER:



59. Calculate the magnitude of the centripetal acceleration of the car. Show all work, including the equation and substitution with units.

ANSWER:

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

$$a_c = \frac{(28 \text{ m/s})^2}{160 \text{ m}}$$

$$a_c = 4.9 \text{ m/s}^2$$

Base your answers to questions 60 and 61 on the information below.

An 8.00-kilogram ball is fired horizontally from a 1.00×10^3-kilogram cannon initially at

rest. After having been fired, the momentum of the ball is 2.40×10^3 kilogram • meters per second east. Neglect friction.

60. Calculate the magnitude of the cannon's velocity after the ball is fired. Show all work, including the equation and substitution with units.

ANSWER:

$$p = mv$$

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

$$v = \frac{2.40 \times 10^3 \text{ kg} \cdot \text{m/s}}{1.00 \times 10^3 \text{ kg}}$$

$$v = 2.40 \text{ m/s}$$

61. Identify the direction of the cannon's velocity after the ball is fired.

ANSWER: West

62. During a 5.0-second interval, an object's velocity changes from 25 meters per second east to 15 meters per second east. Determine the magnitude and direction of the object's acceleration.

ANSWER: 2.0 m/s^2 west

63. A projectile has an initial horizontal velocity of 15 meters per second and an initial vertical velocity of 25 meters per second. Determine the projectile's horizontal displacement if the total time of flight is 5.0 seconds. Neglect friction.

ANSWER: 75 m

Base your answers to questions 64 and 65 on the information below.

A hiker walks 5.00 kilometers due north and then 7.00 kilometers due east.

64. What is the magnitude of her resultant displacement?

ANSWER: 8.6 km

65. What total distance has she traveled?

ANSWER: 12 km

66. When a child squeezes the nozzle of a garden hose, water shoots out of the hose toward the east. What is the compass direction of the force being exerted on the child by the nozzle?

ANSWER: Due west

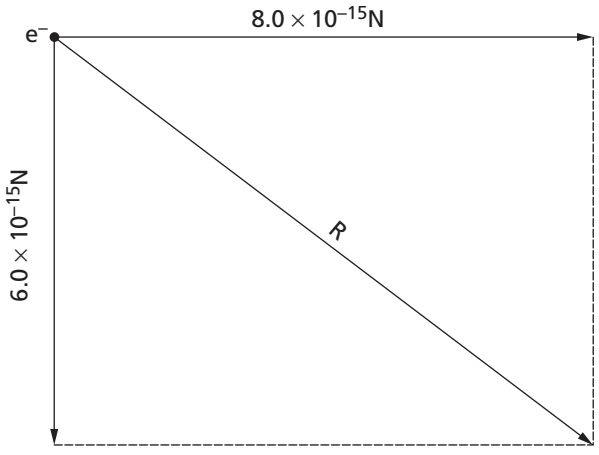
PART C—Pages 50–53

Base your answers to questions 67 through 70 on the information below.

A force of 6.0×10^{-15} newton due south and a force of 8.0×10^{-15} newton due east act concurrently on an electron, e^-.

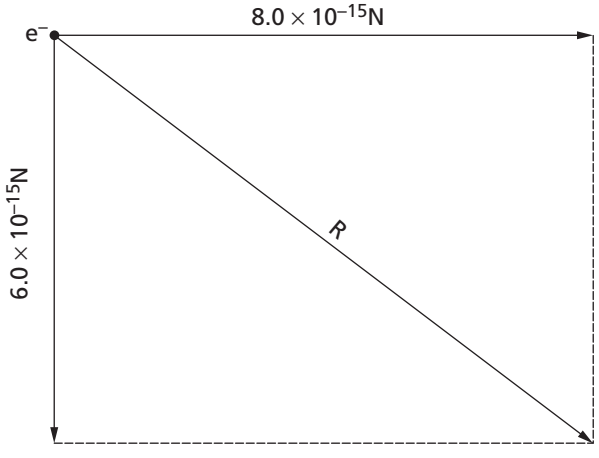
67. Draw a force diagram to represent the two forces acting on the electron with the electron represented by a dot. Use a metric ruler and the scale of 1.0 centimeter = 1.0×10^{-15} newton. Begin each vector at the dot representing the electron and label its magnitude in newtons.

ANSWER:



68. Determine the resultant force on the electron, graphically. Label the resultant vector **R**.

ANSWER:



69. Determine the magnitude of the resultant vector **R**.

ANSWER: 1.00×10^{-14} N

70. Determine the angle between the resultant and the 6.0×10^{-15}-newton vector.

ANSWER: 53°

Base your answers to questions 71 through 75 on the information below.

A force of 10. newtons toward the right is exerted on a wooden crate initially moving to the right on a horizontal wooden floor. The crate weighs 25 newtons.

71. Calculate the magnitude of the force of friction between the crate and the floor. Show all work, including the equation and substitution with units.

ANSWER:

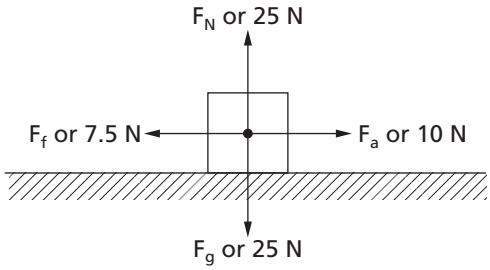
$$F_f = \mu F_N$$

$$F_f = (0.30)(25\text{ N})$$

$$F_f = 7.5\text{ N}$$

72. Draw and label all vertical forces acting on the crate.

ANSWER:



73. Draw and label all horizontal forces acting on the crate.

ANSWER: See #72, above.

74. What is the magnitude of the net force acting on the crate?

ANSWER: 2.5 N

75. Is the crate accelerating? Explain your answer.

ANSWER: The crate is accelerating because a net force acts on it.

Base your answers to questions 76 through 80 on the information below.

A manufacturer's advertisement claims that their 1250-kilogram (12,300-newton) sports car can accelerate on a level road from 0 to 60.0 miles per hour (0 to 26.8 meters per second) in 3.75 seconds.

76. Determine the acceleration, in meters per second^2, of the car according to the advertisement.

ANSWER: 7.15 m/s^2

77. Calculate the net force required to give the car the acceleration claimed in the advertisement. Show all work, including the equation and substitution with units.

ANSWER:

$$F = ma$$

$$F = 1250\text{ kg} \times 7.15\text{ m/s}^2$$

$$F = 8940\text{ N}$$

or

$$Ft = \Delta p$$

$$F = \frac{m\Delta v}{t}$$

$$F = \frac{1250\text{ kg} \times 26.8\text{ m/s}}{3.75\text{ s}}$$

$$F = 8930\text{ N}$$

78. What is the normal force exerted by the road on the car?

ANSWER: 12,300 N

79. The coefficient of friction between the car's tires and the road is 0.80. Calculate the maximum force of friction between the car's tires and the road. Show all work, including the equation and substitution with units.

ANSWER:

$F_f = \mu F\text{N}$

$F_f = (.80)(12{,}300\text{ N}) = 9800\text{ N or } 9.8 \times 10^3\text{ N}$

80. Using the values for the forces you have calculated, explain whether or not the manufacturer's claim for the car's acceleration is possible.

ANSWER: Yes, it is possible, because the available friction force is greater than the needed acceleration force.

81. Two physics students were selected by NASA to accompany astronauts on a future mission to the Moon. The students are to design and carry out a simple experiment to measure the acceleration due to gravity on the surface of the Moon.

Describe an experiment that the students could conduct to measure the acceleration due to gravity on the Moon. Your description must include:

- the equipment needed
- what quantities would be measured using the equipment
- what procedure the students should follow in conducting their experiment
- what equations and/or calculations the students would need to do to arrive at a value for the acceleration due to gravity on the Moon

Answers include, but are not limited to:

Freefall

- object, meterstick, stopwatch
- time of fall, distance of fall

- drop object from measured height, time its fall
- $d = v_i t + \frac{1}{2}at^2$

Pendulum

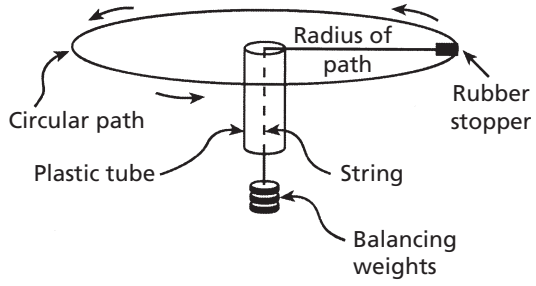
- String, mass stopwatch, meterstick
- Length of pendulum
- Measure length of pendulum, period of pendulum
- $T = 2\pi\sqrt{\frac{\ell}{g}}$

Spring scale

- Spring scale, known mass
- Weight of know mass on moon
- Hang the weight on the spring scale and weigh it
- $F_{g_M} = mg_M$ or $\frac{F_{g_M}}{F_{g_E}} = \frac{g_M}{g_E}$

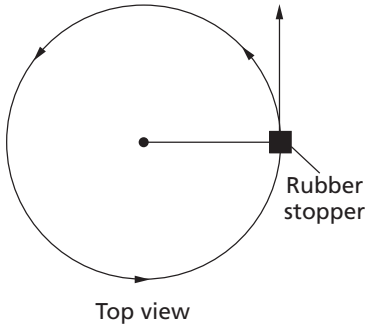
Base your answers to questions 82 through 85 on the information and diagram below.

In an experiment, a rubber stopper is attached to one end of a string that is passed through a plastic tube before weights are attached to the other end. The stopper is whirled in a horizontal circular path at constant speed.



82. Copy the figure below of the top view of the circular path, then draw the path of the rubber stopper if the string breaks at the position shown.

ANSWER:



83. Describe what would happen to the radius of the circle if the student whirls the stopper at a greater speed without changing the balancing weights.

ANSWER: As the speed of the stopper is increased, the radius of the orbit will increase.

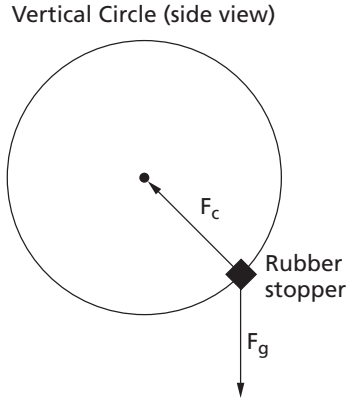
84. List three measurements that must be taken to show that the magnitude of the centripetal force is equal to the balancing weights. Neglect friction.

Acceptable responses include, but are not limited to:

- mass of stopper
- radius of path
- velocity of stopper *or* frequency *or* period
- weight of the balancing weights

85. The rubber stopper is now whirled in a vertical circle at the same speed. Copy the side-view figure below then draw and label vectors to indicate the direction of the weight (F_g) and the direction of the centripetal force (F_c) at the position shown in the figure.

ANSWER:

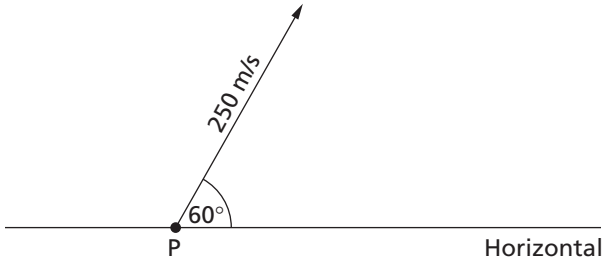


Base your answers to questions 86 through 88 on the information below.

A projectile is fired from the ground with an initial velocity of 250. meters per second at an angle of 60.° above the horizontal.

86. Using a protractor and a ruler, draw a vector to represent the initial velocity of the projectile. Use a scale of 1.0 centimeter = 50. meters per second.

ANSWER:



87. Determine the horizontal component of the initial velocity.

ANSWER: 125 m/s

88. Explain why the projectile has no acceleration in the horizontal direction. Neglect air friction.

Answers include:

- no force on object in horizontal direction
- The only force is vertical.
- Gravity acts only vertically.

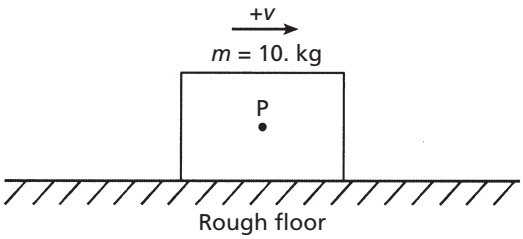
89. Explain how to find the coefficient of kinetic friction between a wooden block of unknown mass and a tabletop in the laboratory. Include the following in your explanation:

- Measurements required
- Equipment needed
- Procedure
- Equation(s) needed to calculate the coefficient of friction

Example of an acceptable answer: To determine the coefficient of friction between a block and the table, we would need to measure the normal force or weight of the block, and the force of friction. The equipment needed is a spring scale. First hang the block on the scale to find its weight. Then pull the block at constant speed across the table with the spring scale to find the force of friction. Once I measured the weight and friction forces, I would use the formula $F_f = \mu F_N$ to calculate the coefficient of friction.

Base your answers to questions 90 through 92 on the information and diagram below.

A 10.-kilogram box, sliding to the right across a rough horizontal floor, accelerates at −2.0 meters per second^2 due to the force of friction.



90. Calculate the magnitude of the net force acting on the box. Show all work, including the equation and substitution with units.

ANSWER:

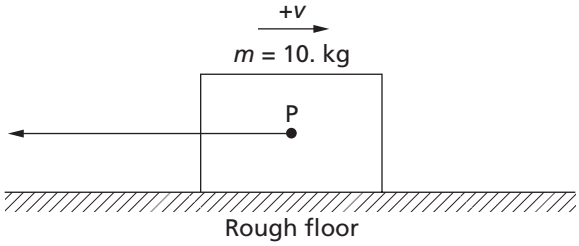
$$F_{net} = ma$$

$$F_{net} = 10.\text{ kg} \times 2.0\text{ m/s}^2$$

$$F_{net} = 20\text{ N}$$

91. Copy the diagram, then, draw a vector representing the net force acting on the box. Begin the vector at point P and use a scale of 1.0 centimeter = 5.0 newtons.

ANSWER:



92. Calculate the coefficient of kinetic friction between the box and the floor. Show all work, including the equation and substitution with units.

ANSWER:

$$F_f = \mu F_N$$

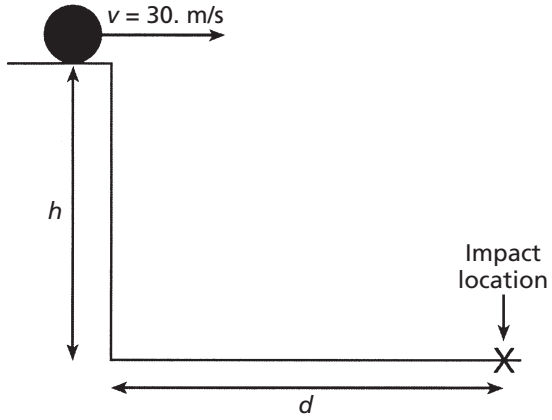
$$\mu = \frac{F_f}{F_N}$$

$$\mu = \frac{20\text{ N}}{98.1\text{ N}}$$

$$\mu = 0.20$$

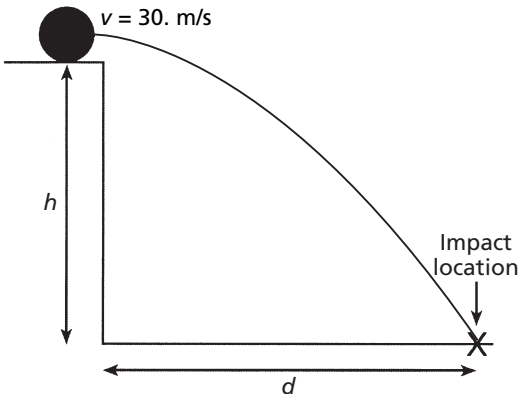
Base your answers to questions 93 through 95 on the information and diagram below.

A projectile is launched horizontally at a speed of 30. meters per second from a platform located a vertical distance *h* above the ground. The projectile strikes the ground after time *t* at horizontal distance *d* from the base of the platform. Neglect friction.



93. Copy the diagram, then sketch the theoretical path of the projectile.

ANSWER:



94. Calculate the horizontal distance, *d*, if the projectile's total time of flight is 2.5 seconds. Show all work, including the equation and substitution with units.

ANSWER:

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

$d = (30.\ \text{m/s})(2.5\ \text{s}) + \frac{1}{2}(0\ \text{m/s}^2)(2.5\ \text{s})^2$

$d = 75\ \text{m}$

or

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

$d = \bar{v}t$

$d = (30.\ \text{m/s})(2.5\ \text{s})$

$d = 75\ \text{ms}$

95. Express the projectile's total time of flight, *t*, in terms of the vertical distance, *h*, and the acceleration due to gravity, *g*. Write an appropriate equation and solve it for *t*.

ANSWER:

$d = v_i t + \frac{1}{2}at^2$ or $h = v_i t + \frac{1}{2}gt^2$ or $t = \sqrt{\frac{2h}{g}}$

$t = \sqrt{\frac{2d}{a}}$ $\quad h = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2h}{g}}$ $\quad t = \sqrt{\frac{2h}{g}}$

Base your answers to questions 96 and 97 on the information below.

A physics class is to design an experiment to determine the acceleration of a student on in-line skates coasting straight down a gentle incline. The incline has a constant slope. The students have tape measures, traffic cones, and stopwatches.

96. Describe a procedure to obtain the measurements necessary for this experiment.

ANSWER: Set up a measured distance and measure the time to travel that distance.

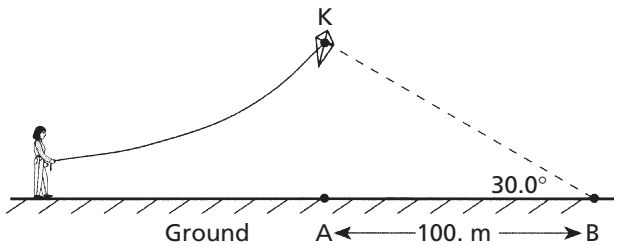
97. Indicate which equation(s) they should use to determine the student's acceleration.

ANSWER:

$$d = v_i t + \tfrac{1}{2}at^2 \quad \text{or} \quad a = \frac{2d}{t^2}$$

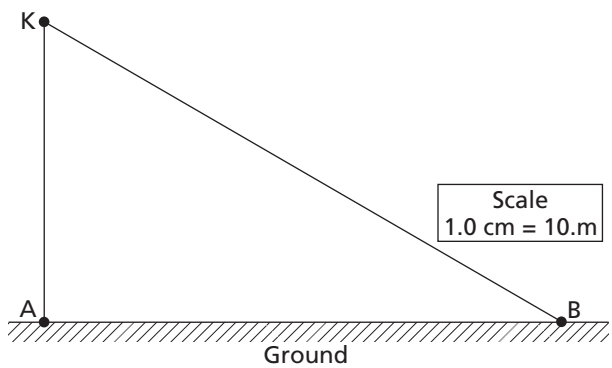
Base your answers to questions 98 through 100 on the information and diagram below.

A child is flying a kite, K. A student at point B, located 100. meters away from point A (directly underneath the kite), measures the angle of elevation of the kite from the ground as 30.°.



98. Using a metric ruler and protractor, draw a triangle representing the positions of the kite, *K*, and point *A* relative to point *B* that is given. Label points *A* and *K*. Use a scale of 1.0 centimeter = 10 meters.

ANSWER:



(Not drawn to scale.)

99. Use a metric ruler and your scale diagram to determine the height, *AK*, of the kite.

ANSWER: 58 m

100. A small lead sphere is dropped from the kite. Calculate the amount of time required for the sphere to fall to the ground. Show all calculations, including the equation and substitution with units. Neglect air resistance.

ANSWER:

$$d = v_i t + \tfrac{1}{2}at^2 \quad \text{or} \quad d = \tfrac{1}{2}at^2$$

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

$$t = \sqrt{\frac{2(58\text{ m})}{9.81\text{ m/s}^2}}$$

$$t = 3.4\text{ s}$$

Base your answers to questions 101 and 102 on the information given below.

Friction provides the centripetal force that allows a car to round a circular curve.

101. Find the minimum coefficient of friction needed between the tires and the road to allow a 1600-kilogram car to round a curve of radius 80. meters at a speed of 20. meters per second. Show all work, including formulas and substitutions with units.

ANSWER:

Formulas: $F_f = \mu F_N \quad F_N = mg \quad F_c = \dfrac{mv^2}{r}$

Rearrangement: $\mu = \dfrac{v^2}{rg}$

Substitution: $\mu = \dfrac{(20.\text{ m/s})^2}{(80.\text{ m})(9.8\text{ m/s}^2)}$

ANSWER: $\mu = 0.51$

102. If the mass of the car were increased, how would that affect the maximum speed at which it could round the curve?

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

ENRICHMENT—Mechanics

Pages 55–56

E1. The path of a planet around the sun is best described as

ANSWER: (2) an ellipse

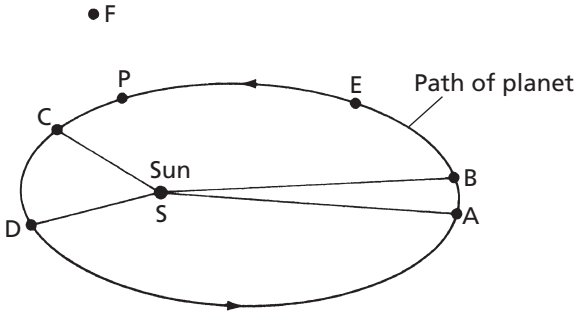
E2. With respect to a planet's orbit, the sun is situated at

ANSWER: (2) one of the foci

E3. Until 1999 Neptune was farther from the sun than Pluto because Pluto

ANSWER: (4) has a very elongated orbit

Questions E4—E10 are based on the following diagram of a planet orbiting the sun. It takes the planet one month to travel from point A to point B, and one month to travel from point C to point D.



E4. Which of the following statements is correct?

ANSWER: (3) area = SCD = SAB

E5. At which point does the planet have the greatest kinetic energy and speed?

ANSWER: (2) C

E6. If this planet is Earth, when is it located at point C?

ANSWER: (1) January

E7. If the planet's mass were suddenly doubled, the period of its revolution in orbit would

ANSWER: (3) remain the same.

E8. When the planet is at point P, the direction of the planet's velocity is toward point

ANSWER: (3) C

E9. The direction of the planet's acceleration at point P is toward point

ANSWER: (1) S

E10. If the mass of the sun were suddenly to increase, then the value of R^3/T^2 would

ANSWER: (2) increase

E11. What is true of a satellite in geosynchronous orbit?

ANSWER: (1) It remains in the same position over a point on the equator.

E12. The radius of orbit for an artificial satellite around Earth may be determined by equating R^3/T^2 for the satellite with R^3/T^2 for the

ANSWER: (2) moon

E13. What occurs if an orbiting satellite's speed exceeds escape velocity?

ANSWER: (3) It spirals outward away from Earth.

CHAPTER 2 Energy

PART A: Pages 59–60

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 applied to the box to do this work?

ANSWER: (3) 12 N

2. A boat weighing 9.0×10^2 newtons requires a horizontal force of 6.0×10^2 newtons to move it across the water at 1.5×10^1 meters per second. The boat's engine must provide energy at the rate of

ANSWER: (4) 9.0×10^3 W

3. A motor used 120. watts of power to raise a 15-newton object in 5.0 seconds. Through what vertical distance was the object raised?

ANSWER: (3) 40. m

4. Through what vertical distance is a 50.-newton object moved if 250 joules of work is done against Earth's gravitational field?

ANSWER: (2) 5.0 m

5. A constant force of 1900 newtons is required to keep an automobile having a mass of 1.0×10^3 kilograms moving at a constant speed of 20. meters per second. The work done in moving the automobile a distance of 2.0×10^3 meters is

ANSWER: (4) 3.8×10^6 J

6. What is the maximum height to which a 1200-watt motor could lift an object weighing 200. newtons in 4.0 seconds?

ANSWER: (4) 24 m

7. A 95-kilogram student climbs 4.0 meters up a rope in 3.0 seconds. What is the power output of the student?

ANSWER: (3) 1.2×10^3 W

8. Two weightlifters, one 1.5 meters tall and one 2.0 meters tall, raise identical 50.-kilogram masses above their heads. Compared to the work done by the weightlifter who is 1.5 meters tall, the work done by the weightlifter who is 2.0 meters tall is

ANSWER: (2) greater

9. A 40.-kilogram student runs up a staircase to a floor that is 5.0 meters higher than her starting point in 7.0 seconds. The student's power output is

ANSWER: (2) 280 W

10. What is the average power developed by a motor as it lifts a 400.-kilogram mass at constant speed through a vertical distance of 10.0 meters in 8.0 seconds?

ANSWER: (3) 4900 W

11. A student develops 250 watts of power running up a 5-meter high staircase in 10 seconds. How much does the student weigh?

ANSWER: (4) 500 N

12. When a student raises an object vertically at a constant speed of 2.0 meters per second, 10. watts of power is developed. The weight of the object is

ANSWER: (1) 5.0 N

13. A force of 80. newtons pushes a 50.-kilogram object across a level floor for 8.0 meters. The work done is

ANSWER: (3) 640 J

14. Which of the following units is used to measure work?

ANSWER: (3) joule

15. If 700 watts of power is needed to keep a boat moving through the water at a constant speed of 10 meters per second, what is the magnitude of the force exerted by the water on the boat?

ANSWER: (2) 70 N

16. A crane raises a 200-newton weight to a height of 50 meters in 5 seconds. The crane does work at the rate of

ANSWER: (3) 2×10^3 W

17. A constant force of 20. newtons applied to a box causes it to move at a constant speed of 4.0 meters per second. How much work is done on the box in 6.0 seconds?

ANSWER: (1) 480 J

18. An object has a mass of 8.0 kilograms. A 2.0-newton force displaces the object a distance of 3.0 meters to the east, and then 4.0 meters to the north. What is the total work done on the object?

ANSWER: (2) 14 J

19. What is the minimum power required for a conveyor to raise an 8.0-newton box 4.0 meters vertically in 8.0 seconds?

ANSWER: (4) 4.0 W

20. As the power of a machine is increased, the time required to move an object a fixed distance

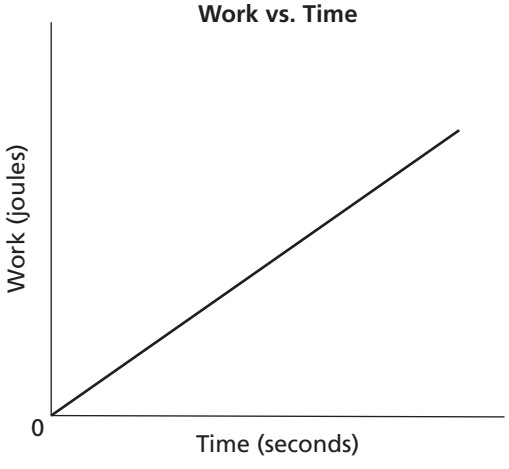
ANSWER: (1) decreases

21. One elevator lifts a mass a given height in 10 seconds and a second elevator does the same work in 5 seconds. Compared with the power developed by the first elevator, the power developed by the second elevator is

ANSWER: (2) twice as great

PART B-1: Page 60

22. The following graph represents the relationship between the work done by a student running up a flight of stairs and the time of ascent.



What does the slope of this graph represent?

ANSWER: (4) power

Base your answers to questions 23 and 24 on the following information.

You push against the handle of a lawn mower with a force of 200 newtons. The handle makes an angle of 60° with the ground. The mower moves at a constant rate of 0.5 meters per second.

23. How much work do you perform in one minute?

ANSWER: (4) 3000 J

24. How much work is performed by the force of friction during this time?

ANSWER: (3) 3000 J

PART A: Pages 64–65

25. An object weighing 15 newtons is lifted from the ground to a height of 0.22 meter. The increase in the object's gravitational potential energy is approximately

ANSWER: (3) 3.3 J

26. As an object falls freely, the kinetic energy of the object

ANSWER: (2) increases

27. If the direction of a moving car changes and its speed remains constant, which quantity must remain the same?

ANSWER: (4) kinetic energy

28. 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?

ANSWER: (2) 2.21×10^3 J

29. A 60.0-kilogram runner has 1920 joules of kinetic energy. At what speed is she running?

ANSWER: (2) 8.00 m/s

30. A vertical spring 0.100 meter long is elongated to a length of 0.119 meter when a 1.00-kilogram mass is attached to the bottom of the spring. The spring constant of this spring is

ANSWER: (4) 520 N/m

31. A 6.8-kilogram block is sliding down a horizontal, frictionless surface at a constant speed of 6.0 meters per second. The kinetic energy of the block is approximately

ANSWER: (3) 120 J

32. When a mass is placed on a spring with a spring constant of 15 newtons per meter, the spring is compressed 0.25 meter. How much elastic potential energy is stored in the spring?

ANSWER: (1) 0.47 J

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

ANSWER: (3) the same

34. An object moving at a constant speed of 25 meters per second possesses 450 joules of kinetic energy. What is the object's mass?

ANSWER: (2) 1.4 kg

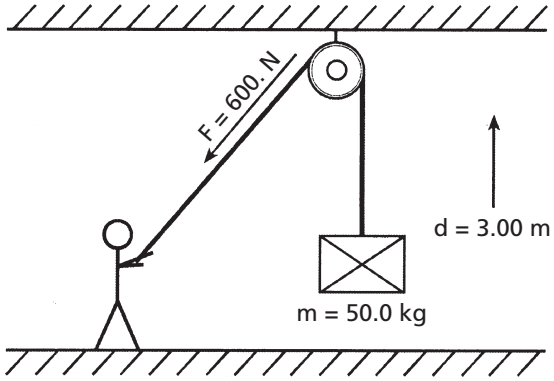
35. A spring of negligible mass has a spring constant of 50. newtons per meter. If the spring is stretched 0.40 meter from its equilibrium position, how much potential energy is stored in the spring?

ANSWER: (4) 4.0 J

36. The spring in a scale in the produce department of a supermarket stretches 0.025 meter when a watermelon weighing 1.0×10^2 newtons is placed on the scale. The spring constant for this spring is

ANSWER: (2) 4.0×10^3 N/m

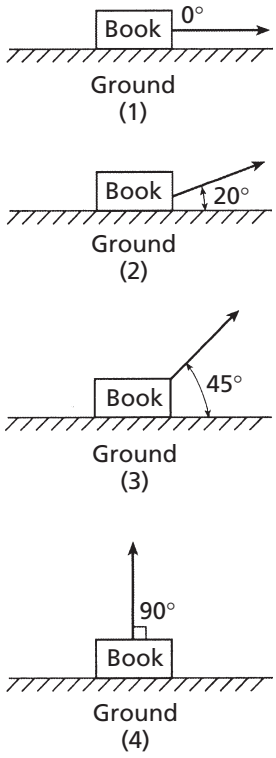
37. As shown in the diagram below, a student exerts an average force of 600. newtons on a rope to lift a 50.0-kilogram crate a vertical distance of 3.00 meters.



Compared to the work done by the student, the gravitational potential energy gained by the crate is

ANSWER: (2) 330 J less

38. A 1.0-kilogram book resting on the ground is moved 1.0 meter at various angles relative to the horizontal. In which direction does the 1.0-meter displacement produce the greatest increase in the book's gravitational potential energy?



ANSWER: (4)

39. A 45.0-kilogram boy is riding a 15.0-kilogram bicycle with a speed of 8.00 meters per second. What is the combined kinetic energy of the boy and the bicycle?

ANSWER: (4) 1920 J

40. A 5-newton force causes a spring to stretch 0.2 meter. What is the potential energy stored in the stretched spring?

ANSWER: (2) 0.5 J

41. A 10.-newton force is required to hold a stretched spring 0.20 meter from its rest position. What is the potential energy stored in the stretched spring?

ANSWER: (1) 1.0 J

42. As a spring is stretched, its elastic potential energy

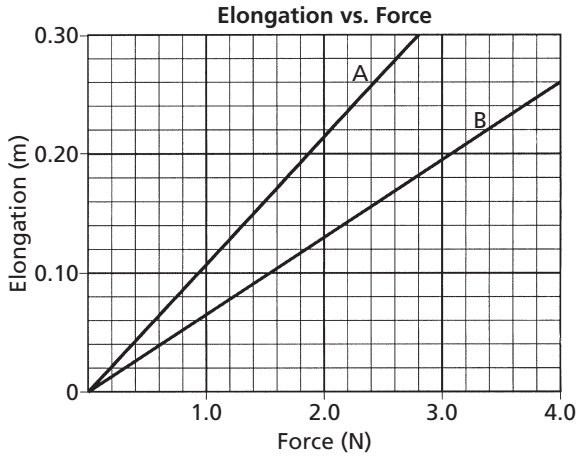
ANSWER: (2) increases

PART B-1: Pages 65–66

43. The spring of a toy car is wound by pushing the car backward with an average force of 15 newtons through a distance of 0.50 meter. How much elastic potential energy is stored in the car's spring during this process?

ANSWER: (2) 7.5 J

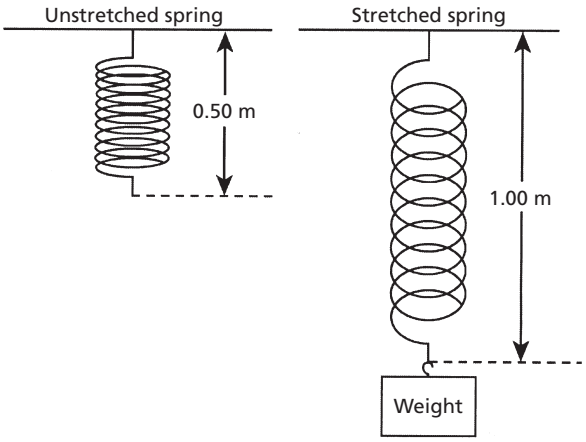
44. The following graph shows elongation as a function of the applied force for two springs, *A* and *B*.



Compared to the spring constant for spring *A*, the spring constant for spring *B* is

ANSWER: (2) larger

45. As shown in the following diagram, a 0.50-meter-long spring is stretched from its equilibrium position to a length of 1.00 meter by a weight.



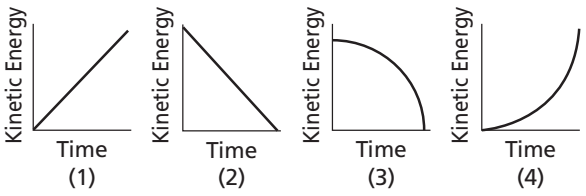
If 15 joules of energy are stored in the stretched spring, what is the value of the spring constant?

ANSWER: (3) 120 N/m

46. Which pair of quantities can be expressed using the same units?

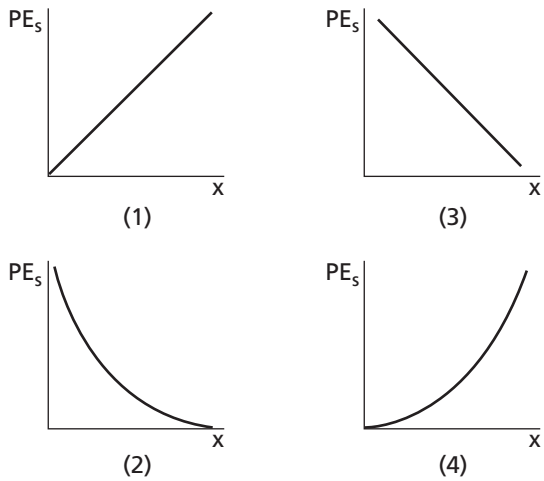
ANSWER: (1) work and kinetic energy

47. 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?



ANSWER: (4)

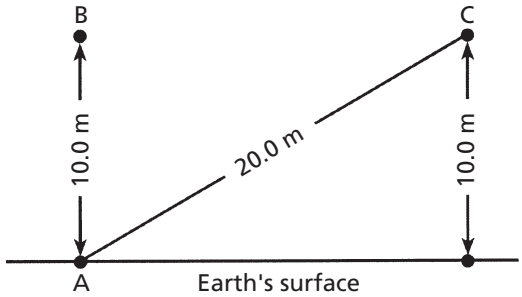
48. Which graph best represents the elastic potential energy stored in a spring (PE_S) as a function of its elongation, *x*?



ANSWER: (4)

PART A: Pages 68–70

49. The diagram below shows points *A*, *B*, and *C* at or near Earth's surface. As a mass is moved from *A* to *B*, 100. joules of work are done against gravity.



What is the amount of work done against gravity as an identical mass is moved from *A* to *C*?

ANSWER: (1) 100. J

50. When a force moves an object over a rough, horizontal surface at a constant velocity, the work done against friction produces an increase in the object's

ANSWER: (4) internal energy

51. A 55.0-kilogram diver falls freely from a diving platform that is 3.00 meters above the surface of the water in a pool. When she is 1.00 meter above the water, what are her gravitational potential energy and kinetic energy with respect to the water's surface?

ANSWER: (4) $PE = 540$ J and $KE = 1080$ J

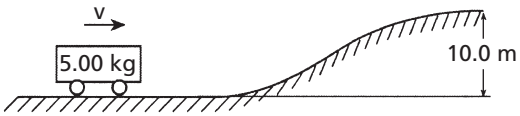
52. A 0.25-kilogram baseball is thrown upward with a speed of 30. meters per second. Neglecting friction, the maximum height reached by the baseball is approximately

ANSWER: (2) 46 m

53. A truck weighing 3.0×10^4 newtons was driven up a hill that is 1.6×10^3 meters long to a level area that is 8.0×10^2 meters above the starting point. If the trip took 480 seconds, what was the *minimum* power required?

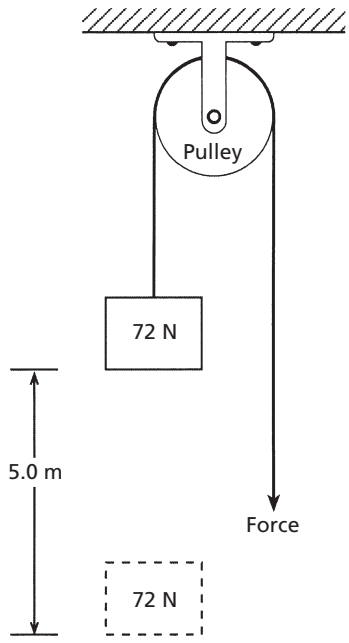
ANSWER: (1) 5.0×10^4 W

54. The diagram below shows a moving, 5.00-kilogram cart at the foot of a hill 10.0 meters high. For the cart to reach the top of the hill, what is the minimum kinetic energy of the cart in the position shown? Neglect energy loss due to friction.



ANSWER: (4) 491 J

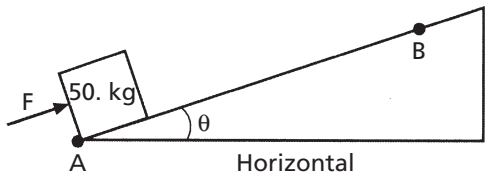
55. In the diagram below, 400. joules of work is done raising a 72-newton weight a vertical distance of 5.0 meters.



How much work is done to overcome friction as the weight is raised?

ANSWER: (1) 40. J

56. The diagram below shows a 50.-kilogram crate on a frictionless plane at angle θ to the horizontal. The crate is pushed at constant speed up the incline from point *A* to point *B* by force *F*.



If angle θ were increased, what would be the effect on the magnitude of force *F* and the total work *W* done on the crate as it is moved from *A* to *B*?

ANSWER: (4) *W* would increase and the magnitude of *F* would increase.

57. As a ball falls freely (without friction) toward the ground, its total mechanical energy

ANSWER: (3) remains the same

58. A 0.50-kilogram ball is thrown vertically upward with an initial kinetic energy of 25 joules. Approximately how high will the ball rise?

ANSWER: (2) 5.1 m

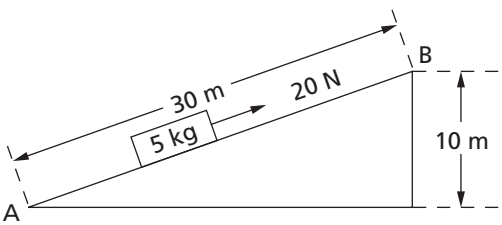
59. A 1.0-kilogram rubber ball traveling east at 4.0 meters per second hits a wall and bounces back toward the west at 2.0 meters per second. Compared to the kinetic energy of the ball before it hits the wall, the kinetic energy of the ball after it bounces off the wall is

ANSWER: (1) one-fourth as great

60. A catapult with a spring constant of 1.0×10^4 newtons per meter is required to launch an airplane from the deck of an aircraft carrier. The plane is released when it has been displaced 0.50 meter from its equilibrium position by the catapult. The energy acquired by the airplane from the catapult during takeoff is approximately

ANSWER: (1) 1.3×10^3 J

Base your answers to questions 61 through 64 on the following diagram, which shows a 20-newton force pulling an object up a hill at a constant rate of 2 meters per second.



61. The work done by the force in pulling the object from *A* to *B* is

ANSWER: (4) 600 J

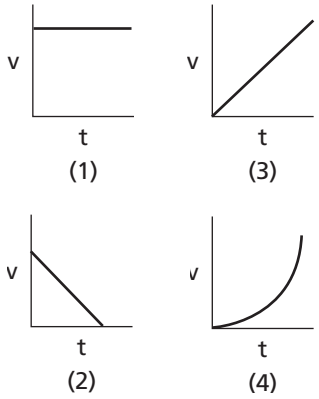
62. The kinetic energy of the moving object is

ANSWER: (2) 10 J

63. The work done against gravity in moving the object from point *A* to point *B* is approximately

ANSWER: (3) 500 J

64. Which graph best represents the relationship between velocity and time for the object?



ANSWER: (1)

65. The work done on an object by a nonconservative force depends on:

ANSWER: (1) the path taken

66. An example of a nonconservative force is

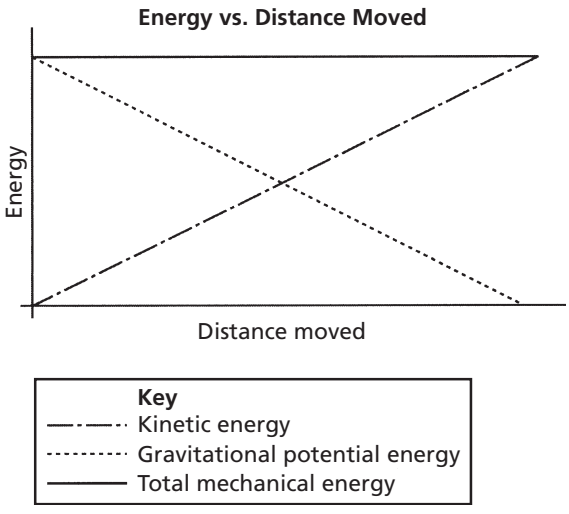
ANSWER: (3) friction force

PART B-1: Pages 70–71

67. 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

ANSWER: (2) internal energy, only

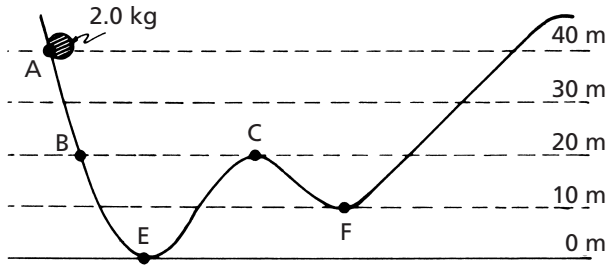
68. The graph below represents the kinetic energy, gravitational potential energy, and total mechanical energy of a moving block.



Which best describes the motion of the block?

ANSWER: (3) falling freely

Base your answers to questions 69 through 73 on the diagram below, which represents a 2.0-kilogram mass placed on a frictionless track at point A *and released from rest. Assume the gravitational potential energy of the system to be zero at point* E.



69. The gravitational potential energy of the system at point *A* is approximately

ANSWER: (3) 8.0×10^2 J

70. Compared with the kinetic energy of the mass at point *B*, the kinetic energy of the mass at point *E* is

ANSWER: (2) twice as great

71. As the mass travels along the track, the maximum height it will reach above point *E* will be closest to

ANSWER: (4) 40. m

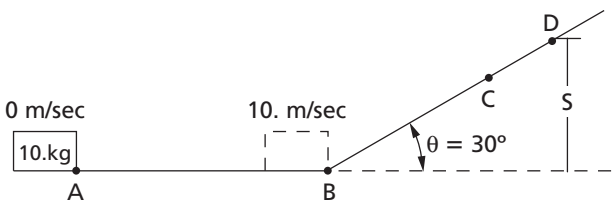
72. If the mass were released from rest at point *B*, its speed at point *C* would be

ANSWER: (1) 0 m/s

73. Compared with the total mechanical energy of the system at point *A*, the total mechanical energy of the system at point *F* is

ANSWER: (3) the same

Base your answers to questions 74 through 77 on the diagram below, which represents a 10-kilogram object at rest at point A. *The object accelerates uniformly from point* A *to point* B *in 4 seconds, attaining a maximum speed of 10 meters per second at point* B. *The object then moves up the incline. [Neglect friction.]*



74. The kinetic energy of the object at point *B* is

ANSWER: (2) 500 J

75. What distance did the object travel in moving from point *A* to point *B*?

ANSWER: (3) 20. m

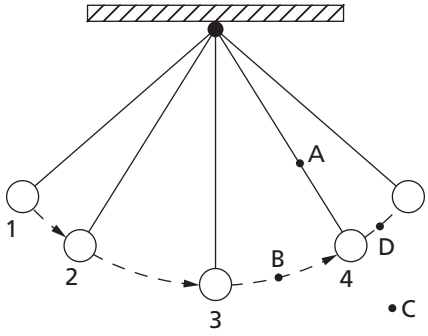
76. As the mass moves up the incline, its potential energy

ANSWER: (2) increases

77. The object comes to rest at a vertical height of S (point D) when $\angle\theta = 30°$. If $\angle\theta$ were increased to 40°, the object would come to rest at a vertical height

ANSWER: (3) equal to S

Base your answers to questions 78 through 80 on the diagram below, which represents a simple pendulum with a 2.0-kilogram bob and a length of 10. meters. The pendulum is released from rest at position 1 and swings without friction through position 4. At position 3, its lowest point, the speed of the bob is 6.0 meters per second.



78. At which position does the bob have its maximum kinetic energy?

ANSWER: (3) 3

79. What is the potential energy of the bob at position 1 in relation to position 3?

ANSWER: (2) 36 J

80. Compared with the sum of the kinetic and potential energies of the bob at position 1, the sum of the kinetic and potential energies of the bob at position 2 is

ANSWER: (3) the same

PHYSICS IN YOUR LIFE— Heat Exchange

Page 71

1. How is the action of a refrigerator comparable to pumping water uphill?

A refrigerator moves heat from a low temperature region to a high temperature region, which is the reverse of the way heat normally flows, just as pumping water uphill moves the water in the reverse direction of the way it normally flows.

2. What happens to the heat energy lost by the refrigerant as it condenses?

It is transferred to the air in the room.

3. From where does the liquid refrigerant get the heat it needs to boil?

From inside the refrigerator. This cools the food in the refrigerator.

4. Which part of the refrigerator does work on the refrigerant?

The compressor.

5. In what way is a heat pump different from an air conditioner?

A heat pump transfers heat from outside a building to inside the building, while an air conditioners transfers heat from inside to outside.

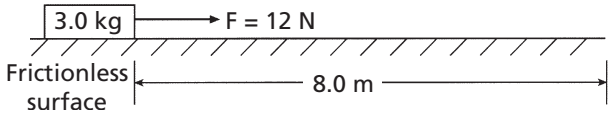
Chapter Review Questions

PART A: Pages 72–73

1. The amount of work done against friction to slide a box in a straight line across a uniform, horizontal floor depends most on the

ANSWER: (2) distance the box is moved

2. 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 12-newton horizontal force, as shown in the diagram below.



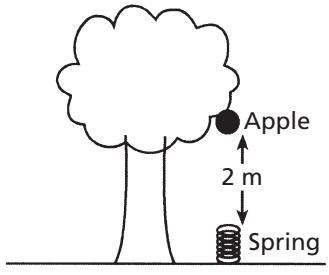
What is the average power developed while moving the block?

ANSWER: (3) 48 W

3. One watt is equivalent to one

ANSWER: (4) J/s

4. The following diagram shows a 0.1-kilogram apple attached to a branch of a tree 2 meters above a spring on the ground below.



The apple falls and hits the spring, compressing it 0.1 meter from its rest position. If all of the gravitational potential energy of the apple on the tree is transferred to the spring when it is compressed, what is the spring constant of this spring?

ANSWER: (4) 400 N/m

5. A 1-kilogram rock is dropped from a cliff 90 meters high. After falling 20 meters, the kinetic energy of the rock is approximately

ANSWER: (2) 200 J

6. A unit for kinetic energy is the

ANSWER: (2) joule

7. A 2.0-newton book falls from a table 1.0 meter high. After falling 0.5 meter, the book's kinetic energy is

ANSWER: (1) 1.0 J

8. An object is lifted at constant speed a distance h above Earth's surface in a time t. The total potential energy gained by the object is equal to the

ANSWER: (3) total work done on the object

9. If a 5-kilogram mass is raised vertically 2 meters from the surface of Earth, its gain in potential energy is approximately

ANSWER: (4) 100 J

10. If the kinetic energy of a given mass is to be doubled, its speed must be multiplied by

ANSWER: (3) $\sqrt{2}$

11. A 2.0-kilogram mass falls freely for 10. meters near Earth's surface. The total kinetic energy gained by the object during its free fall is approximately

ANSWER: (2) 200 J

12. If the velocity of a moving object is doubled, the object's kinetic energy is

ANSWER: (4) quadrupled

13. Which mass has the greatest potential energy with respect to the floor?

ANSWER: (4) 6-kg mass 5 meters above the floor

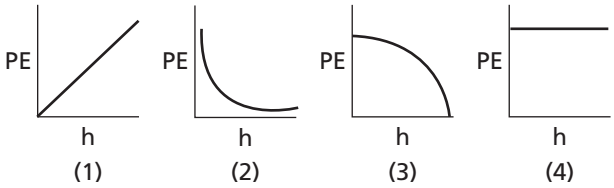
14. A ball is thrown upward from Earth's surface. While the ball is rising, its gravitational potential energy will

ANSWER: (2) increase

15. Ten joules of work are done in accelerating a 2.0-kilogram mass from rest across a horizontal frictionless table. The total kinetic energy gained by the mass is

ANSWER: (3) 10.J

16. Which graph best represents the relationship between potential energy (*PE*) and height above ground (*h*) for a freely falling object released from rest?



ANSWER: (1)

17. A 10.-kilogram object and a 5.0-kilogram object are released simultaneously from a height of 50. meters above the ground. After falling freely for 2.0 seconds, the objects will have different

ANSWER: (3) kinetic energies

18. At what point in its fall does the kinetic energy of a freely falling object equal its potential energy?

ANSWER: (2) halfway between the start and the end

19. A 20.-newton block falls freely from rest from a point 3.0 meters above the surface of Earth. With respect to Earth's surface, what is the gravitational potential energy of the block-Earth system after the block has fallen 1.5 meters?

ANSWER: (2) 30. J

20. A 24-N force applied to a spring causes the spring to increase in length by 0.40 m. What is the spring constant?

ANSWER: (4) 60. N/m

21. A 2.0 N force is applied to a spring with a spring constant of 10. N/m. What is the resultant change in the length of the spring?

ANSWER: (1) 0.20 m

22. An unstretched spring has a length of 0.50 m and a spring constant of 100. N/m. What force is required to stretch this spring to a length of 0.60 m?

ANSWER: (1) 10. N

23. What is the potential energy stored in a spring with a spring constant of 100. N/m when it is stretched 0.10 m from the original length?

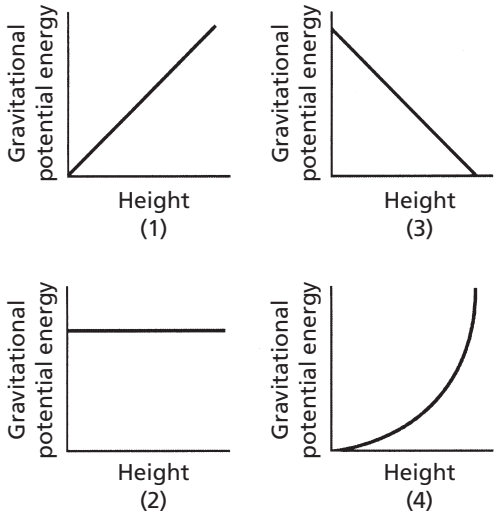
ANSWER: (1) 0.50 J

24. What work is required to make a spring's length increase by 3.0 m if its spring constant is 60. N/m?

ANSWER: (3) 270 J

PART B-1: Pages 73–74

25. Which graph best represents the relationship between the gravitational potential energy of a freely falling object and the object's height above the ground near the surface of Earth?

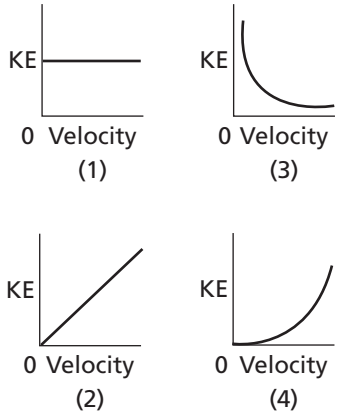


ANSWER: (1)

26. When a 1.53-kilogram mass is placed on a spring with a spring constant of 30.0 newtons per meter, the spring is compressed 0.500 meter. How much energy is stored in the spring?

ANSWER: (1) 3.75 J

27. Which graph best represents the relationship between the kinetic energy, *KE*, and the velocity of an object accelerating in a straight line?



ANSWER: (4)

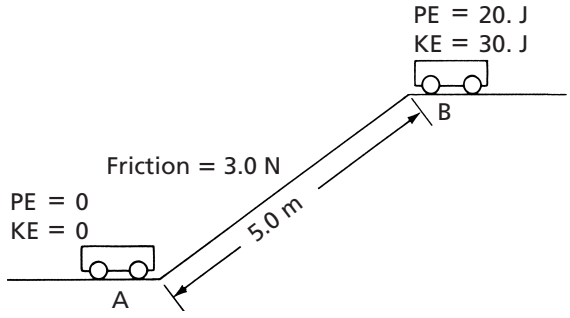
28. When 800 J of work are done on an object, its potential energy increases by 300 J and its kinetic energy increases by 400 J. What was the work done against friction?

ANSWER: (1) 100 J

29. In driving down a hill, a car loses 500 J of potential energy but gains 1500 J of kinetic energy. If the work done to overcome friction was 200 J, determine the total work done by the engine to go down the hill.

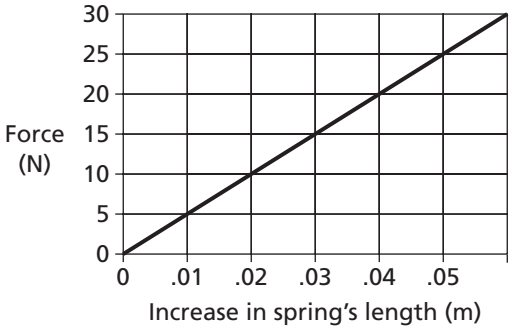
ANSWER: (2) 1200 J

30. In the following diagram a cart starts from rest at ground level (point A). It is pulled up the inclined plane to the top at a constant speed where its potential energy is 20. J and its kinetic energy is 30. J (point B). The friction force was 3.0 N. The length of the inclined plane is 5.0 m. What is the total work done in moving the object from A to B?



ANSWER: (4) 65 J

Base your answers to questions 31 through 33 on the following graph taken from an experiment with a spring of original length 1.0 m.



31. What is the spring constant of this spring?

ANSWER: (4) 500 N/m

32. How much force must be applied to this spring to change its length to 1.025 m?

ANSWER: (3) 12.5 N

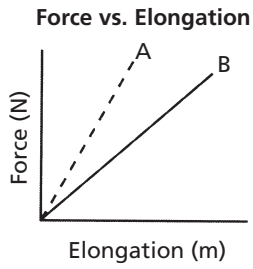
33. What is the potential energy stored in the spring when it has been stretched 0.40 m from its original length?

ANSWER: (2) 40 J

PART B-2: Pages 74–75

Base your answers to questions 34 and 35 on the information and graph below.

The graph represents the relationship between the force applied to each of two springs, *A* and *B*, and their elongations.



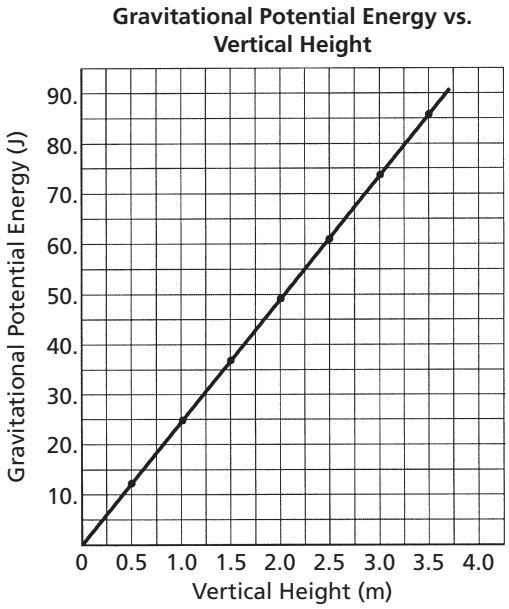
34. What physical quantity is represented by the slope of each line?

ANSWER: The quantity represented by the slope of each line is the spring constant.

35. A 1.0-kilogram mass is suspended from each spring. If each mass is at rest, how does the potential energy stored in spring *A* compare to the potential energy stored in spring *B*?

ANSWER: The potential energy stored in spring *A* is less than the potential energy stored in spring *B*.

Base your answers to questions 36 through 39 on the following graph, which represents the relationship between vertical height and gravitational potential energy for an object near Earth's surface.



36. Based on the graph, what is the gravitational potential energy of the object when it is 2.25 meters above the surface of Earth?

ANSWER: 55 J

37. Using the graph, calculate the mass of the object. Show all work, including the equation and substitution with units.

ANSWER:

$$PE = mgh$$

$$m = \frac{PE}{gh} = \frac{55\text{ J}}{9.81\text{ m/s} \times 2.25\text{ m}}$$

$$m = 2.5\text{ kg}$$

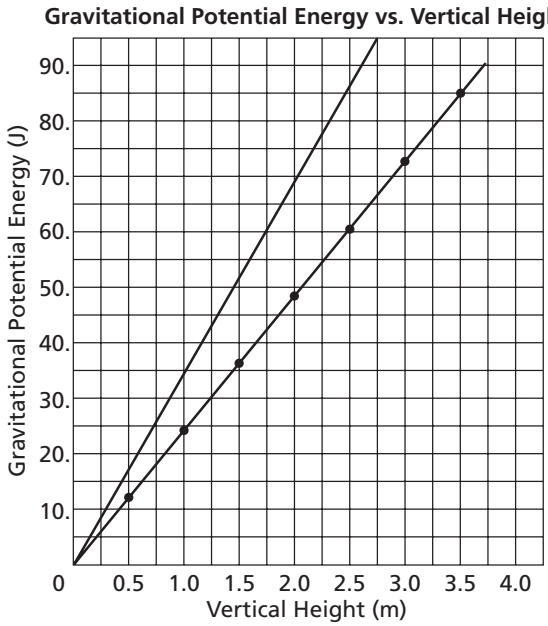
38. What physical quantity does the slope of the graph represent?

Acceptable responses include, but are not limited to:

Weight of object *or* weight, *mg*, force, F_g

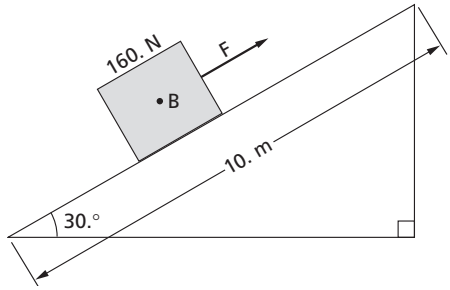
39. Copy the graph then, using a straightedge, draw a line on the graph to represent the relationship between gravitational potential energy and vertical height for an object having a greater mass.

ANSWER:



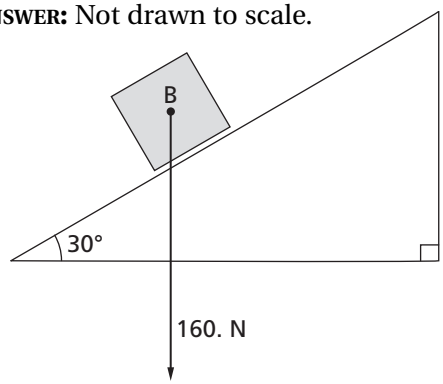
Base your answers to questions 40 and 41 on the information and diagram below.

A 160.-newton box sits on a 10.-meter-long frictionless plane inclined at an angle of 30.° to the horizontal as shown. Force (*F*) applied to a rope attached to the box causes the box to move with a constant speed up the incline.



40. Copy the diagram, then construct a vector to represent the weight of the box. Use a metric ruler and a scale of 1.0 centimeter = 40. newtons. Begin the vector at point *B* and label its magnitude in newtons.

ANSWER: Not drawn to scale.



41. Calculate the amount of work done in moving the box from the bottom to the top of the inclined plane. Show all work, including the equation and substitution with units.

ANSWER:

$F_y = F \sin\theta$ and $w = Fd$

$F_y = (160.\text{ N})(\sin 30.°) = 80.\text{ N}$

$w = (80.\text{ N})(10.\text{ m}) = 800\text{ J}$

or

$w = Fd \sin\theta$

$w = (160.\text{ N})(10.\text{ m})(\sin 30°)$

$w = 800\text{ J}$

or

$w = Fd = E_T = mgh$ and $h = d \sin\theta$

$w = mgd \sin\theta$

$w = (160.\text{ N})(10.\text{ m})(\sin 30°)$

$w = 800\text{ J}$

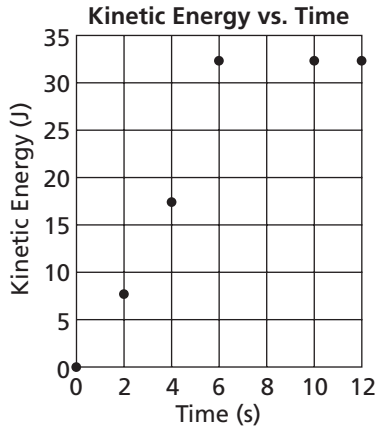
Base your answers to questions 42 through 45 on the information and table below.

The table lists the kinetic energy of a 4.0-kilogram mass as it travels in a straight line for 12.0 seconds. Using the information in the data table, construct a graph following the directions below.

Time (s)	Kinetic Energy (J)	Time (s)	Kinetic Energy (J)
0.0	0.0	6.0	32
2.0	8.0	10.0	32
4.0	18	12.0	32

42. The title of the graph is Kinetic Energy vs. Time. Label the *x*-axis "Time." Label the *y*-axis Kinetic Energy (J) and mark it with an appropriate scale.

ANSWER:



43. Plot the data points for kinetic energy versus time.

ANSWER: See # 42, above.

44. Calculate the speed of the mass at 10.0 seconds. Show all work, including the equation and substitution with units.

ANSWER:

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

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

$v = \sqrt{\frac{2\ (32\text{ J})}{4.0\text{ kg}}}$

$v = \sqrt{\frac{16\text{ m}^2}{\text{s}^2}}$

$v = 4.0\text{ m/s}$ *or* $v = 4.0\sqrt{\frac{\text{J}}{\text{kg}}}$

45. Compare the speed of the mass at 6.0 seconds to the speed of the mass at 10.0 seconds.

Examples of Acceptable Responses

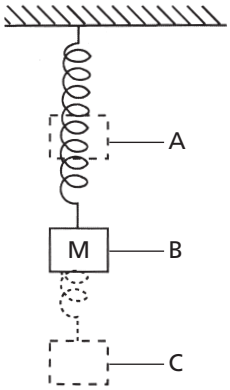
The speeds are the same. *or* The speed of the mass at 6.0 seconds and the speed of the mass at 10.0 seconds are both 4.0 m/s.

PART C: Pages 75–77

Base your answers to questions 46 through 48 on the information and diagram below.

A mass, *M*, is hung from a spring and reaches equilibrium at position *B*. The mass is then raised to position *A* and released. The mass

oscillates between positions *A* and *C*. (Neglect friction.)



46. At which position, *A*, *B*, or *C*, is mass *M* located when the kinetic energy of the system is at a maximum? Explain your choice.

Acceptable responses include, but are not limited to:

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

47. At which position, *A*, *B*, or *C*, is mass *M* located when the gravitational potential energy of the system is at a maximum? Explain your choice.

Acceptable responses include, but are not limited to:

A, because it is the highest point of travel

48. At which position, *A*, *B*, or *C*, is mass *M* located when the elastic potential energy of the system is at a maximum? Explain your choice.

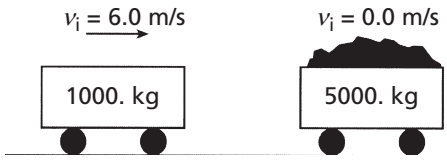
Acceptable responses include, but are not limited to:

C, because the spring is stretched the maximum amount

C, because the *KE* and gravitational *PE* are a minimum

Base your answers to questions 49 through 51 on the information and diagram below.

A 1000.-kilogram empty cart moving with a speed of 6.0 meters per second is about to collide with a stationary loaded cart having a total mass of 5000. kilograms, as shown. After the collision, the carts lock and move together. Assume friction is negligible.



49. Calculate the speed of the combined carts after the collision. Show all work, including the equation and substitution with units.

ANSWER:

$$p_{\text{before}} = p_{\text{after}}$$

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

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

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

$$v_f = 1.0\text{ m/s}$$

50. Calculate the kinetic energy of the combined carts after the collision. Show all work, including the equation and substitution with units.

ANSWER:

$$KE = \tfrac{1}{2} m v^2$$

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

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

51. How does the kinetic energy of the combined carts after the collision compare to the kinetic energy of the carts before the collision?

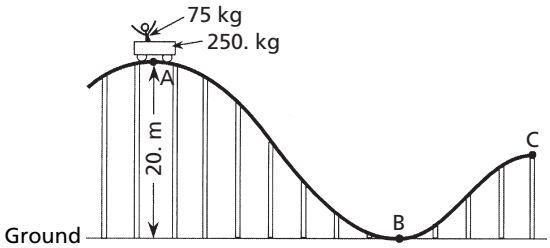
Acceptable responses include, but are not limited to:

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

$$KE_{\text{before}} > KE_{\text{after}}$$

Base your answers to questions 52 through 54 on the information and diagram below.

A 250.-kilogram car is initially at rest at point *A* on a roller coaster track. The car carries a 75-kilogram passenger and is 20. meters above the ground at point *A*. (Neglect friction.)



52. Calculate the total gravitational potential energy, relative to the ground, of the car and the passenger at point *A*. Show all work, including the equation and substitution with units.

ANSWER:

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

$$\Delta PE = (250.\text{ kg} + 75\text{ kg})(9.81\text{ m/s}^2)(20.\text{ m})$$

$$\Delta PE = 6.4 \times 10^4\text{ J}$$

53. Calculate the speed of the car and passenger at point *B*. Show all work, including the equation and substitution with units.

Examples of acceptable responses:

$$\Delta PE = KE = \tfrac{1}{2}mv^2$$

$$v = \sqrt{\frac{2\Delta PE}{m}} = \sqrt{\frac{2(6.4 \times 10^4 \text{ J})}{325 \text{ kg}}} = 20. \text{ m/s}$$

or

$$\Delta PE = KE = \tfrac{1}{2}mv^2$$

$$6.4 \times 10^4 \text{ J} = \tfrac{1}{2}(250. \text{ kg} + 75 \text{ kg})v^2$$

$$v^2 = 394$$

$$v = 20. \text{ m/s}$$

54. Compare the total mechanical energy of the car and passenger at points *A*, *B*, and *C*.

ANSWER: The total mechanical energy is the same at all three points.

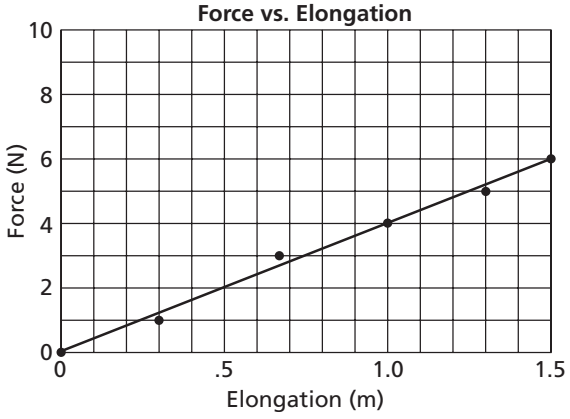
Base your answers to questions 55 through 57 on the information and data table below.

In an experiment, a student applied various forces to a spring and measured the spring's corresponding elongation. The table below shows his data.

Force (N)	Elongation (m)
0	0
1.0	0.30
3.0	0.67
4.0	1.00
5.0	1.30
6.0	1.50

55. Plot the data points for force versus elongation on a grid.

ANSWER:



56. Draw the best-fit line.

See # 55, above.

57. Using your graph, calculate the spring constant of the spring. Show all work, including the equation and substitution with units.

ANSWER:

$$k = \text{slope}$$

$$k = \frac{\Delta F}{\Delta x}$$

$$k = \frac{4.0 \text{ N} - 2.0 \text{ N}}{1.0 \text{ m} - 0.5 \text{ m}}$$

$$k = 4.0 \text{ N/m}$$

Base your answers to questions 58 through 61 on the information below.

The driver of a car made an emergency stop on a straight horizontal road. The wheels locked and the car skidded to a stop. The marks made by the rubber tires on the dry asphalt are 16 meters long, and the car's mass is 1200 kilograms.

58. Determine the weight of the car.

ANSWER: 11,800 N or 12,000 N

59. Calculate the magnitude of the frictional force the road applied to the car in stopping it. Show all work, including the equation and substitution with units.

ANSWER:

$$F_f = \mu F_n$$

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

$$F_f = 8040 \text{ N} \quad \textit{or} \quad 8000 \text{ N}$$

60. Calculate the work done by the frictional force in stopping the car. Show all work, including the equation and substitution with units.

ANSWER:

$$W = Fd$$

$$W = (8000 \text{ N})(16 \text{ m})$$

$$W = 1.3 \times 10^5 \text{ J} \quad \textit{or} \quad 128{,}000 \text{ J}$$

61. Assuming that energy is conserved, calculate the speed of the car before the brakes were applied. Show all work, including the equation and substitution with units.

Examples of acceptable responses:

$$W = KE = \tfrac{1}{2}mv^2$$

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

$$v = \sqrt{\frac{2(1.3 \times 10^5 \text{ J})}{1.2 \times 10^3 \text{ kg}}}$$

$$v = 15 \text{ m/s}$$

or

$$a = \frac{F_{net}}{m}$$

$$a = 6.7 \text{ m/s}$$

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

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

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

$$v_i = 14.6 \text{ m/s}$$

Base your answers to questions 62 through 64 on the information below.

A 50.-kilogram child running at 6.0 meters per second jumps onto a stationary 10.-kilogram sled. The sled is on a level frictionless surface.

62. Calculate the speed of the sled with the child after she jumps onto the sled. Show all work, including the equation and substitution with units.

ANSWER:

$$p_{\text{before}} = p_{\text{after}}$$

or

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

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

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

$$v_{\text{after}} = 5.0 \text{ m/s}$$

63. Calculate the kinetic energy of the sled with the child after she jumps onto the sled. Show all work, including the equation and substitution with units.

ANSWER:

$$KE = \tfrac{1}{2}mv^2$$

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

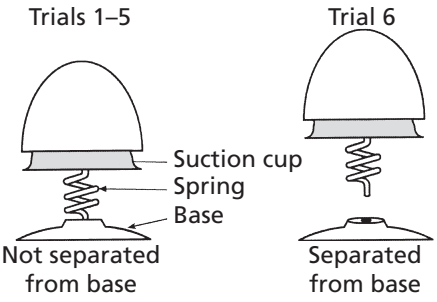
$$KE = 750 \text{ J}$$

64. After a short time, the moving sled with the child aboard reaches a rough level surface that exerts a constant frictional force of 54 newtons on the sled. How much work must be done by friction to bring the sled with the child to a stop?

ANSWER: 750 J of work must be done.

Base your answers to questions 65 and 66 on the information below and on your knowledge of physics.

Using a spring toy like the one shown in the diagram, a physics teacher pushes on the toy, compressing the spring, causing the suction cup to stick to the base of the toy.



When the teacher removes her hand, the toy pops straight up and just brushes against the ceiling. She does this demonstration five times, always with the same result.

When the teacher repeats the demonstration for the sixth time the toy crashes against the ceiling with considerable force. The students notice that in this trial, the spring and toy separated from the base at the moment the spring released.

The teacher puts the toy back together, repeats the demonstration and the toy once again just brushes against the ceiling.

65. Describe the conversions that take place between pairs of the three forms of mechanical energy, beginning with the work done by the teacher on the toy and ending with the form(s) of energy possessed by the toy as it hits the ceiling. Neglect friction.

ANSWER:

work into

potential energy (spring) into

kinetic energy into

potential energy (gravity)

66. Explain, in terms of mass and energy, why the spring toy hits the ceiling in the sixth trial and not in the other trials.

ANSWER: The toy has less mass without the base but the same energy. Therefore it can go higher.

The work put into the toy is the same but the mass is less. With less mass the toy could go higher because it is moving faster.

ENRICHMENT—Mechanics

Pages 55–56

E1. As the temperature of a substance increases, the average kinetic energy of its molecules

ANSWER: (2) increases

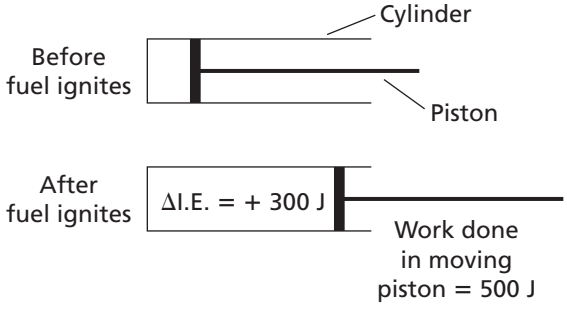
E2. The direction of exchange of internal energy between objects is determined by their relative

ANSWER: (3) temperatures

E3. When an object moves at a constant speed against friction on a horizontal tabletop, there is an increase in the object's

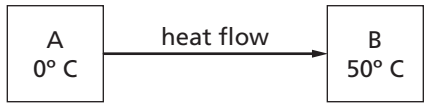
ANSWER: (1) temperature

E4. Below, is a sketch of a cylinder in an automobile engine. After the fuel is ignited the internal energy of the cylinder (and its contents) increases by 300 J. As the piston is pushed forward, 500 J of work is done by the system. How much heat energy was added to the cylinder when the fuel ignited?



ANSWER: (4) 800 J

E5. In the following system, heat energy is flowing from region A at 0°C to region B at 50°C. Which statement is true about this situation?



ANSWER: (3) It occurs only if external work is done on the system.

E6. An increase in the entropy of a system means the system is

ANSWER: (2) less ordered

E7. There is a tendency in nature for systems to proceed toward

ANSWER: (4) less order

E8. Which statement describes the thermodynamics involved when water evaporates to a gas?

ANSWER: (1) the water absorbs energy, and entropy increases

E9. The total energy of the universe is

ANSWER: (2) constant

E10. The total entropy of the universe is

ANSWER: (3) increasing

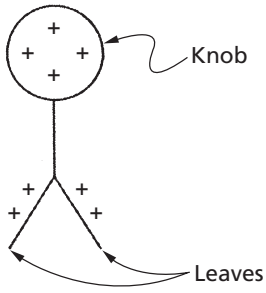
E11. According to the third law of thermodynamics, a substance can be cooled to

ANSWER: (3) a little above 0 K

CHAPTER 3 Electricity and Magnetism

PART A: Pages 84–87

1. An electroscope is a device with a metal knob, a metal stem, and freely hanging metal leaves used to detect charges. The diagram below shows a positively charged leaf electroscope.



As a positively charged glass rod is brought near the knob of the electroscope, the separation of the electroscope leaves will

ANSWER: (2) increase

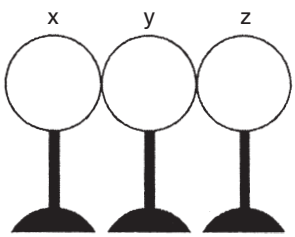
2. The ratio of the magnitude of the charge on one electron to the magnitude of charge on one coulomb is

ANSWER: (4) 1.6×10^{-19}:1

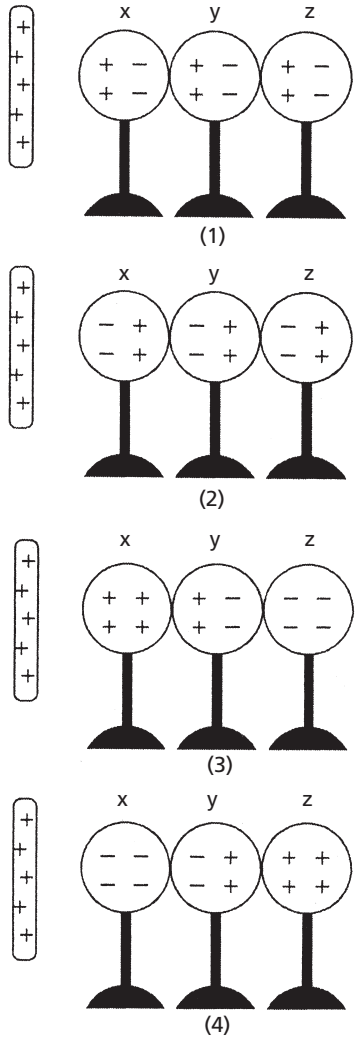
3. A negatively charged plastic comb is brought close to, but does not touch, a small piece of paper. If the comb and the paper are attracted to each other, the charge on the paper

ANSWER: (2) may be positive or neutral

4. The diagram below shows three neutral metal spheres, *x*, *y*, and *z*, in contact and on insulating stands.



Which diagram best represents the charge distribution on the spheres when a positively charged rod is brought near sphere *x*, but does not touch it?



ANSWER: (4)

5. When a neutral metal sphere is charged by contact with a positively charged glass rod, the sphere

ANSWER: (1) loses electrons

6. After two neutral solids, *A* and *B*, were rubbed together, solid *A* acquired a net negative charge. Solid *B*, therefore, experienced a net

ANSWER: (3) loss of electrons

7. The ratio of the magnitude of charge on an electron to the magnitude of charge on a proton is

ANSWER: (2) 1:1

8. How many electrons are contained in a charge of 8.0×10^{-19} coulomb?

ANSWER: (1) 5

9. Which is equivalent to three elementary charges?

ANSWER: (3) 4.8×10^{-19} C

10. The coulomb is a unit of electrical

ANSWER: (1) charge

11. After a neutral object loses 2 electrons, it will have a net charge of

ANSWER: (2) +2 elementary charges

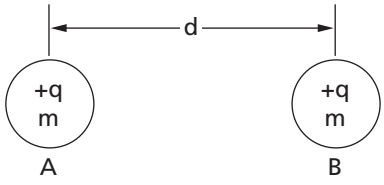
12. If a positively charged rod touches a neutral metal sphere, the number of electrons on the rod will

ANSWER: (2) increase

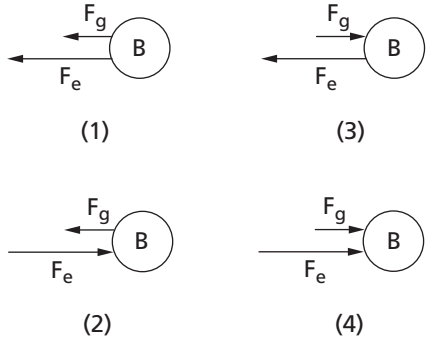
13. An object *cannot* have a charge of

ANSWER: (2) 4.5×10^{-19} C

14. The following diagram shows two identical metal spheres, *A* and *B*, separated by distance *d*. Each sphere has mass *m* and possesses charge *q*.

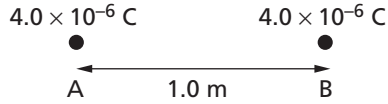


Which diagram best represents the electrostatic force F_e and the gravitational force F_g acting on sphere *B* due to sphere *A*?

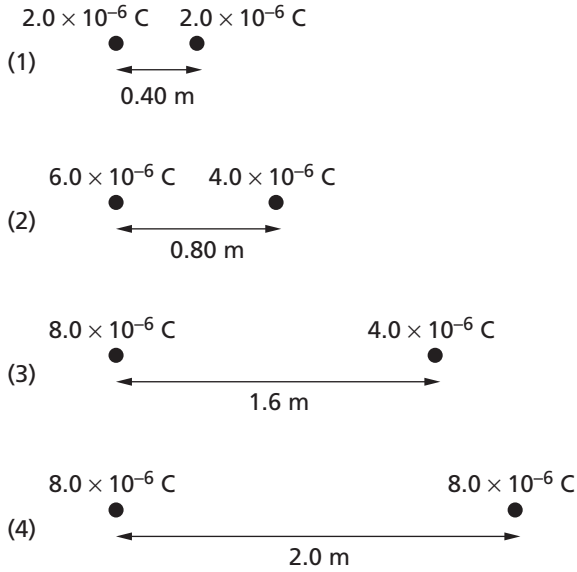


ANSWER: (2)

15. The diagram below shows two small metal spheres, *A* and *B*. Each sphere possesses a net charge of 4.0×10^{-6} coulomb. The spheres are separated by a distance of 1.0 meter.

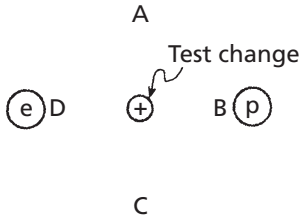


Which combination of charged spheres and separation distance produces an electrostatic force of the same magnitude as the electrostatic force between spheres *A* and *B*?



ANSWER: (4)

16. A positive test charge is placed between an electron, *e*, and a proton, *p*, as shown in the following diagram.



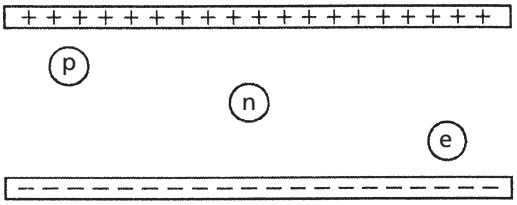
When the test charge is released, it will move toward

ANSWER: (4) *D*

17. Two protons are located one meter apart. Compared to the gravitational force of attraction between the two protons, the electrostatic force between the protons is

ANSWER: (1) stronger and repulsive

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



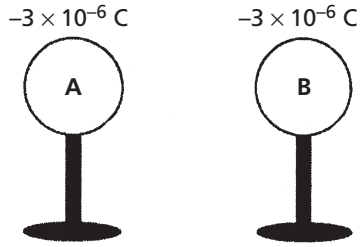
The magnitude of acceleration will be greatest for the

ANSWER: (3) electron, because it has the smallest mass

19. Oil droplets may gain electrical charges as they are projected through a nozzle. Which quantity of charge is *not* possible on an oil droplet?

ANSWER: (4) 2.6×10^{-19} C

20. The diagram below shows two identical metal spheres, *A* and *B*, on insulated stands. Each sphere possesses a net charge of -3×10^{-6} coulomb.



If the spheres are brought into contact with each other and then separated, the charge on sphere A will be

ANSWER: (3) -3×10^{-6} C

21. If the charge on each of two small charged metal spheres is doubled and the distance between the spheres remains fixed, the magnitude of the electric force between the spheres will be

ANSWER: (4) four times as great

22. What is the smallest electric charge that can be put on an object?

ANSWER: (2) 1.6×10^{-19} C

23. Two positively charged masses are separated by distance, *r*. Which statement best describes the gravitational and electrostatic forces between the two masses?

ANSWER: (4) The gravitational force is attractive and the electrostatic force is repulsive.

24. 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?

ANSWER: (3) 6.9×10^{12}

25. The electrostatic force of attraction between two small spheres that are 1.0 meter apart is *F*. If the distance between the spheres is decreased to 0.5 meter, the electrostatic force will then be

ANSWER: (4) $4F$

26. If the charge on one of two small charged spheres is doubled while the distance between them remains the same, the electrostatic force between the spheres will be

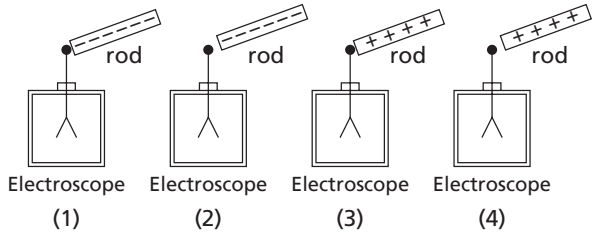
ANSWER: (2) doubled

27. Charge *A* is $+2.0 \times 10^{-6}$ coulomb and charge *B* is $+1.0 \times 10^{-6}$ coulomb. If the force that *A* exerts on *B* is 1.0×10^{-2} newton, the force that *B* exerts on *A* is

ANSWER: (1) 1.0×10^{-2} N

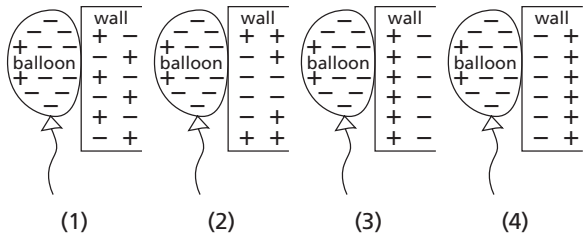
PART B-1: Pages 87–88

28. Which of the following diagrams shows the leaves of the electroscope charged negatively by induction?



ANSWER: (2)

29. An inflated balloon that has been rubbed against a person's hair is touched to a neutral wall and remains attracted to it. Which diagram best represents the charge distribution on the balloon and wall?



ANSWER: (3)

30. What is the approximate electrostatic force between two protons separated by a distance of 1.0×10^{-6} meter?

ANSWER: (1) 2.3×10^{-16} N and repulsive

31. The magnitude of the electrostatic force between two point charges is *F*. If the distance between the charges is doubled, the electrostatic force between the charges will become

ANSWER: (1) F/4

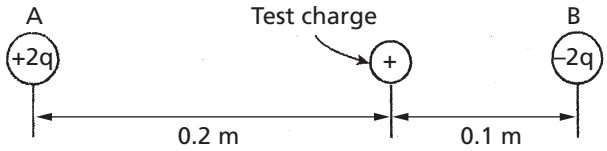
32. An object possessing an excess of 6.0×10^6 electrons has a net charge of

ANSWER: (4) 9.6×10^{-13} C

33. The charge-to-mass ratio of an electron is

ANSWER: (3) 1.76×10^{11} C/kg

34. In the diagram below, a positive test charge is located between two charged spheres, *A* and *B*. Sphere *A* has a charge of $+2q$ and is located 0.2 meter from the test charge. Sphere *B* has a charge of $-2q$ and is located 0.1 meter from the test charge.



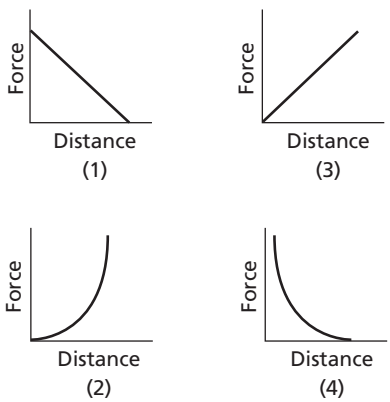
If the magnitude of the force on the test charge due to sphere *A* is *F*, what is the magnitude of the force on the test charge due to sphere *B*?

ANSWER: (4) 4F

35. An object that has a net charge of 3 coulombs possesses and excess of

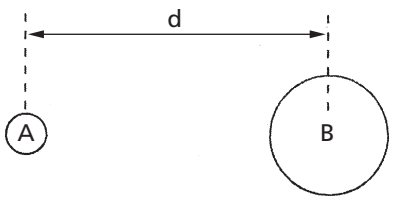
ANSWER: (1) 1.9×10^{19} electrons

36. Which graph best represents the relationship between the magnitude of the electrostatic force and the distance between two oppositely charged particles?

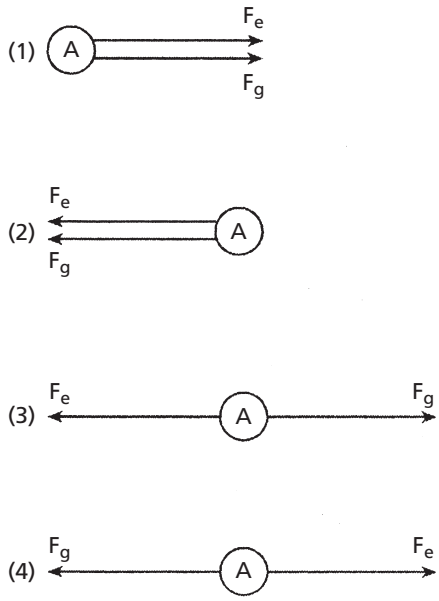


ANSWER: (4)

37. In the diagram below, two positively charged spheres, *A* and *B*, of masses m_A and m_B are located a distance *d* apart.

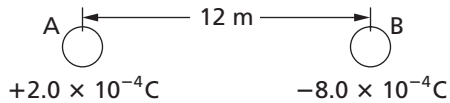


Which diagram best represents the directions of the gravitational force, F_g, and the electrostatic force, F_e, acting on sphere *A* due to the mass and charge of sphere *B*? Vectors are not drawn to scale.



ANSWER: (3)

Base your answers to questions 38 through 40 on the following diagram, which represents a system consisting of two charged metal spheres with equal radii.



38. What is the magnitude of the electrostatic force exerted on sphere *A*?

ANSWER: (4) 10. N

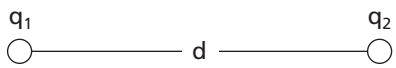
39. Compared with the force exerted on sphere *B* at a separation of 12 meters, the force exerted on sphere *B* at a separation of 6.0 meters would be

ANSWER: (4) 4 times as great

40. If the two spheres were touched together and then separated, the charge on sphere *A* would be

ANSWER: (3) -3.0×10^{-4} C

41. The following diagram represents two charges at a separation of *d*. Which would produce the greatest increase in the force between the two charges?



ANSWER: (1) doubling charge q_1 only

Base your answers to questions 42 through 44 on the following diagram, which shows two identical metal spheres. Sphere A *has a charge of* +12 *coulombs and sphere* B *is a neutral sphere.*

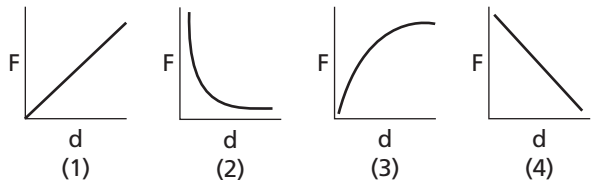
42. When sphere *A* and *B* are in contact, the total charge of the system is

ANSWER: (3) +12 C

43. After contact, when spheres *A* and *B* are separated, the charge on *A* will be

ANSWER: (3) 1/2 the original amount

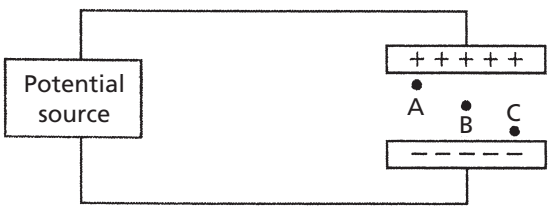
44. After spheres *A* and *B* are separated, which graph best represents the relationship of the force between the spheres and their separation?



ANSWER: (2)

PART A: Pages 92–93

45. The following diagram represents a source of potential difference connected to two large, parallel metal plates separated by a distance of 4.0×10^{-3} meter.



Which statement best describes the electric field strength between the plates?

ANSWER: (4) It is the same at points *A*, *B*, and *C*.

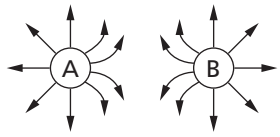
46. An object with a net charge of 4.80×10^{-6} coulomb experiences an electrostatic force having a magnitude of 6.00×10^{-2} newton when placed near a negatively charged metal sphere. What is the electric field strength at this location?

ANSWER: (2) 1.25×10^{4} N/C directed toward the sphere

47. The electric field intensity at a given distance from a point charge is *E*. If the charge is doubled and the distance remains fixed, the electric field intensity will be

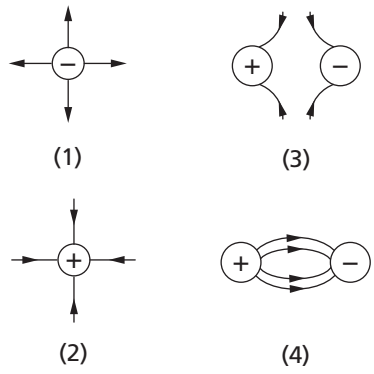
ANSWER: (2) $2E$

48. Two charged spheres are shown in the diagram. Which polarities will produce the electric field shown?



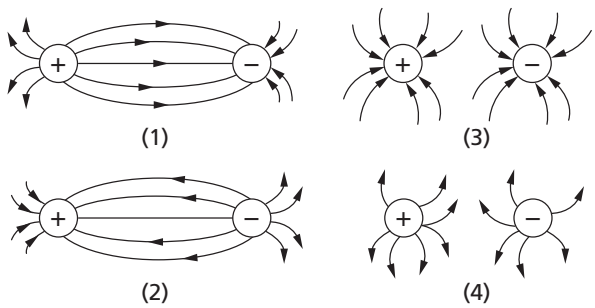
ANSWER: (2) *A* and *B* both positive

49. Which diagram best represents an electric field?



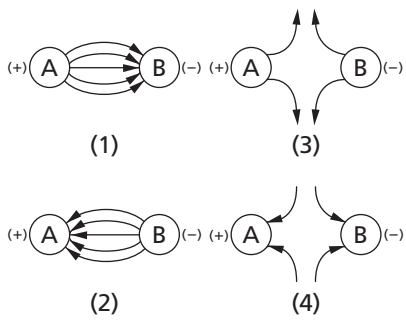
ANSWER: (4)

50. Which of the following diagrams best represents the electric field around the two spheres?



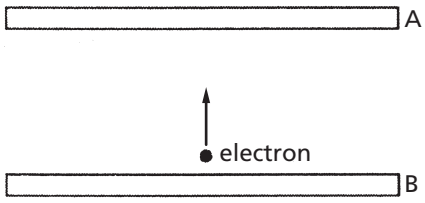
ANSWER: (1)

51. Which diagram best represents the electric field between the two spheres?



ANSWER: (1)

52. An electron placed between oppositely charged parallel plates *A* and *B* moves toward plate *A*, as represented in the diagram below.



What is the direction of the electric field between the plates?

ANSWER: (2) toward plate *B*

53. How much work is required to move a single electron through a potential difference of 100. volts?

ANSWER: (3) 1.6×10^{-17} J

54. 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?

ANSWER: (3) 3.0×10^{2} V

55. In an electric field, 0.90 joule of work is required to bring 0.45 coulomb of charge from point *A* to point *B*. What is the electric potential difference between points *A* and *B*?

ANSWER: (2) 2.0 V

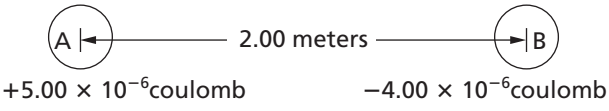
56. How much electric energy is required to move a 4.00-microcoulomb charge through a potential difference o 36.0 volts?

ANSWER: (3) 1.44×10^{-4} J

57. The energy required to move one elementary charge through a potential difference of 5.0 volts is

ANSWER: (3) 8.0×10^{-19} J

Base your answers to questions 58 and 59 on the following diagram, which represents two small, charged conducting spheres, identical in size, located 2.0 meters apart.



58. What is the net combined charge on both spheres?

ANSWER: (1) $+1.0 \times 10^{-6}$ C

59. The force between these spheres is

ANSWER: (3) 4.5×10^{-2} N

60. What is the magnitude of the force acting on an electron when it is in the 1.00×10^{6} N/C electric field?

ANSWER: (2) 1.6×10^{-13} N

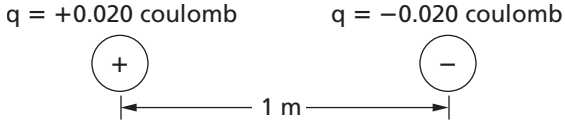
61. As an electron moves between two parallel plates from a negatively charged plate to a positively charged plate, the force on the electron due to the electric field

ANSWER: (3) remains the same

62. The electron above is replaced by a proton. Compared with the magnitude of the force on the electron, the magnitude of the force on the proton will be

ANSWER: (3) the same

Base your answer to question 63 on the following diagram, which represents two charged metal spheres.

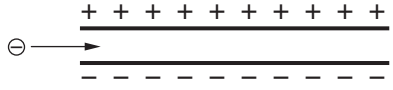


63. What is the magnitude of the force between the two spheres?

ANSWER: (1) 3.6×10^{6} N

PART B-1: Pages 93–94

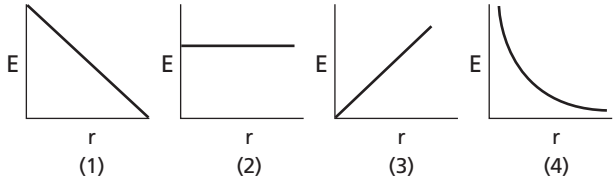
Base your answer to question 64 on the following diagram, which represents an electron projected into the region between two parallel charged plates.



64. In which direction will the electron be deflected?

ANSWER: (4) toward the top of the page

65. 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?



ANSWER: (4)

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66. The table below lists various characteristics of two metallic wires, *A* and *B*.

Wire	Material	Temperature (°C)	Length (m)	Cross-Sectional Area (m^2)	Resistance (Ω)
A	Silver	20.	0.10	0.010	R
B	Silver	20.	0.20	0.020	???

If wire *A* has resistance *R*, then wire *B* has resistance

ANSWER: (2) *R*

67. If 10. coulombs of charge are transferred through an electric circuit in 5.0 seconds, then the current in the circuit is

ANSWER: (2) 2.0 A

68. One watt is equivalent to one

ANSWER: (4) J/s

69. In a simple electric circuit, a 110-volt electric heater draws 2.0 amperes of current. The resistance of the heater is

ANSWER: (3) 55 Ω

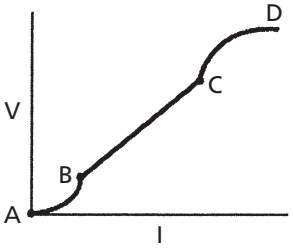
70. In a flashlight, a battery provides a total of 3.0 volts to a bulb. If the flashlight bulb has an operating resistance of 5.0 ohms, the current through the bulb is

ANSWER: (2) 0.60 A

71. A complete circuit is left on for several minutes, causing the connecting copper wire to become hot. As the temperature of the wire increases, the electrical resistance of the wire

ANSWER: (2) increases

72. The graph below represents the relationship between the potential difference (*V*) across a resistor and the current (*I*) through the resistor.

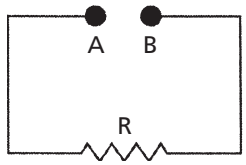


Through which entire interval does the resistor obey Ohm's law?

ANSWER: Regents' answer Key (2) *B-C*

In the author's opinion, the correct answer is (4) *A-D* for the following reason. As current increases, the temperature increases and so does the resistance. Ohm' law is always obeyed (for solids); however, the resistance of a material may change, thus producing the curved part of the graph. Ohm's law does not state that the relationship between voltage and current must always be linear.

73. What must be inserted between points *A* and *B* to establish a steady electric current in the incomplete circuit represented in the diagram below?



ANSWER: (4) source of potential difference

74. An incandescent light bulb is supplied with a constant potential difference of 120 volts. As the filament of the bulb heats up, its resistance

ANSWER: (1) increases and the current through it decreases

75. During a thunderstorm, a lightning strike transfers 12 coulombs of charge in 2.0×10^{-3} second. What is the average current produced in this strike?

ANSWER: (3) 6.0×10^3 A

76. How much current flows through a 12-ohm flashlight bulb operating at 3.0 volts?

ANSWER: (1) 0.25 A

77. Which physical quantity is correctly paired with its unit?

ANSWER: (4) electric potential difference and joules/coulomb

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

ANSWER: (3) 120 C

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

ANSWER: (2) 15.2 mA

PART B-1: Pages 98–99

80. What is the total electrical energy used by a 1500-watt hair dryer operating for 6.0 minutes?

ANSWER: (4) 5.4×10^5 J

81. As the potential difference across a given resistor is increased, the power expended in moving charge through the resistor

ANSWER: (2) increases

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

ANSWER: (4) 3.6×10^4 J

83. A 1200-watt speaker used 6.3×10^5 joules of electrical energy. How long did it operate?

ANSWER: (2) 8.75 minutes

84. The current traveling from the cathode to the screen in a television picture tube is 5.0×10^{-5} ampere. How many electrons strike the screen in 5.0 seconds?

ANSWER: (3) 1.6×10^{15}

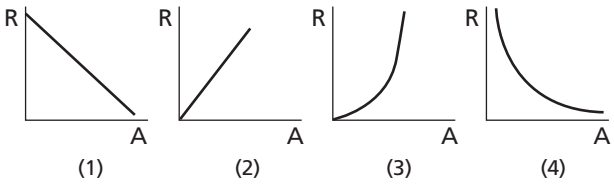
85. A 10.-meter length of wire with a cross-sectional area of 3.0×10^{-6} square meter has a resistance of 9.4×10^{-2} ohm at 20° Celsius. The wire is most likely made of

ANSWER: (3) aluminum

86. A 12.0-meter length of copper wire has a resistance of 1.50 ohms. How long must an aluminum wire with the same cross-sectional area be to have the same resistance?

ANSWER: (1) 7.32 m

87. Several pieces of copper wire, all having the same length but different diameters, are kept at room temperature. Which graph best represents the resistance, *R*, of the wires as a function of their cross-sectional areas, *A*?

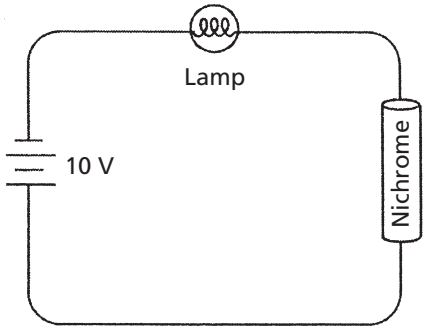


ANSWER: (4)

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

ANSWER: (3) 10. W

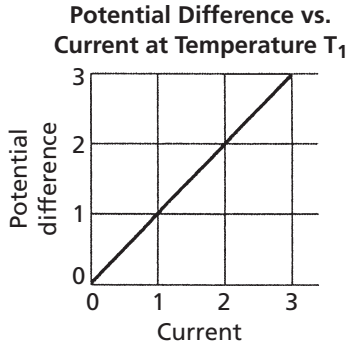
89. The diagram below represents a lamp, a 10-volt battery, and a length of nichrome wire connected in series.



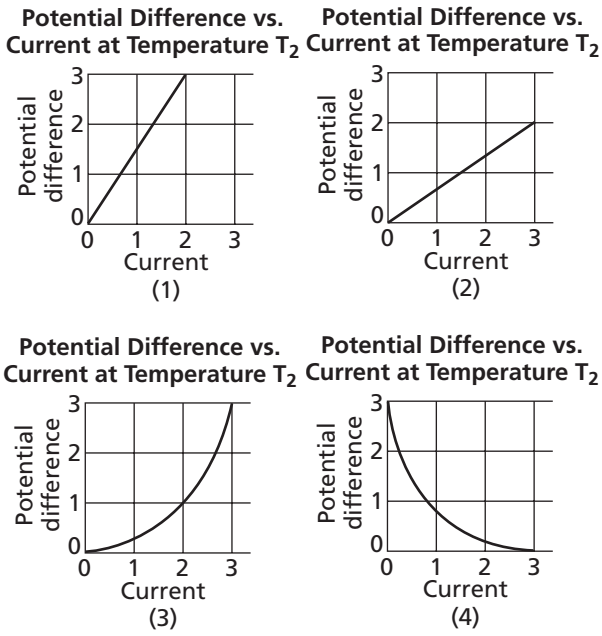
As the temperature of the nichrome is decreased, the brightness of the lamp will

ANSWER: (2) increase

90. The graph below shows the relationship between the potential difference across a metallic conductor and the electric current through the conductor at constant temperature T_1.

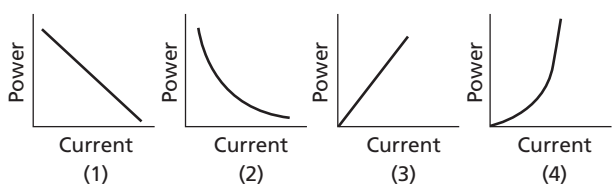


Which graph best represents the relationship between potential difference and current for the same conductor maintained at a higher constant temperature, T_2?



ANSWER: (1)

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



ANSWER: (4)

92. A 1.5-volt, AAA cell supplies 750 milliamperes of current through a flashlight bulb for 5.0 minutes, while a 1.5-volt, C cell supplies 750

milliamperes of current through the same flashlight bulb for 20. minutes. Compared to the total charge transferred by the AAA cell through the bulb, the total charge transferred by the C cell through the bulb is

ANSWER: (4) four times as great

93. If the potential difference applied to a fixed resistance is doubled, the power dissipated by that resistance

ANSWER: (4) quadruples

94. Aluminum, copper, gold, and nichrome wires of equal lengths of 1.0×10^{-1} meter and equal cross-sectional areas of 2.5×10^{-6} meter^2 are at 20.°C. Which wire has the greatest electrical resistance?

ANSWER: (4) nichrome

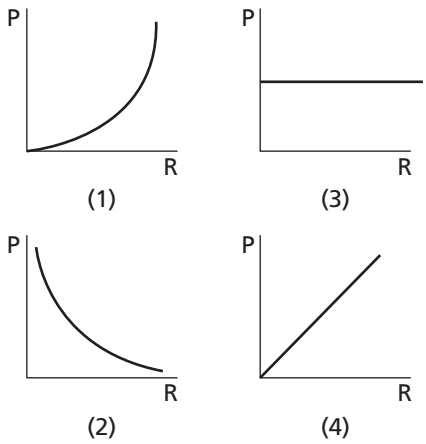
95. Which changes would cause the greatest increase in the rate of flow of charge through a conducting wire?

ANSWER: (1) increasing the applied potential difference and decreasing the length of wire

96. An operating electric heater draws a current of 10. amperes and has a resistance of 12 ohms. How much energy does the heater use in 60. seconds?

ANSWER: (4) 72,000 J

97. The potential difference applied to a circuit element remains constant as the resistance of the element is varied. Which graph best represents the relationship between power (P) and resistance (R) of this element?



ANSWER: (2)

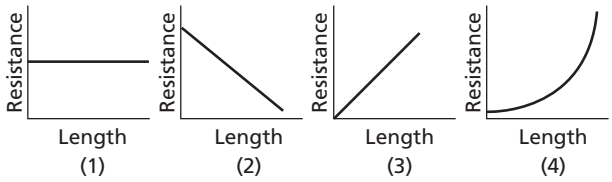
98. What is the resistance at 20°C of a 1.50-meter-long aluminum conductor that has a cross-sectional area of 1.13×10^{-6} meter^2?

ANSWER: (3) $3.74 \times 10^{-2}\ \Omega$

99. An immersion heater has a resistance of 5.0 ohms while drawing a current of 3.0 amperes. How much electrical energy is delivered to the heater during 200. seconds of operation?

ANSWER: (3) 9.0×10^3 J

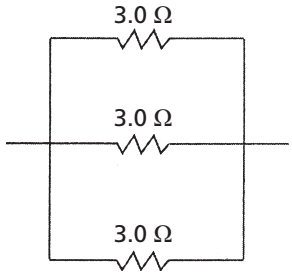
100. Which graph best represents the relationship between resistance and length of a copper wire of uniform cross-sectional area at constant temperature?



ANSWER: (3)

PART A: Pages 103–104

101. What is the total resistance of the circuit segment shown in the diagram below?

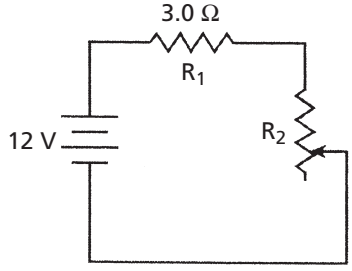


ANSWER: (1) 1.0 Ω

102. A 10.-ohm resistor and a 20.-ohm resistor are connected in series to a voltage source. When the current through the 10.-ohm resistor is 2.0 amperes, what is the current through the 20.-ohm resistor?

ANSWER: (2) 2.0 A

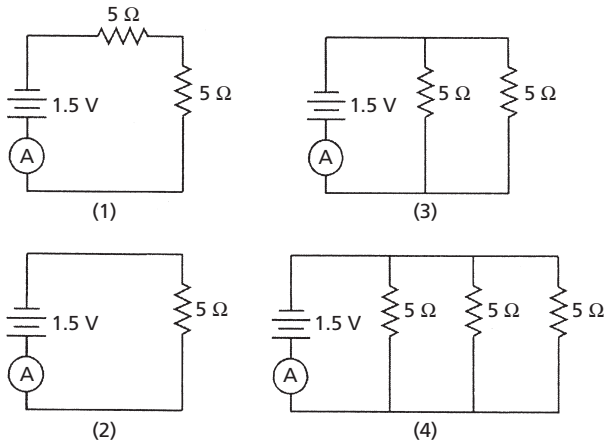
103. The diagram below represents an electric circuit consisting of a 12-volt battery, a 3.0-ohm resistor, R_1, and a variable resistor, R_2.



At what value must the variable resistor be set to produce a current of 1.0 ampere through R_1?

ANSWER: (2) 9.0 Ω

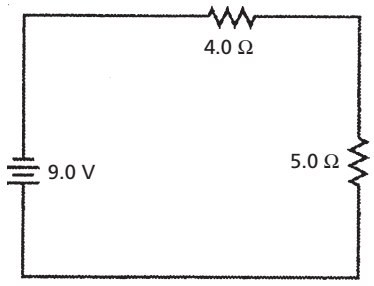
104. In which circuit would ammeter A show the greatest current?



ANSWER: (4)

Base your answers to questions 105 and 106 on the following diagram

105. 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?

ANSWER: (1) 1.0 A

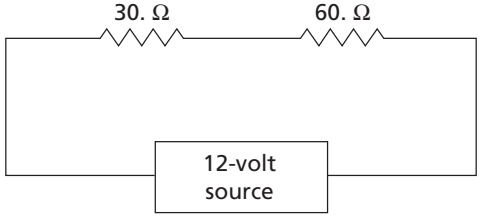
106. How much electric energy is expended in both resistors per second?

ANSWER: (1) 9 J

107. In a series circuit containing two lamps, the battery supplies a potential difference of 1.5 volts. If the current in the circuit is 0.10 ampere, at what rate does the circuit use energy?

ANSWER: (2) 0.15 W

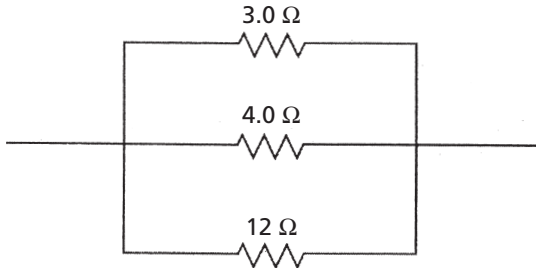
108. A 30.-ohm resistor and a 60.-ohm resistor are connected in an electric circuit as shown below.



Compared to the electric current through the 30.-ohm resistor, the electric current through the 60.-ohm resistor is

ANSWER: (3) the same

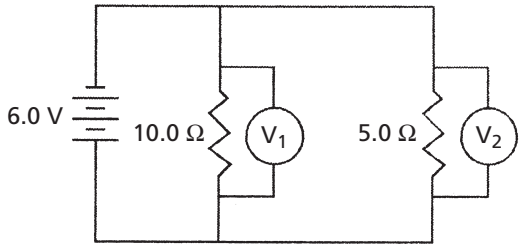
109. The diagram below represents part of an electric circuit containing three resistors.



What is the equivalent resistance of this part of the circuit?

ANSWER: (2) 1.5 Ω

110. In the circuit diagram below, what are the correct readings of voltmeters V_1 and V_2?



ANSWER: (4) V_1 reads 6.0 V and V_2 reads 6.0 V

111. A unit of electric potential difference is the

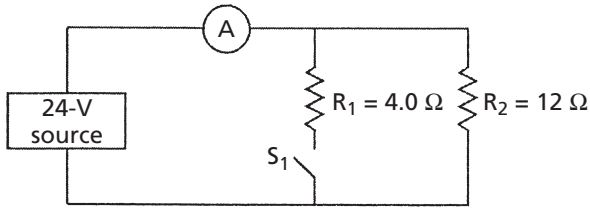
ANSWER: (3) volt

112. The electron volt is a unit of

ANSWER: (4) energy

PART B-1: Pages 104–106

Base your answers to questions 113 and 114 on the circuit diagram below.



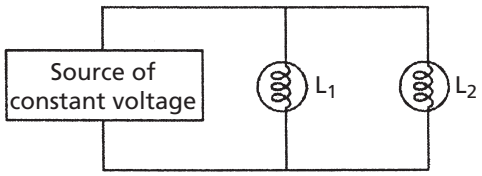
113. If switch S_1 is open, the reading of ammeter A is

ANSWER: (2) 2.0 A

114. If switch S_1 is closed, the equivalent resistance of the circuit is

ANSWER: (3) 3.0 Ω

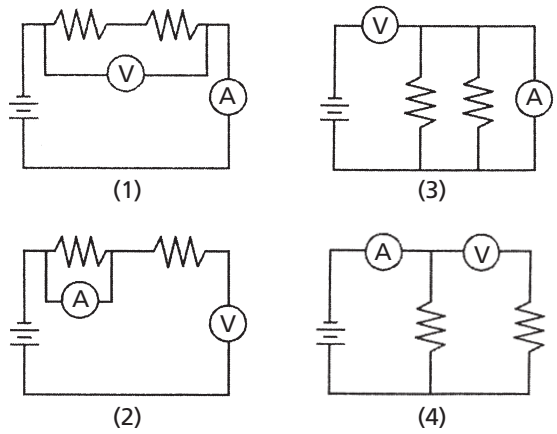
115. In the diagram below, lamps L_1 and L_2 are connected to a constant voltage power supply.



If lamp L_1 burns out, the brightness of L_2 will

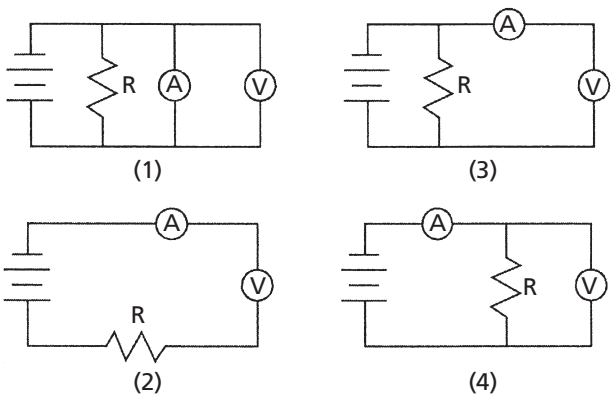
ANSWER: (1) decrease

116. Which circuit diagram shows voltmeter V and ammeter A correctly positioned to measure the total potential difference of the circuit and the current through each resistor?



ANSWER: (1)

117. Which of the following circuit diagrams correctly shows the connection of ammeter A and voltmeter V to measure the current through and potential difference across resistor R?



ANSWER: (4)

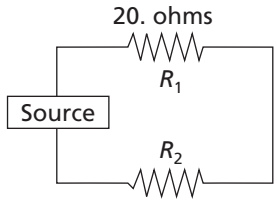
118. Three resistors of 10 ohms, 20 ohms, and 30 ohms are connected in series to a 120-volt source. The power developed is

ANSWER: (3) greatest in the 30-ohm resistor

119. Compared with the potential drop across the 10-ohm resistor shown in the diagram, the potential drop across the 5-ohm resistor is

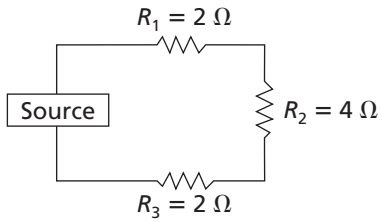
ANSWER: (3) one-half as great

120. The diagram represents a circuit with two resistors in series. If the total resistance of R_1 and R_2 is 24 ohms, the resistance of R_2 is



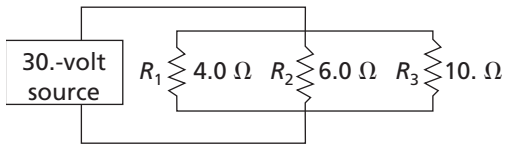
ANSWER: (4) 4.0 Ω

121. In the circuit shown in the diagram below, the rate at which electrical energy is being expended in resistor R_1 is



ANSWER: (1) less than in R_2

Base your answers to questions 122 and 123 on the diagram, which represents an electrical circuit.



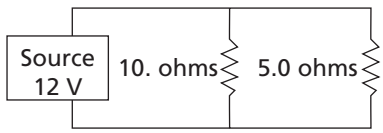
122. The equivalent resistance of R_1, R_2, and R_3 is approximately

ANSWER: (2) 2 Ω

123. The current in R_1 is

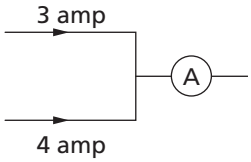
ANSWER: (2) 7.5 A

124. Compared with the current in the 10.-ohm resistor in the circuit shown below, the current in the 5.0-ohm resistor is



ANSWER: (4) twice as great

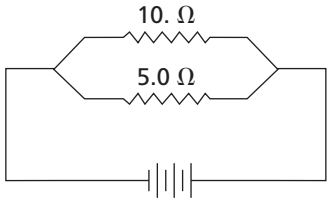
125. The following diagram represents a segment of a circuit.



What is the current in ammeter *A*?

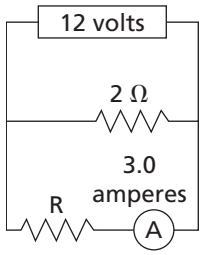
ANSWER: (4) 7 A

126. Two resistors of 10 ohms and 5 ohms are connected as shown in the diagram. If the current through the 10-ohm resistor is 1.0 ampere, then the current through the 5.0-ohm resistor is



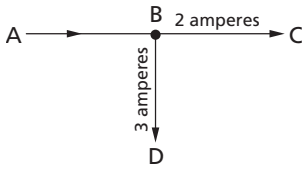
ANSWER: (2) 2.0 A

127. Two resistors are connected in parallel to a 12-volt battery as shown in the diagram. If the current in resistance *R* is 3.0 amperes, the rate at which *R* consumes electrical energy is



ANSWER: (2) 36 W

128. The diagram below represents a segment of an electrical circuit. What is the current in wire *AB*?

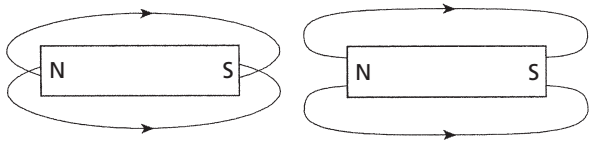


ANSWER: (3) 5 A

PART A: Pages 108–109

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

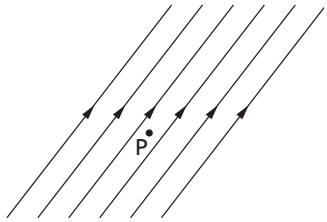
(1) (2)



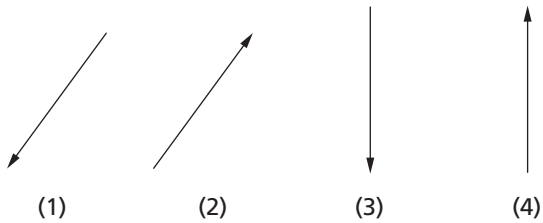
(3) (4)

ANSWER: (4)

130. The diagram below represents the magnetic field near point *P*.



If a compass is placed at point *P* in the same plane as the magnetic field, which arrow represents the direction the north end of the compass needle will point?

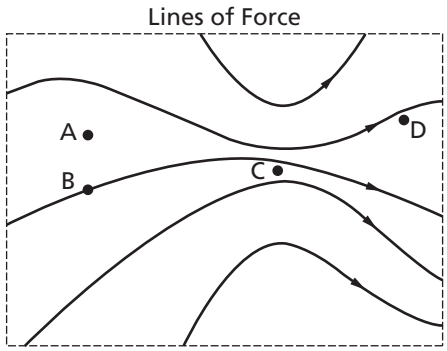


ANSWER: (2)

131. Which type of field is present near a moving electric charge?

ANSWER: (3) both an electric field and a magnetic field

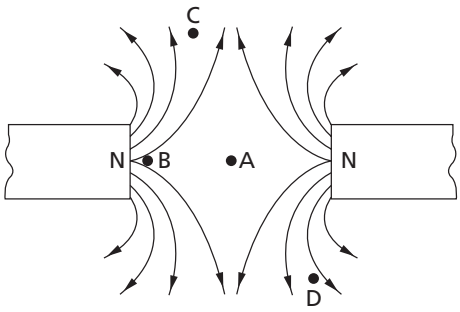
132. The diagram below represents magnetic lines of force within a region of space



The magnitude of the field is strongest at point

ANSWER: (3) C

133. The diagram below shows the lines of magnetic force between two north magnetic poles.



At which point is the magnetic field strength the greatest?

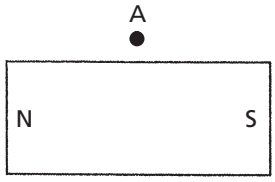
ANSWER: (2) B

134. As two parallel conductors with currents in the same direction are moved apart, their force of

ANSWER: (2) attraction decreases

PART B-1: Page 109

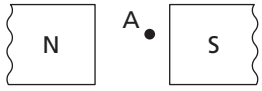
135. The diagram below shows a bar magnet.



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

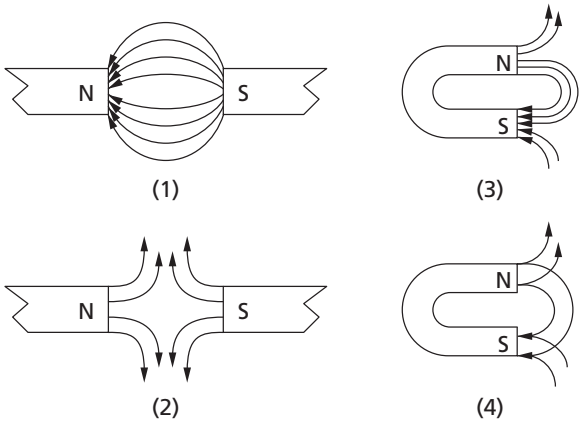
ANSWER: (3) →

136. In the following diagram, what is the direction of the magnetic field at point *A*?



ANSWER: (2) to the right

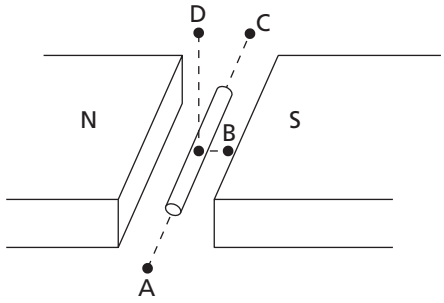
137. Which diagram correctly shows a magnetic field configuration?



ANSWER: (3)

PART A: Page 111

138. The following diagram shows a copper wire located between the poles of a magnet. Maximum electric potential will be induced in the wire when it is moved at a constant speed toward which point?

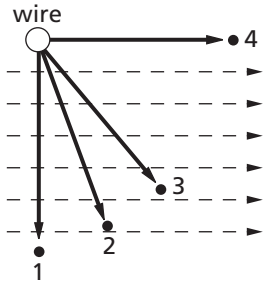


ANSWER: (4) D

139. A conductor is moving perpendicularly to a uniform magnetic field. Increasing the speed of the conductor will cause the potential difference induced across the ends of the conductor to

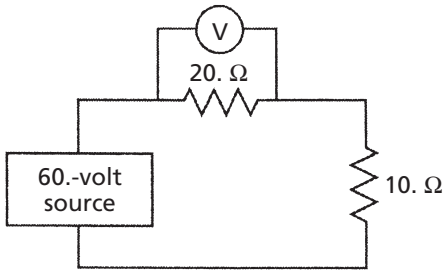
ANSWER: (2) increase

140. The following diagram shows the cross section of a wire which is perpendicular to the page and a uniform magnetic field directed to the right. Toward which point should the wire be moved to induce the maximum electric potential? (Assume the same speed would be used in each direction.)



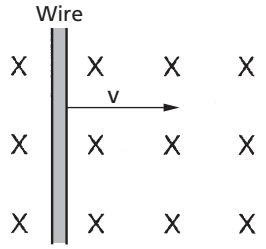
ANSWER: (1) 1

141. In the circuit represented by the diagram below, what is the reading of voltmeter *V*?



ANSWER: (4) 40. V

142. The diagram below shows a wire moving to the right at speed v through a uniform magnetic field that is directed into the page.



Magnetic field directed into page

As the speed of the wire is increased, the induced potential difference will

ANSWER: (2) increase

143. A motor is to rotational mechanical energy as a generator is to

ANSWER: (2) induced electrical energy

144. A student uses a voltmeter to measure the potential difference across a circuit resistor. To obtain a correct reading, the student must connect the voltmeter

ANSWER: (1) in parallel with the circuit resistor

PART B-1: Page 112

145. Which statement best describes the torque experienced by a current-carrying loop of wire in an external magnetic field?

ANSWER: (1) It is due to the current in the loop of wire, only.

146. The turning force on the armature of an operating electric motor may be increased by

ANSWER: (3) increasing the potential difference applied to the armature

PHYSICS IN YOUR LIFE—Storing Information Magnetically

Page 112

1. What roles do electricity and magnetism play in the recording and playback of a movie on a videotape?

In recording, the image is converted to a variable electric current which in turn creates a varying magnetic field at the recording head. The recording head magnetizes the metal oxide particles on the tape as it passes over the head. During playback the sequence is reversed. The magnetized tape creates a variable magnetic field that induces a variable current. This induced current then creates the signal that is converted into the image.

2. Describe the process in which digital information is stored on a hard disk.

When data is stored on a hard disk, the orientation of magnetized particles on the disk is changed. Orientation in one direction represents "zero", while orientation in the other direction represents "one".

3. Why could bringing a computer disk near a strong magnet destroy the information stored on the disk?

The strong magnet could alter the orientation of the magnetic particles on the disk.

Chapter Review Questions

PART A: Pages 113–114

1. How much work is done in moving 6 electrons through a potential difference of 2.0 volts?

ANSWER: (4) 12 eV

2. If 6.0 joules of work is done to move 2.0 coulombs of charge from point *A* to point *B*, what is the electric potential difference between points *A* and *B*?

ANSWER: (3) 3.0 V

3. The work required to move a charge of 0.04 coulomb from one point to another point in an electric field is 200 joules. What is the potential difference between the two points?

ANSWER: (4) 5000 V

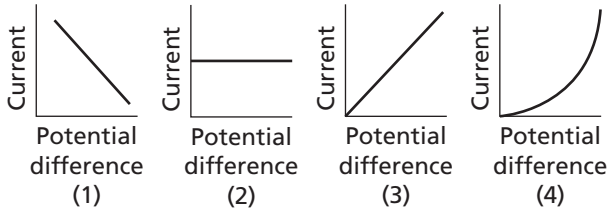
4. If 4 joules of work are required to move 2 coulombs of charge through a 6-ohm resistor, the potential difference across the resistor is

ANSWER: (2) 2 V

5. When 20. coulombs of charge pass a given point in a conductor in 4.0 seconds, the current in the conductor is

ANSWER: (4) 5.0 A

6. Which graph best represents the relationship between the current in a metallic conductor and the applied potential difference?



ANSWER: (3)

7. A potential difference of 12 volts is applied across a circuit which has a 4.0-ohm resist-

ance. What is the magnitude of the current in the circuit?

ANSWER: (3) 3.0 A

8. The ratio of the potential difference across a metallic conductor to the current in the conductor is known as

ANSWER: (3) resistance

9. If the current in a wire is 2.0 amperes and the potential difference across the wire is 10. volts, what is the resistance of the wire?

ANSWER: (1) 5.0 Ω

10. Which condition must exist between two points in a conductor in order to maintain a flow of charge?

ANSWER: (1) a potential difference

11. As the temperature of a metal conductor is reduced, the resistance of the conductor will

ANSWER: (1) decrease

12. The resistance of a metallic wire conductor is inversely proportional to its

ANSWER: (2) cross-sectional area

13. If the cross-sectional area of a fixed length of wire were decreased, the resistance of the wire would

ANSWER: (2) increase

14. A piece of wire has a resistance of 8 ohms. A second piece of wire of the same composition, diameter, and temperature, but one-half as long as the first wire, has a resistance of

ANSWER: (4) 4 Ω

15. If energy is used in an electric circuit at the rate of 20. joules per second, then the power supplied to the circuit is

ANSWER: (2) 20. W

16. What is the current in a 1200-watt heater operating on 120 volts?

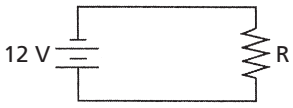
ANSWER: (3) 10. A

17. The potential difference across a 100.-ohm resistor is 4.0 volts. What is the power dissipated in the resistor?

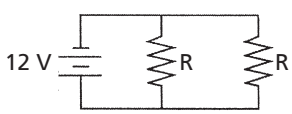
ANSWER: (1) 0.16 W

PART B-1: Pages 113–114

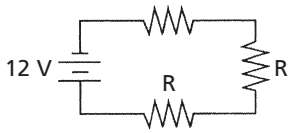
18. Identical resistors (*R*) are connected across the same 12-volt battery. Which circuit uses the greatest power?



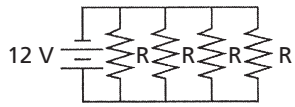
(1)



(2)



(3)



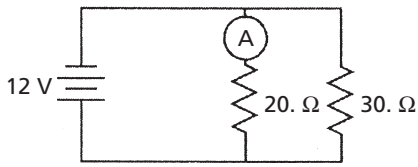
(4)

ANSWER: (4)

19. Two identical resistors connected in parallel have an equivalent resistance of 40. ohms. What is the resistance of each resistor?

ANSWER: (3) 80. Ω

Base your answers to questions 20 through 22 on the information and diagram below.



A 20.-ohm resistor and a 30.-ohm resistor are connected in parallel to a 12-volt battery as shown. An ammeter is connected as shown.

20. What is the equivalent resistance of the circuit?

ANSWER: (2) 12 Ω

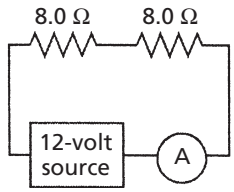
21. What is the current reading of the ammeter?

ANSWER: (2) 0.60 A

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

ANSWER: (1) 4.8 W

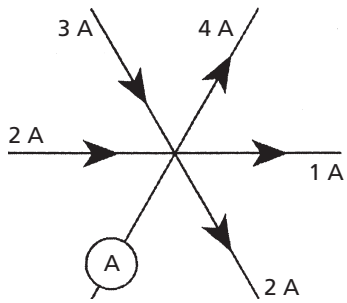
23. The diagram below shows a circuit with two resistors



What is the reading on ammeter *A*?

ANSWER: (4) 0.75 A

24. The diagram below represents currents in a segment of an electric circuit.



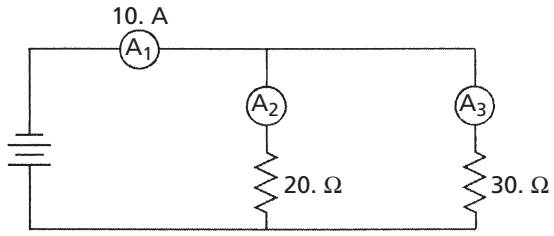
What is the reading in ammeter *A*?

ANSWER: (2) 2 A

25. A 100.-ohm resistor and an unknown resistor are connected in series to a 10.0-volt battery. If the potential drop across the 100.-ohm resistor is 4.00 volts, the resistance of the unknown resistor is

ANSWER: (3) 150. Ω

26. In the following circuit diagram, ammeter A_1 reads 10. amperes.

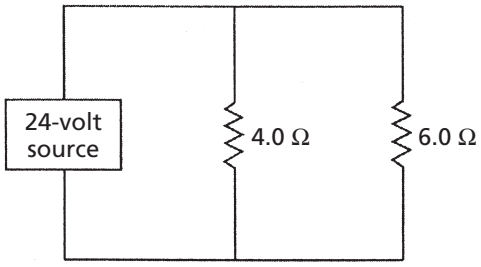


What is the reading of ammeter A_2?

ANSWER: (1) 6.0 A

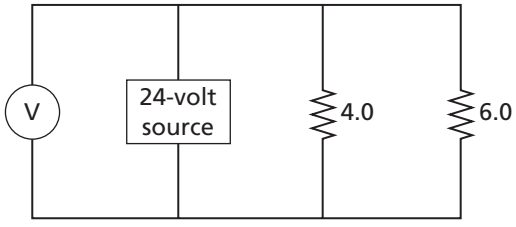
PART B-2: Pages 114–116

Base your answers to questions 27 and 28 on the circuit diagram below, which shows two resistors connected to a 24-volt source of potential difference.

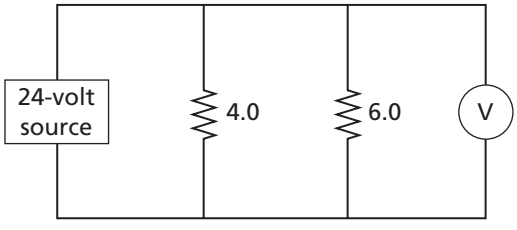


27. Copy the diagram then, using the appropriate circuit symbol, indicate a correct placement of a voltmeter to determine the potential difference across the circuit.

ANSWER:



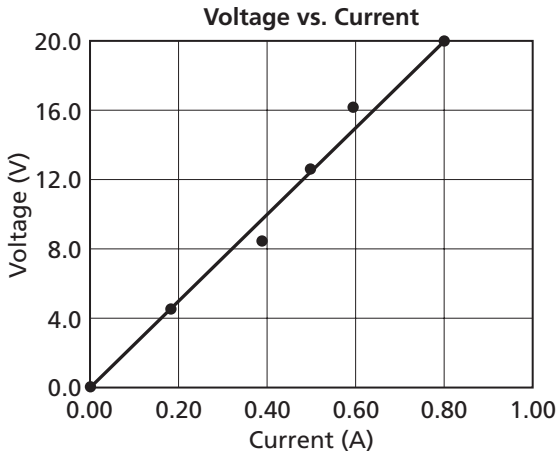
or



28. What is the total resistance of the circuit?

ANSWER: (2) 2.4 Ω

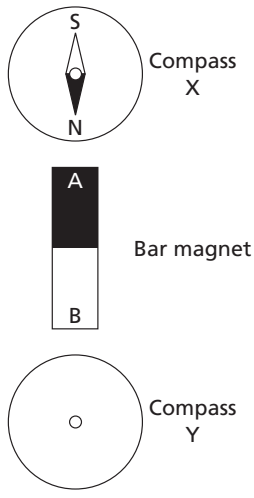
29. A long copper wire was connected to a voltage source. The voltage was varied and the current through the wire measured, while temperature was held constant. The collected data are represented by the graph below.



Using the graph, determine the resistance of the copper wire.

ANSWER: 25.O Ω

30. The diagram below shows two compasses located near the ends of a bar magnet. The north pole of compass *X* points toward end *A* of the magnet.

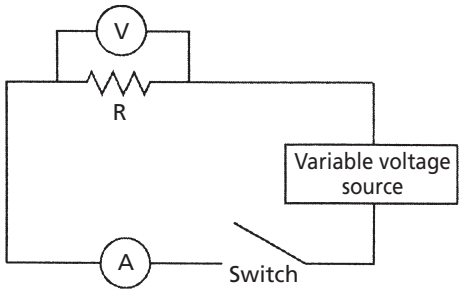


On your own paper, draw the correct orientation of the needle of compass *Y* and label its polarity.

ANSWER:

Base your answers to questions 31 through 34 on the information, circuit diagram, and data table below.

In a physics lab, a student used the circuit shown to measure the current through and the potential drop across a resistor of unknown resistance, *R*. The instructor told the student to use the switch to operate the circuit only long enough to take each reading. The student's measurements are recorded in the data table.



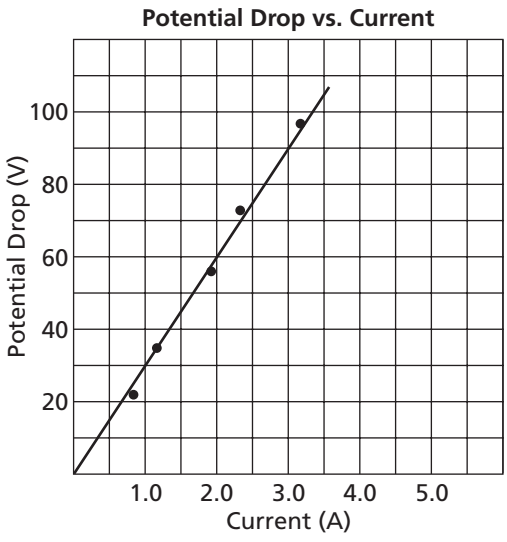
Data Table

Current (A)	Potential Drop (V)
0.80	21.4
1.20	35.8
1.90	56.0
2.30	72.4
3.20	98.4

Using the information in the data table, construct a graph as follows:

31. Mark appropriate scale on the axis labeled "Potential Drop (V)" and "Current (I)."

ANSWER:



32. Plot the data points for potential drop versus current.

ANSWER: See # 31, above.

33. Draw the line or curve of best fit.

ANSWER: See # 31, above.

34. Calculate the slope of the line or curve of best fit. Show all work, including the equation and substitution with units.

ANSWER:

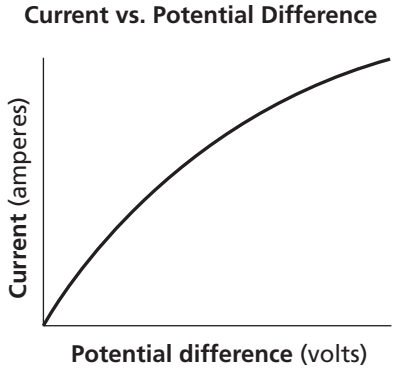
$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{\Delta V}{\Delta A}$$

$$\text{Slope} = \frac{90.\ \text{V} - 30.\ \text{V}}{3.0\ \text{A} - 1.0\ \text{A}}$$

$$\text{Slope} = 30.\ \frac{\text{V}}{\text{A}} = 30.\ \Omega$$

Base your answers to questions 35 through 37 on the information and graph below.

A student conducted an experiment to determine the resistance of a lightbulb. As she applied various potential differences to the bulb, she recorded the voltages and corresponding currents and constructed the graph below.



35. The student concluded that the resistance of the lightbulb was not constant. What evidence from the graph supports the student's conclusion?

ANSWER:

- The slope changes.
- The graph is not a straight line.
- The line curves.

36. According to the graph, as the potential difference increased, the resistance of the lightbulb

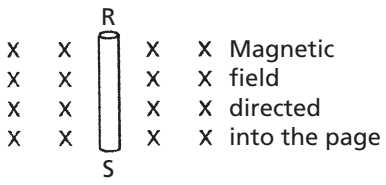
ANSWER: (2) increased

37. While performing the experiment the student noticed that the lightbulb began to glow and became brighter as she increased the voltage. Of the factors affecting resistance, which fac-

tor caused the greatest change in the resistance of the bulb during her experiment?

ANSWER: As the voltage increased, the temperature increased, causing a higher resistance.

38. The diagram below represents a wire conductor, *RS*, positioned perpendicular to a uniform magnetic field directed into the page.



Describe the direction in which the wire could be moved to produce the maximum potential difference across its ends, *R* and *S*.

ANSWER: perpendicular to both the length of the wire and the magnetic field, toward the *x*'s

39. What is the magnitude of the charge, in coulombs, of a lithium nucleus containing three protons and four neutrons?

ANSWER: 4.8×10^{-19} C

40. A light bulb attached to a 120.-volt source of potential difference draws a current of 1.25 amperes for 35.0 seconds. Calculate how much electrical energy is used by the bulb.

ANSWER:

$$W = VIt$$

$$W = 120 \text{ V} \times 1.25 \text{ A} \times 35.0 \text{ s}$$

$$W = 5250 \text{ W}$$

41. A student is given two pieces of iron and told to determine if one or both of the pieces are magnets. First, the student touches an end of one piece to one end of the other. The two pieces of iron attract. Next, the student reverses one of the pieces and again touches the ends together. The two pieces attract again. What does the student definitely know about the initial magnetic properties of the two pieces of iron?

ANSWER: At least one is a magnet.

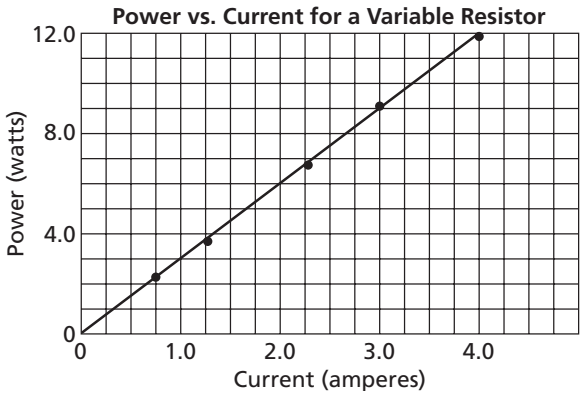
Base your answers to questions 42 through 46 on the information and data table below.

A variable resistor was connected to a battery. As the resistance was adjusted, the current and power in the circuit were determined. The data are recorded in the table below.

Current (A)	Power (W)
0.75	2.27
1.25	3.72
2.25	6.75
3.00	9.05
4.00	11.9

42. Plot the data points as a graph for power versus current.

ANSWER:



43. Draw the best-fit line

ANSWER: See # 42, above.

44. Using your graph, determine the power delivered to the circuit at a current of 3.5 amperes.

ANSWER: 10.5 W

45. Calculate the slope of the graph. Show all calculations, including the equation and substitution with units.

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{\Delta P}{\Delta I}$$

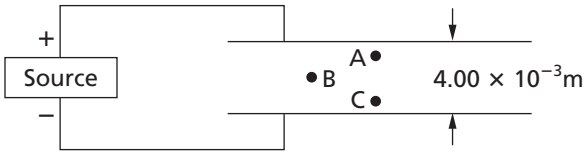
$$\text{Slope} = \frac{10.5 \text{ W} - 0.0 \text{ W}}{3.5 \text{ A} - 0.0 \text{ A}}$$

$$\text{Slope} = 3.0 \frac{\text{W}}{\text{A}} \text{ or } 3.0 \text{ V}$$

46. What is the physical significance of the slope of the graph?

ANSWER: Voltage or potential difference

*Base your answers to questions 47 and 48 on the following diagram, which represents a source connected to two large, parallel metal plates. The electric field intensity between the plates is 3.75×10^4 newtons per coulomb; the distance between the plates is 4.00×10^{-3} m. The relationship between electric field intensity (*E*), voltage (*V*), and distance between the plates (d) is given by* $E = \frac{V}{d}$.



47. What is the potential difference of the source?

ANSWER: 150 V

48. What would be the magnitude of the electric force on a proton at point *A*?

ANSWER: 6×10^{-15} N

Base your answers to questions 49 and 50 on the information below.

A proton starts from rest and gains 8.35×10^{-14} joule of kinetic energy as it accelerates between points *A* and *B* in an electric field.

49. What is the final speed of the proton?

ANSWER: (2) 1.00×10^{7} m/s

50. Calculate the potential difference between points *A* and *B* in the electric field. Show all work, including the equation and substitution with units.

ANSWER:

$$V = \frac{w}{q}$$

$$V = \frac{8.35 \times 10^{-14}\ \text{J}}{1.60 \times 10^{-19}\ \text{C}}$$

$$V = 5.22 \times 10^{5}\,\frac{\text{J}}{\text{C}} \quad \textit{or} \quad 5.22 \times 10^{5}\ \text{V}$$

PART C: Pages 116–118

Base your answers to questions 51 and 52 on the information below.

A lightweight sphere hangs by an insulating thread. A student wishes to determine if the sphere is neutral or electrostatically charged. She has a negatively charged hard rubber rod and a positively charged glass rod. She does not touch the sphere with the rods, but runs tests by bringing them near the sphere one at a time.

51. Describe the test result that would prove that the sphere is neutral.

ANSWER: The sphere is attracted to both rods.

52. Describe the test result that would prove that the sphere is positively charged.

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

Base your answers to questions 53 through 56 on the information and data table below.

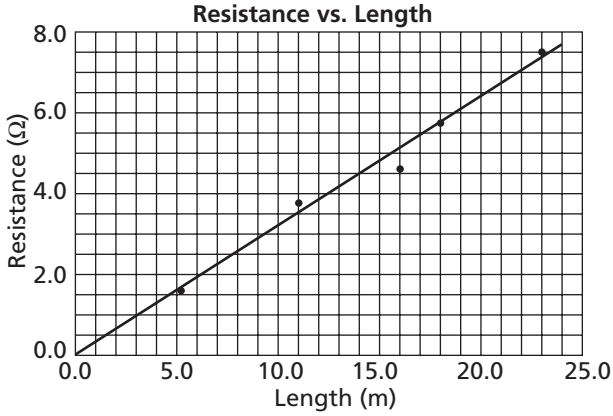
An experiment was performed using various lengths of a conductor of uniform cross-sectional area. The resistance of each length was measured and the data recorded in the table below.

Length (m)	Resistance (Ω)
5.1	1.6
11.0	3.8
16.0	4.6
18.0	5.9
23.0	7.5

Using the information in the data table, construct a graph following the directions below.

53. Mark appropriate scales on the axis labeled "Length (m)" and "Resistance (Ω)".

ANSWER:



54. Plot the data points for resistance versus length.

ANSWER: See # 53, above.

55. Draw the best-fit line.

ANSWER: See # 53, above.

56. Calculate the slope of the best-fit line. Show all work, including the equation and substitution with units.

ANSWER:

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{\Delta\,\text{resistance}}{\Delta\,\text{length}}$$

$$\text{Slope} = \frac{4.5\ \Omega - 0.0\ \Omega}{14.0\ \text{m} - 0.0\ \text{m}}$$

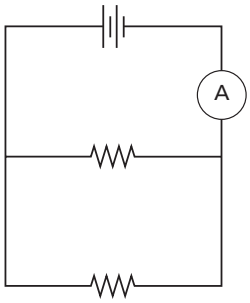
$$\text{Slope} = 0.32\ \Omega/\text{m}$$

Base your answers to questions 57 through 59 on the information below.

An 18-ohm resistor and a 36-ohm resistor are connected in parallel with a 24-volt battery. A single ammeter is placed in the circuit to read its total current.

57. Draw a diagram of this circuit using appropriate symbols

ANSWER:



58. Calculate the equivalent resistance of the circuit. Show all work, including the equation and substitution with units.

ANSWER:

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

$$\frac{1}{R_{eq}} = \frac{1}{18\ \Omega} + \frac{1}{36\ \Omega}$$

$$R_{eq} = 12\ \Omega$$

59. Calculate the total power dissipated in the circuit. Show all work, including the equation and substitution with units.

ANSWER:

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

$$P = \frac{(24\ \text{V})^2}{12\ \Omega} = 48\ \text{W}$$

or

$$I = \frac{V}{R} = \frac{24\ \text{V}}{12\ \Omega} = 2\ \text{A}$$

and

$$P = VI = (24\ \text{V})(2\ \text{A}) = 48\ \text{W}$$

Base your answers to questions 60 and 61 on the information below.

A 1.00-meter length of nichrome wire with a cross-sectional area of 7.85×10^{-7} meter^2 is connected to a 1.50-volt battery.

60. Calculate the resistance of the wire. Show all work, including the equation and substitution with units.

ANSWER:

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

$$R = \frac{(150 \times 10^{-8}\ \Omega \cdot \text{m})(1.00\ \text{m})}{(7.85 \times 10^{-7}\ \text{m}^2)}$$

$$R = 1.91\ \Omega$$

61. Determine the current in the wire.

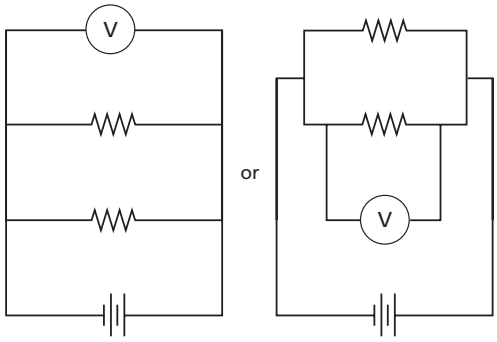
ANSWER: The current in the wire is 0.785 A.

Base your answers to questions 62 and 63 on the following information.

An electric circuit contains two 3.0-ohm resistors connected in parallel with a battery. The circuit also contains a voltmeter that reads the potential difference across one of the resistors.

62. On your own paper draw a diagram of this circuit, using appropriate symbols.

ANSWER:



63. Calculate the total resistance of the circuit. Show all work, including the equation and substitution with units.

ANSWER:

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

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

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

$$R_{eq} = 1.5\ \Omega$$

or

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2} = \frac{(3.0\ \Omega)(3.0\ \Omega)}{3.0\ \Omega + 3.0\ \Omega}$$

$$R_{eq} = 1.5\ \Omega$$

Base your answers to questions 64 and 65 on the information below.

A toaster having a power rating of 1050 watts is operated at 120. volts.

64. Calculate the resistance of the toaster. Show all work, including the equation and substitution with units.

ANSWER:

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

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

$$R = \frac{(120\ \text{V})^2}{1050\ \text{W}} = 13.7\ \Omega$$

or

$$P = VI$$

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

$$I = \frac{1050\ \text{W}}{120\ \text{V}}$$

$$I = 8.75\ \text{A}$$

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

$$R = \frac{120\ \text{V}}{8.75\ \text{A}}$$

$$R = 13.7\ \Omega$$

65. The toaster is connected in a circuit protected by a 15-ampere fuse. (The fuse will shut down the circuit if it carries more than 15 amperes.) Is it possible to simultaneously operate the toaster and a microwave oven that requires a current of 10.0 amperes on this circuit? Justify your answer mathematically.

ANSWER: No

$$I = \frac{P}{V} = \frac{1050\ \text{W}}{120\ \text{V}} = 8.75\ \text{A}$$

$$I_{total} = 8.75\ \text{A} + 10.0\ \text{A} = 18.8\ \text{A}$$

66. An electron is accelerated through a potential difference of 2.5×10^4 volts in the cathode ray tube of a computer monitor. Calculate the work, in joules, done on the electron. Show all work, including the equation and substitution with units.

ANSWER:

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

$$W = qV$$

$$W = (1.6 \times 10^{-19}\ \text{C})(2.5 \times 10^4\ \text{V})$$

$$W = 4.0 \times 10^{-15}\ \text{J}$$

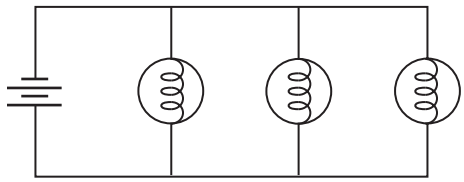
Base your answers to questions 67 through 71 on the information and data table below.

Three lamps were connected in a circuit with a battery of constant potential. The current, potential difference, and resistance for each lamp are listed in the data table below. There is negligible resistance in the wires and the battery.

Lamp	Current (A)	Potential Difference (V)	Resistance (Ω)
1	0.45	40.1	89
2	0.11	40.1	365
3	0.28	40.1	143

67. Using appropriate circuit symbols, draw a circuit showing how the lamps and battery are connected.

ANSWER:



68. What is the potential difference supplied by the battery?

ANSWER: 40.1 V

69. Calculate the equivalent resistance of the circuit. Show all work, including the equation and substitution with units.

ANSWER:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{89\ \Omega} + \frac{1}{365\ \Omega} + \frac{1}{143\ \Omega}$$

$$R_{eq} = 48\ \Omega \quad \textit{or} \quad 47.7\ \Omega$$

or

$$I = I_1 + I_2 + I_3$$

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

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

70. If lamp 3 is removed from the circuit, what would be the value of the potential difference across lamp 1 after lamp 3 is removed?

ANSWER: 40.1 V

71. If lamp 3 is removed from the circuit, what would be the value of the current in lamp 2 after lamp 3 is removed?

ANSWER: 0.11 A

72. Your school's physics laboratory has the following equipment available for conducting experiments:

accelerometers	lasers	stopwatches
ammeters	light bulbs	thermometers
bar magnets	meter sticks	voltmeters
batteries	power supplies	wires
electromagnets	spark timers	

Explain how you would find the resistance of an unknown resistor in the laboratory. Your explanation must include:

(a) measurements required

(b) equipment needed

(c) complete circuit diagram

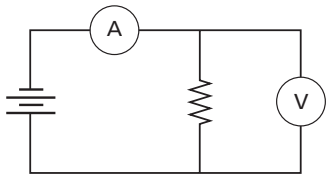
(d) any equation(s) needed to calculate the resistance

ANSWER:

(a) To determine the resistance of an unknown resistor, you would need to measure the current and potential difference for the resistor in a circuit.

(b) The equipment you would need would be the resistor, an ammeter, a voltmeter, a battery or power supply, and connecting wires.

(c) The circuit would be connected as in the diagram below.

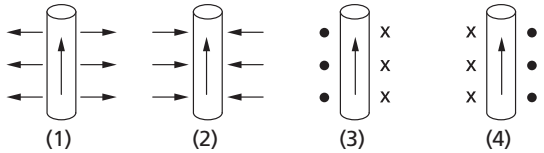


(d) Once you measured the current and potential for the resistor, use would be made of the formula for Ohm's law ($R = V/I$) to calculate the resistance.

ENRICHMENT—Electricity and Magnetism

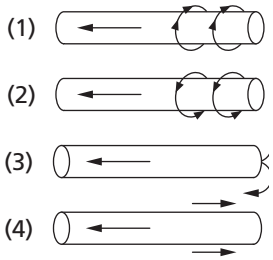
Pages 121–122

E1. Which diagram best represents the direction of the magnetic field around a wire conductor in which the current is moving as indicated? (The *X*'s indicate that the field is directed into the paper and the dots indicate that the field is directed out of the page.)



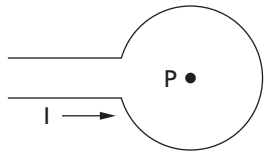
ANSWER: (3)

E2. Which diagram best represents the magnetic field around a current-carrying conductor?



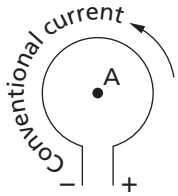
ANSWER: (1)

E3. The diagram represents a current-carrying loop of wire. The direction of the magnetic field at point *P* is



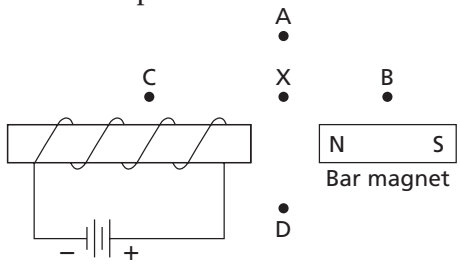
ANSWER: (4) out of the page

E4. Current flows in a loop of wire as shown in the diagram. What is the direction of the magnetic field at point *A*?



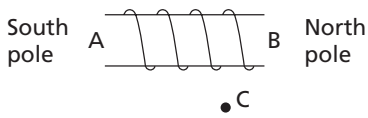
ANSWER: (2) out of the paper

E5. In the diagram, in which direction is the magnetic field at point *X*?

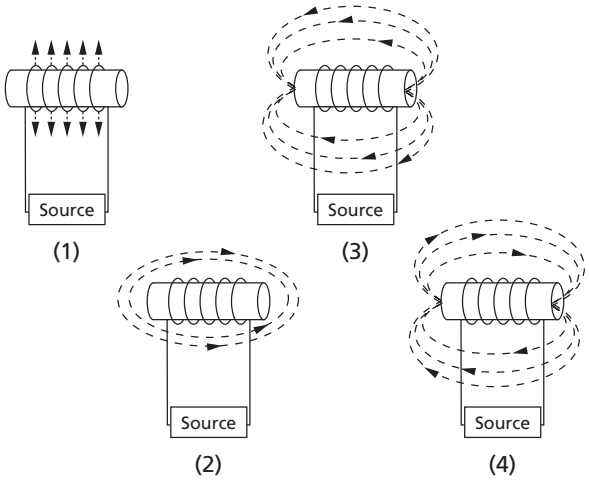


ANSWER: (1) toward *A*

Base your answers to questions E6 through E8 on the following diagram, which represents a cross section of an operating solenoid. A compass is located at point C.

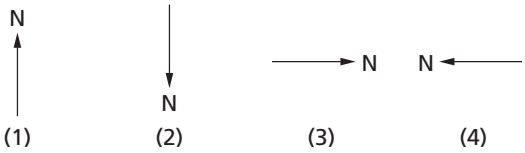


E6. Which diagram best represents the shape of the magnetic field around the solenoid?



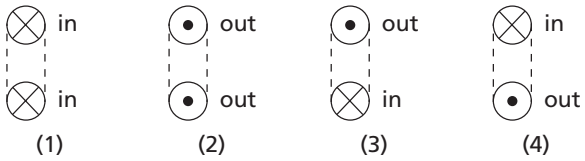
ANSWER: (3)

E7. Which shows the direction of the compass needle at point *C*?



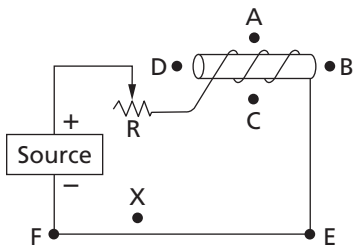
ANSWER: (4)

E8. If *B* is the north pole of the solenoid, which diagram best represents the direction of current in one of the wire loops?



ANSWER: (3)

Base your answers to questions E9 through E12 on the following diagram, which represents a circuit containing a solenoid on a cardboard tube, a variable resistor R*, and a source of potential difference.*



E9. The north pole of the solenoid is nearest to point

ANSWER: (4) *D*

E10. Due to the current in the *FE* section of the circuit, the direction of the magnetic field at point *X* is

ANSWER: (1) into the page

E11. If the resistance of resistor *R* is increased, the magnetic field strength of the solenoid will

ANSWER: (1) decrease

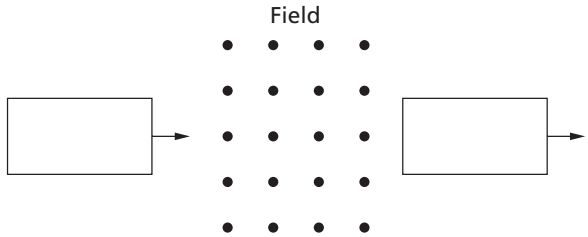
E12. If the number of turns in the solenoid is increased and the current is kept constant, the magnetic field strength of the solenoid will

ANSWER: (2) increase

E13. Two long, straight parallel conductors carry equal currents and are spaced 1 meter apart. If the current in each conductor is doubled, the magnitude of the magnetic force acting between the conductors will be

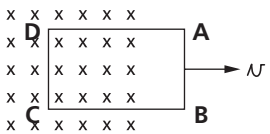
ANSWER: (4) quadrupled

E14. A rectangular loop of wire is moving perpendicularly to a magnetic field directed out of the page, as illustrated below. For each of the following steps, state whether or not current is induced in the loop and in what direction the current, if any, flows. (a) the loop has not yet entered the field, (b) the loop has partially entered the field, (c) the loop is entirely inside the field, moving across its field lines, (d) the loop has partially exited the field, and (e) the loop has entirely exited the field.



ANSWER: (a) No current induced. (b) Clockwise current induced. (c) No current. (d) Counterclockwise. (e) No current.

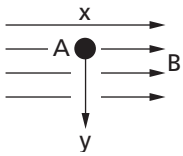
E15. The diagram represents a rectangular conducting loop *ABCD* being moved to the right through a magnetic field, which is directed into the page. Which path will the induced current follow?



ANSWER: (2) *DABCD*

Base your answers to questions E16 through E19 on the following diagram, which shows a cross section of a wire (A) *moving down through a uniform magnetic field* (B)*. The flux density of the field is 5.0 newtons per ampere-meter. The wire is 1.0 meter long and has*

a velocity of 2.0 meters per second perpendicular to the magnetic field.



E16. What is the direction of the magnetic force on the electrons in the wire?

ANSWER: (3) into the page

E17. What is the direction of the magnetic force on the wire due to the induced current in the wire?

ANSWER: (1) toward *x*

E18. What is the potential difference across the ends of the wire?

ANSWER: (4) 10. V

E19. The maximum potential difference will be induced across the wire when the angle between the direction of the motion of the wire and the direction of the magnetic field is

ANSWER: (3) 90°

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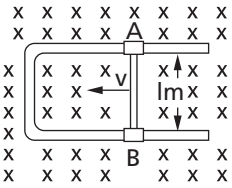
Base your answers to questions E20 through E23 on the following diagram, which represents a U-shaped wire conductor positioned perpendicular to a uniform magnetic field directed into the page. AB *represents a second wire, which is free to slide along the U-shaped wire. The length of wire* AB *is 1 meter, and the magnitude of the magnetic field is 8.0 webers/meter^2.*



E20. If wire *AB* is moved to the left at a constant speed, the direction of the induced electron motion in wire *AB* will be

ANSWER: (1) toward *A*, only

E21. If wire *AB* is moved to the left with a constant speed of 10. meters per second, the potential difference induced across wire *AB* will be

ANSWER: (4) 80 V

E22. Wire *AB* is moved at a constant speed to the left. The current induced in the conducting loop will produce a force on wire *AB* which acts

ANSWER: (1) to the right

E23. The resistance of wire *AB* is increased, and the wire is moved to the left at a constant speed of 10 meters per second. Compared to the induced potential difference before the resistance was increased, the new potential difference will be

ANSWER: (3) the same

E24. Which is the unit of magnetic flux in the MKS system?

ANSWER: (1) Weber

E25. Magnetic flux density may be measured in

ANSWER: (2) Weber/m^2

E26. If the current in the solenoid is doubled and the number of turns halved, the magnetic field strength of the solenoid will

ANSWER: (3) remain the same

E27. Electromagnetic radiation can be produced by charged particles that are

ANSWER: (4) being accelerated

E28. Electromagnetic radiations such as radio, light, and gamma are propagated by the interchange of energy between

ANSWER: (4) electric and magnetic fields

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E29. Doubling the current in a loop of wire situated in a magnetic field

ANSWER: (3) doubles the torque

E30. A galvanometer measures

ANSWER: (1) small amounts of current

E31. The torque produced by the magnetic field in a galvanometer on the coil is opposed by

ANSWER: (2) tension in the spring

E32. When no current exists in a galvanometer, the plane of the coil should be

ANSWER: (1) parallel to the field

E33. Ammeters are used to measure

ANSWER: (3) larger amounts of current

E34. To perform its mission, an ammeter is connected

ANSWER: (1) in series with the circuit

E35. The total resistance of an ammeter

ANSWER: (2) must be very small

E36. To raise the maximum current an ammeter can read, the shunt resistance should be

ANSWER: (1) decreased

E37. An ammeter is a galvanometer with a

ANSWER: (2) low resistance in parallel

E38. A voltmeter is a galvanometer with a

ANSWER: (3) high resistance in series

E39. The purpose of the shunt in an ammeter is to provide

ANSWER: (4) a path for some current to bypass the coil.

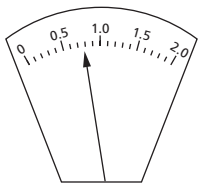
E40. To function properly, a voltmeter is connected

ANSWER: (2) in parallel with the circuit

E41. The total resistance of a voltmeter

ANSWER: (1) must be very large

E42. The reading of the ammeter in the diagram should be recorded as



ANSWER: (2) 0.76 A

E43. One milliampere produces a full-scale deflection in a galvanometer whose internal resistance is 50 ohms. To convert this instrument into an ammeter whose full-scale deflection is 1 A, it should be shunted with a resistance of approximately

ANSWER: (2) 0.50 Ω

Pages 127–128

E44. As a torque causes the current-carrying loop in an electric motor to begin rotating, the current in that loop

ANSWER: (1) decreases

E45. A current-carrying loop of wire in a magnetic field is forced to

ANSWER: (2) rotate

E46. The current in the armature of a dc motor

ANSWER: (3) alternates in direction

E47. The current in the armature of an electric motor switches direction with each rotation. Which motor part produces this phenomenon?

ANSWER: (2) split-ring commutator

E48. The coil in an electric motor is made to rotate by

ANSWER: (4) a magnetic force

E49. The wire loops in a motor are wrapped around soft iron to

ANSWER: (1) increase the intensity of the magnetic field

E50. If the rotation of the coil in an electric motor is stopped while the motor is still connected to the battery, the current in the coil will

ANSWER: (2) increase

E51. The back EMF in an electric motor guarantees that which of the following laws is not violated by the operation of the motor?

ANSWER: (4) conservation of energy

Pages 132–133

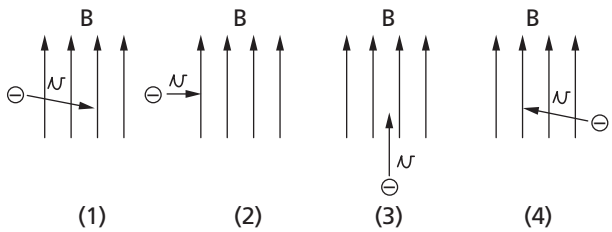
E52. The space charge near an incandescent cathode is

ANSWER: (1) negative

E53. The cathode-anode arrangement is designed to

ANSWER: (3) accelerate electrons

E54. An electron traveling at a speed v in the plane of this paper enters a uniform magnetic field. Which diagram best represents the condition under which the electron will experience the greatest magnitude force as it enters the magnetic field?



ANSWER: (2)

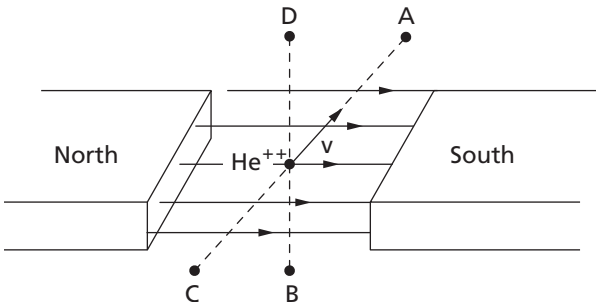
E55. If a charged particle moving through a magnetic field experiences a magnetic force, the angle between the magnetic field and the force exerted on the particle is

ANSWER: (3) 90°

E56. If a charged particle moving perpendicularly to a uniform magnetic field increases in velocity, the magnetic force on the charge

ANSWER: (2) increases

Base your answers to questions E57 through E61 on the following diagram, which represents a helium ion with a charge of +2 elementary charges moving toward point A *with a constant speed* v *of 2.0 meters per second perpendicular to a uniform magnetic field between the poles of a magnet. The strength of the magnetic field is 0.10 weber per square meter.*



E57. The direction of the magnetic force on the helium ion is toward point

ANSWER: (2) *B*

E58. The magnitude of the magnetic force exerted on the helium ion is

ANSWER: (2) 6.4×10^{-20} N

E59. If the strength of the magnetic field and the speed of the helium ion are both doubled, the force on the helium ion will be

ANSWER: (4) quadrupled

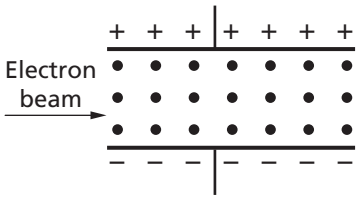
E60. If the polarity of the magnet is reversed, the magnitude of the magnetic force on the helium ion will

ANSWER: (3) remain the same

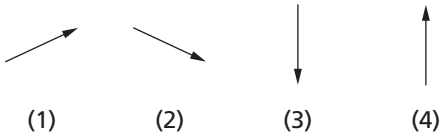
E61. The helium ion is replaced by an electron moving at the same speed. Compared to the magnitude of the force on the helium ion, the magnitude of the force on the electron is

ANSWER: (1) less

Base your answers to questions E62 through E65 on the following diagram, which represents an electron beam entering the space between two parallel, oppositely charged plates. A uniform magnetic field, directed out of the page, exists between the plates.



E62. If the magnitude of the electric force on each electron and the magnetic force on each electron are the same, which diagram best represents the direction of the *vector sum* of the forces acting on one of the electrons?

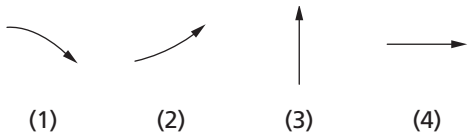


ANSWER: (4)

E63. In which direction would the magnetic field have to point in order for the magnetic force on the electrons to be opposite in direction from the electric force on the electrons?

ANSWER: (4) into the page

E64. If the electric force were equal and opposite to the magnetic force on the electrons, which diagram would best represent the path of the electrons as they travel in the space between the plates?

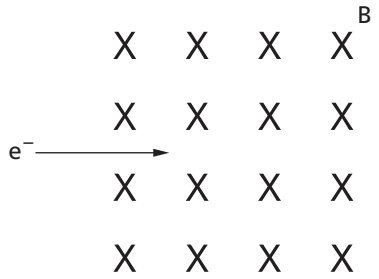


ANSWER: (4)

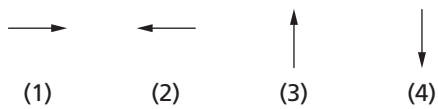
E65. If only the potential difference between the plates is increased, the force on the electron will

ANSWER: (2) increase

Base your answers to questions E66 through E70 on the following diagram, which represents an electron moving at 2.0×10^6 meters per second into a magnetic field which is directed into the paper. The magnetic field has a strength of 2.0 newtons per ampere meter.



E66. Which vector best indicates the direction of the force on the electron?



ANSWER: (4)

E67. What is the magnitude of the force on the electron?

ANSWER: (1) 6.4×10^{-13} N

E68. If the strength of the magnetic field were increased, the force on the electron would

ANSWER: (2) increase

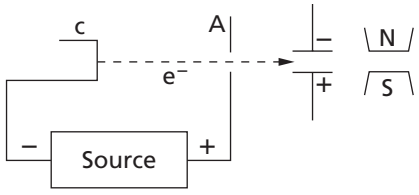
E69. If the velocity of the electron were increased, the force on the electron would

ANSWER: (2) increase

E70. The electron is replaced with a proton moving with the same velocity. Compared to the magnitude of the force on the electron, the magnitude of the force on the proton would be

ANSWER: (3) the same

Base your answers to questions E71 through E74 on the following diagram, which represents an electron beam in a vacuum. The beam is emitted by the cathode C, accelerated by anode A, and passes through electric and magnetic fields.



E71. If an electron in the beam is accelerated to a kinetic energy of 4.8×10^{-16} joule, the potential difference between the cathode and the anode is

ANSWER: (3) 3.0×10^{3} V

E72. In which direction will the electron beam be deflected by the electric field?

ANSWER: (4) toward the bottom of the page

E73. In which direction will the force of the magnetic field act on the electron beam?

ANSWER: (2) out of the page

E74. If an electron in the beam moves at 2.0×10^{8} meters per second between the magnetic poles where the flux density is 0.20 weber per square meter, the force on the electron is

ANSWER: (1) 6.4×10^{-12} N

Page 135

E75. Compared with the voltage in the coil of a transformer with more turns of wire, the voltage in the coil with fewer turns is

ANSWER: (1) smaller

E76. An ideal transformer cannot

ANSWER: (3) increase the power

E77. A transformer is connected to a source of alternating current. The only factor always common to both primary and secondary windings is the

ANSWER: (3) frequency

E78. The current flowing in the primary of a transformer depends upon

ANSWER: (2) the resistance of the primary coil

E79. A transformer has 50 turns on the primary and 100 turns on the secondary. If the primary is connected to a 6-volt battery the voltage on the secondary will be

ANSWER: (3) twice the voltage on the primary

E80. A transformer changes

ANSWER: (4) low voltage ac to high voltage ac or vice versa

Base your answers to questions E81 through E84 on the following information: A transformer consists of a primary connected to a 120-volt ac source that drives 4 A of current through the primary, and a secondary that contains one-third as many turns of wire as the primary. The transformer's efficiency is 80 percent.

E81. The voltage of the secondary is

ANSWER: (3) 40 V

E82. The current through the secondary is closest to

ANSWER: (4) 10 A

E83. The current in the secondary

ANSWER: (1) is of the ac type

E84. The power output of the secondary is

ANSWER: (3) less than the power input to the primary.

E85. To step up 6 V to 30 V with a transformer whose primary contains 10 coils of wire, the secondary should consist of

ANSWER: (3) 50 coils

E86. What is the power output of a transformer whose efficiency is 60 percent, if the power input to the primary is 240 W?

ANSWER: (1) 144 W

CHAPTER 4 Wave Phenomena

PART A: Pages 139–140

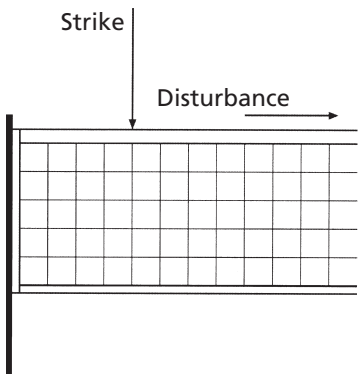
1. A periodic wave transfers

ANSWER: (1) energy, only

2. A surfacing whale in an aquarium produces water wave crests having an amplitude of 1.2 meters every 0.40 second. If the water wave travels at 4.5 meters per second, the wavelength of the wave

ANSWER: (1) 1.8 m

3. A student strikes the top rope of a volleyball net, sending a single vibratory disturbance along the length of the net, as shown in the diagram below.



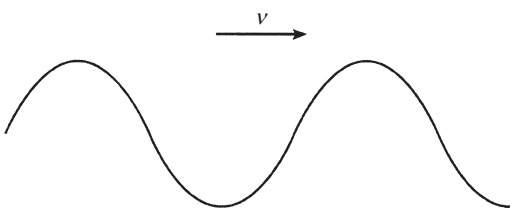
This disturbance is best described as

ANSWER: (1) a pulse

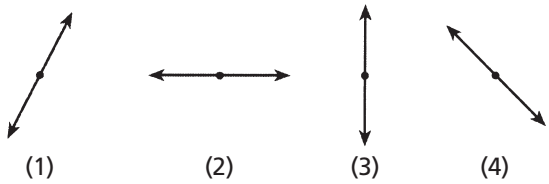
4. Which form(s) of energy can be transmitted through a vacuum?

ANSWER: (1) light, only

5. A transverse wave passes through a uniform material medium from left to right, as shown in the diagram below.



Which diagram best represents the direction of vibration of the particles of the medium?



ANSWER: (3)

6. An electric bell connected to a battery is sealed inside a large jar. What happens as the air is removed from the jar?

ANSWER: (4) The bell's loudness decreases because sound waves *cannot* travel through a vacuum.

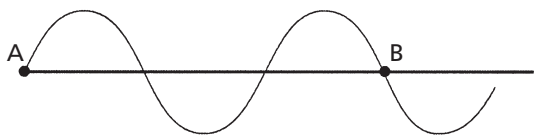
7. A tuning fork oscillates with a frequency of 256 hertz after being struck by a rubber hammer. Which phrase best describes the sound waves produced by this oscillating tuning fork?

ANSWER: (4) mechanical waves that require a medium for transmission

8. A physics student notices that 4.0 waves arrive at the beach every 20. seconds. The frequency of these waves is

ANSWER: (1) 0.20 Hz

9. The diagram below shows two points, *A* and *B*, on a wave train.



How many wavelengths separate point *A* and point *B*?

ANSWER: (2) 1.5

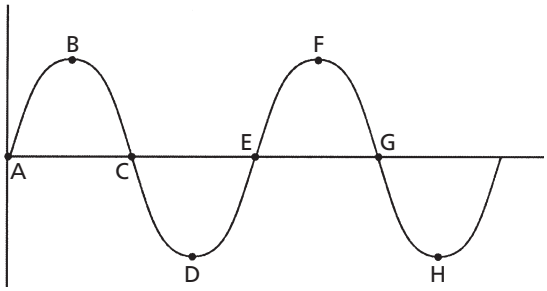
10. The energy of a water wave is most closely related to its

ANSWER: (4) amplitude

11. A tuning fork vibrating in air produces sound waves. These waves are best classified as

ANSWER: (3) longitudinal, because the air molecules are vibrating parallel to the direction of wave motion

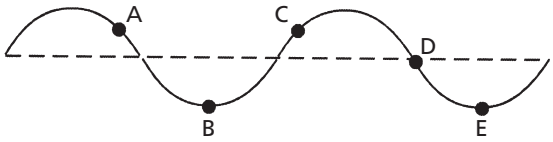
12. The diagram below represents a transverse wave traveling in a string.



Which two labeled points are 180° out of phase?

ANSWER: (3) *D* and *F*

13. The diagram below represents a periodic wave.



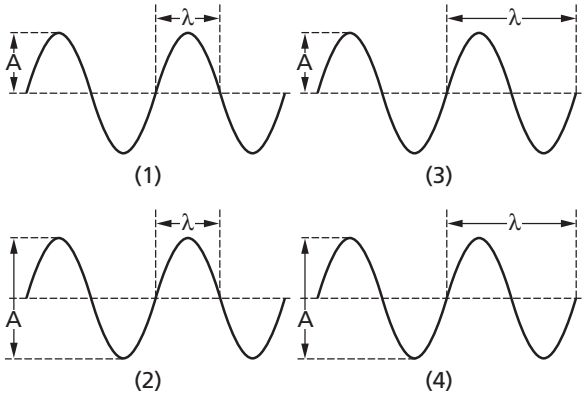
Which two points on the wave are in phase?

ANSWER: (4) *B* and *E*

14. If the speed of a wave doubles, its wavelength will be

ANSWER: (2) doubled

15. Which wave diagram has both wavelength (λ) and amplitude (*A*) labeled correctly?



ANSWER: (3)

16. An electric guitar is generating a sound of constant frequency. An increase in which sound wave characteristic would result in an increase in loudness?

ANSWER: (4) amplitude

17. A student notices the frequency of a periodic wave is 3.0 hertz. What is the wave's period?

ANSWER: (3) 0.33 second

18. A single vibratory disturbance that moves from point to point in a material medium is known as a

ANSWER: (2) pulse

19. In which type of wave is the disturbance parallel to the direction of wave travel?

ANSWER: (2) longitudinal

20. If the frequency of a sound wave in air remains constant, its energy can be varied by changing its

ANSWER: (1) amplitude

21. The reciprocal of the frequency of a periodic wave is the wave's

ANSWER: (1) period

22. As the frequency of the wave generated by a radio transmitter is increased, the wavelength

ANSWER: (1) decreases

23. If the period of a radio wave is doubled, its wavelength will be

ANSWER: (2) doubled

24. As the frequency of a wave increases, the period of that wave

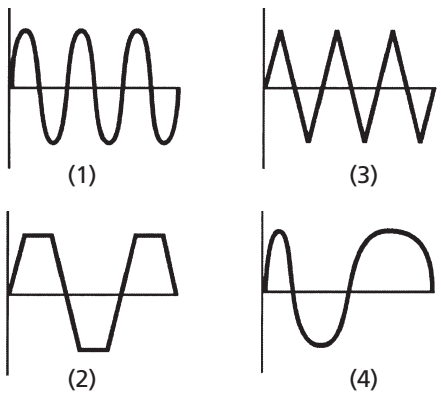
ANSWER: (1) decreases

25. Periodic waves are produced by a wave generator at the rate of one wave every 0.50 second. The period of the wave is

ANSWER: (4) 0.50 s

PART B-1: Pages 140–141

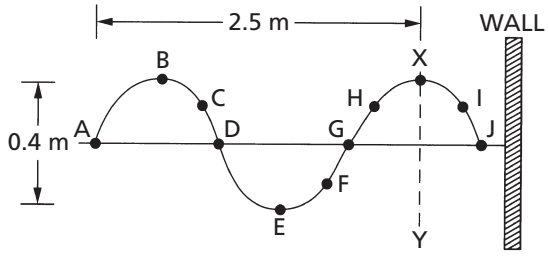
26. Which diagram below does *not* represent a periodic wave?



ANSWER: (4)

Base your answers to questions 27 through 29 on the following diagram, which represents a

segment of a periodic wave traveling to the right in a steel spring.



27. What is the amplitude of the wave?

ANSWER: (3) 0.2 m

28. What is the wavelength of the wave?

ANSWER: (2) 2.0 m

29. If a wave crest passes line *XY* every 0.40 second, the frequency of the wave is

ANSWER: (2) 2.5 Hz

Base your answers to questions 30 and 31 on the following information.

The frequency of a wave is 2.0 cycles per second, and its speed is 0.04 meter per second.

30. The period of the wave is

ANSWER: (3) 0.50 sec

31. The wavelength of the wave is

ANSWER: (2) 0.02 m

32. If the frequency of a sound wave is 440. cycles per second its period is closest to

ANSWER: (1) 2.27×10^{-3} second/cycle

33. Periodic waves with a wavelength of 0.05 meter move with a speed of 0.30 meter per second. When the waves enter a dispersive medium, they travel at 0.15 meter per second. What is the wavelength of the waves in the dispersive medium?

ANSWER: (4) 0.025m

PART A: Page 142

34. A radar gun can determine the speed of a moving automobile by measuring the difference in frequency between emitted and reflected radar waves. This process illustrates

ANSWER: (2) the Doppler effect

35. A train sounds a whistle of constant frequency as it leaves the train station. Compared to the sound emitted by the whistle, the sound that the passengers standing on the platform hear has a frequency that is

ANSWER: (1) lower, because the sound-wave fronts reach the platform at a frequency lower than the frequency at which they are produced

36. A source of sound waves approaches a stationary observer through a uniform medium. Compared to the frequency and wavelength of the emitted sound, the observer would detect waves with a

ANSWER: (1) higher frequency and shorter wavelength

37. A source of waves and an observer are moving relative to each other. The observer will detect a steadily increasing frequency if

ANSWER: (3) he accelerates toward the source

38. A change in the speed of a wave as it enters a new medium produces a change in

ANSWER: (3) wavelength

39. A sound of constant frequency is produced by the siren on top of a firehouse. Compared to the frequency produced by the siren, the frequency observed by a firefighter approaching the firehouse is

ANSWER: (2) higher

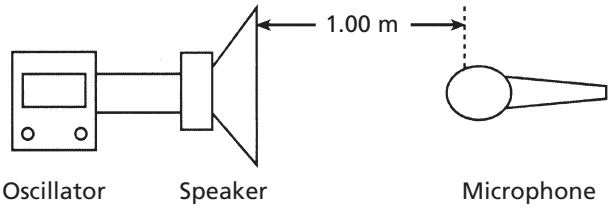
PART B-1: Pages 142–143

40. A 2.00×10^6-hertz radio signal is sent a distance of 7.30×10^{10} meters from Earth to a spaceship orbiting Mars. Approximately how much time does it take the radio signal to travel from Earth to the spaceship?

ANSWER: (2) 2.43×10^2 s

Base your answers to questions 41 through 43 on the information and diagram below.

A system consists of an oscillator and a speaker that emits a 1000.-hertz sound wave. A microphone detects the sound wave 1.00 meter from the speaker.



41. Which type of wave is emitted by the speaker?

ANSWER: (2) longitudinal

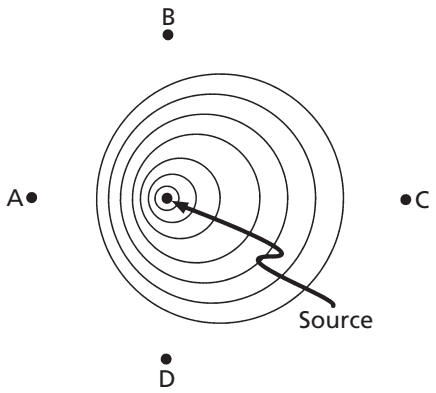
42. The microphone is moved to a new fixed location 0.50 meter in front of the speaker. Compared to the sound waves detected at the 1.00-meter position, the sound waves detected at the 0.50-meter position have a different

ANSWER: (4) amplitude

43. The microphone is moved at constant speed from the 0.50-meter position back to its original position 1.00 meter from the speaker. Compared to the 1000.-hertz frequency emitted by the speaker, the frequency detected by the moving microphone is

ANSWER: (1) lower

Base your answers to questions 44 through 46 on the following diagram which represents waves around a sound source that is moving with a constant velocity through air. The source produces waves of a constant frequency.



44. The diagram illustrates

ANSWER: (4) the Doppler effect

45. The source is moving toward point

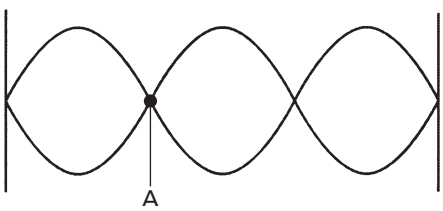
ANSWER: (1) *A*

46. Compared with the frequency of the waves observed at *C*, the frequency of the waves observed at *A* is

ANSWER: (2) greater

PART A: Pages 145–146

47. The diagram below shows a standing wave.



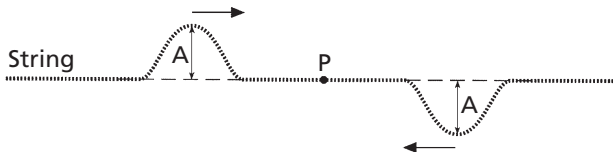
Point *A* on the standing wave is

ANSWER: (2) a node resulting from destructive interference

48. The superposition of two waves traveling in the same medium produces a standing wave pattern if the two waves have

ANSWER: (2) the same frequency, the same amplitude, and travel in opposite directions

49. The diagram below shows two pulses of equal amplitude, *A*, approaching point *P* along a uniform string.

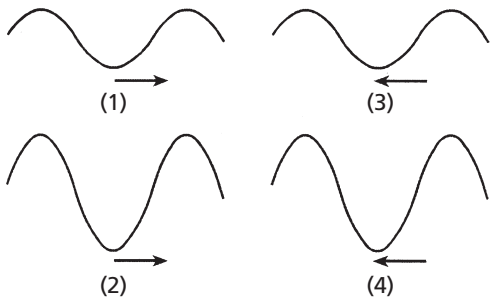


When the two pulses meet at *P*, the vertical displacement of the string at *P* will be

ANSWER: (3) 0

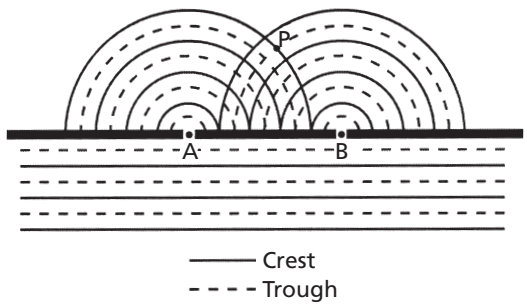
50. The diagram below represents a wave moving toward the right side of this page.

Which wave shown below could produce a standing wave with the original wave?



ANSWER: (3)

51. The diagram below represents shallow water waves of constant wavelength passing through two small openings, *A* and *B*, in a barrier.



Which statement best describes the interference at point *P*?

ANSWER: (4) It is destructive, and causes a decrease in amplitude.

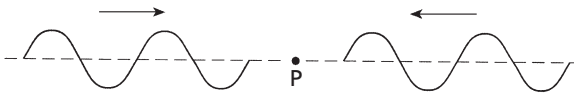
52. A standing wave pattern is produced when a guitar string is plucked. Which characteristic of the standing wave immediately begins to decrease?

ANSWER: (4) amplitude

53. Which phenomenon occurs when an object absorbs wave energy that matches the object's natural frequency?

ANSWER: (3) resonance

54. The diagram below represents two waves of equal amplitude and frequency approaching point *P* as they move through the same medium.



As the two waves pass through each other, the medium at point *P* will

ANSWER: (4) remain stationary

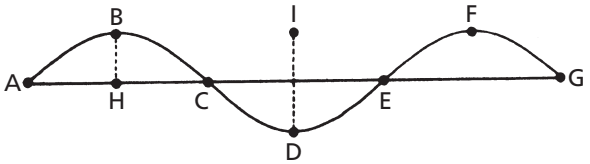
55. Standing waves in water are produced most often by periodic water waves

ANSWER: (4) reflecting from a barrier

56. In a demonstration, a vibrating tuning fork causes a nearby second tuning fork to begin to vibrate with the same frequency. Which wave phenomenon is illustrated by this demonstration?

ANSWER: (3) resonance

Base your answers to questions 57 through 61 on the following diagram which represents a transverse wave.



57. Which two points are in phase?

ANSWER: (4) *B* and *F*

58. The amplitude of the wave is the distance between points

ANSWER: (3) *B* and *H*

59. How many cycles are shown in the diagram?

ANSWER: (4) 1.5

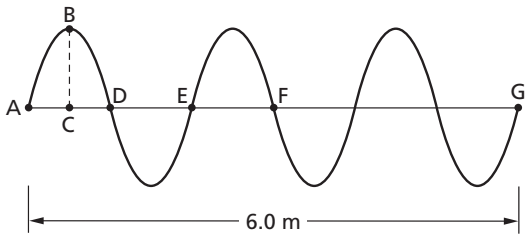
60. A wavelength is the distance between points

ANSWER: (2) *A* and *E*

61. If the period of the wave is 2 seconds, its frequency is

ANSWER: (1) 0.5 cycle/sec

Base your answers to questions 62 through 66 on the following diagram which represents a vibrating string with a periodic wave originating at A *and moving to* G*, a distance of 6.0 meters.*



62. What type of wave is represented by the diagram?

ANSWER: (4) transverse

63. What is the wavelength of this wave?

ANSWER: (2) 2.0 m

64. Which phenomenon would occur if the waves were reflected at *G* and returned back to *A* through the oncoming waves?

ANSWER: (3) standing waves

65. As the wave moves toward *G*, point *E* on the string will move

ANSWER: (2) vertically down and then vertically up

66. If the waves were produced at a faster rate, the distance between points *D* and *E* would

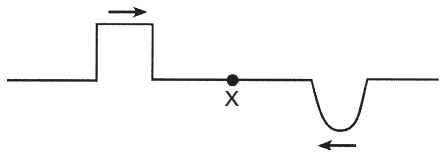
ANSWER: (1) decrease

67. A tuning fork that vibrates at a frequency of 100 Hz can produce resonance in a fork having which of the following frequencies?

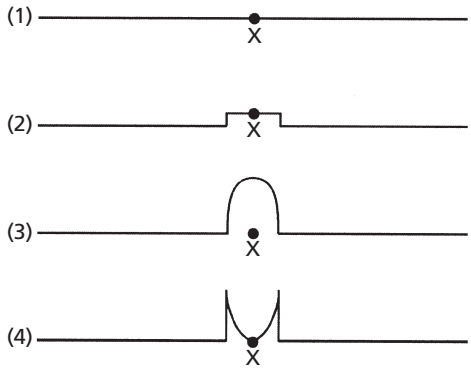
ANSWER: (1) 100 Hz

PART B-1: Pages 146–147

68. The diagram below shows two pulses traveling toward each other in a uniform medium.

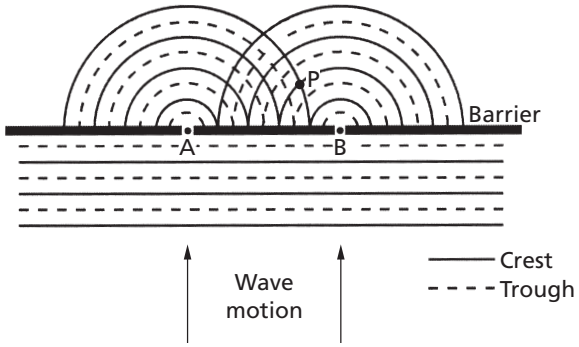


Which diagram best represents the medium when the pulses meet at point *X*?



ANSWER: (4)

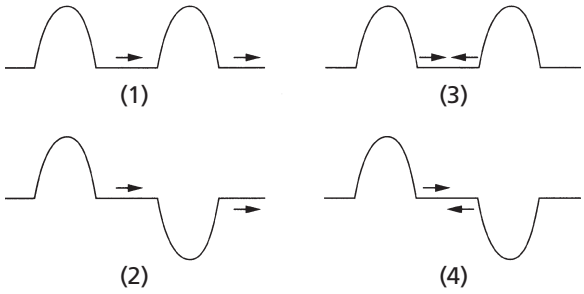
69. The diagram below represents shallow water waves of wavelength λ passing through two small openings, *A* and *B*, in a barrier.



How much longer is the length of path *AP* than the length of path *BP*?

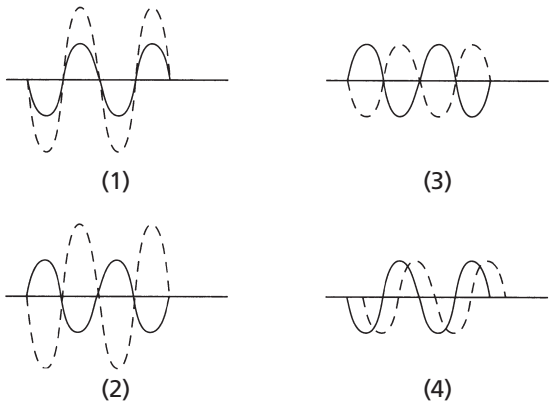
ANSWER: (2) 2λ

70. Which pair of moving pulses in a rope will produce destructive interference?



ANSWER: (4)

71. Which pair of waves will produce a resultant wave with the smallest amplitude?



ANSWER: (3)

PART A: Pages 149–150

72. Orange light has a frequency of 5.0×10^{14} hertz in a vacuum. What is the wavelength of this light?

ANSWER: (3) 6.0×10^{-7} m

73. How much time does it take light from a flash camera to reach a subject 6.0 meters across a room?

ANSWER: (2) 2.0×10^{-8} s

74. Which wave phenomenon makes it possible for a player to hear the sound from a referee's whistle in an open field even when standing behind the referee?

ANSWER: (1) diffraction

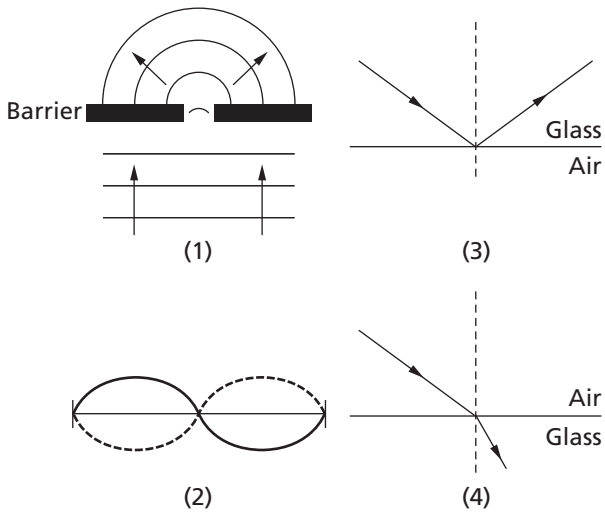
75. The spreading of a wave into the region behind an obstruction is called

ANSWER: (1) diffraction

76. In a vacuum, light with a frequency of 5.0×10^{14} hertz has a wavelength of

ANSWER: (2) 6.0×10^{-7} m

77. Which diagram below best represents the phenomenon of diffraction?



ANSWER: (1)

78. Radio waves diffract around buildings more than light waves do because, compared to light waves, radio waves

ANSWER: (4) have a longer wavelength

79. Which wave characteristic is the same for all types of electromagnetic radiation traveling in a vacuum?

ANSWER: (1) speed

80. A wave is diffracted as it passes through an opening in a barrier. The amount of diffraction that the wave undergoes depends on both the

ANSWER: (3) wavelength of the incident wave and the size of the opening

81. At STP, sound with a wavelength of 1.66 meters has a frequency of

ANSWER: (3) 200 Hz

82. Waves pass through a 10.-centimeter opening in a barrier without being diffracted. This observation provides evidence that the wavelength of the waves is

ANSWER: (1) much shorter than 10. cm

83. The pattern of bright and dark bands observed when monochromatic light passes though two narrow slits is due to

ANSWER: (4) interference

84. Which is *not* in the electromagnetic spectrum?

ANSWER: (3) sound waves

85. Which characterizes a polarized wave?

ANSWER: (1) transverse and vibrating in one plane

86. Whether or not a wave is longitudinal or transverse may be determined by its ability to be

ANSWER: (3) polarized

PART B-1: Page 150

87. Electrons oscillating with a frequency of 2.0×10^{10} hertz produce electromagnetic waves. These waves would be classified as

ANSWER: (3) microwave

88. Compared to the period of a wave of red light the period of a wave of green light is

ANSWER: (1) less

PART A: Page 154

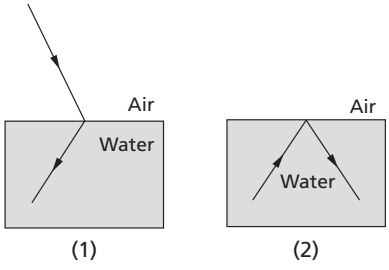
89. As a sound wave passes from water, where the speed is 1.49×10^3 meters per second, into air, the wave's speed

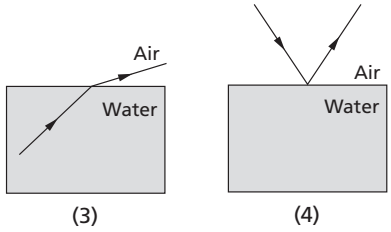
ANSWER: (1) decreases and its frequency remains the same

90. In a certain material, a beam of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) has a speed of 2.25×10^8 meters per second. The material could be

ANSWER: (4) water

91. Which ray diagram correctly represents the phenomenon of refraction?



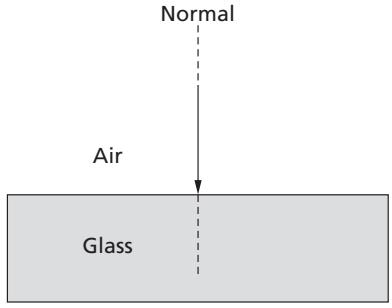


ANSWER: (3)

92. A beam of monochromatic light travels through flint glass, crown glass, Lucite, and water. The speed of the light beam is slowest in

ANSWER: (1) flint glass

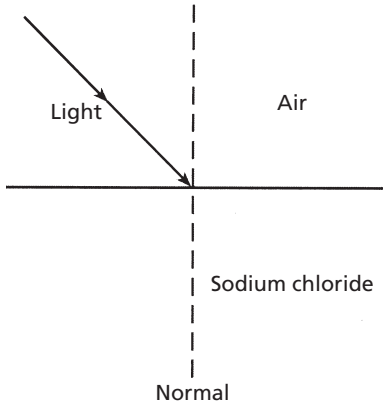
93. The diagram below shows a ray of light passing from air into glass at an angle of incidence of 0°.



Which statement best describes the speed and direction of the light ray as it passes into the glass?

ANSWER: (1) Only speed changes.

94. A ray of monochromatic light is incident on an air-sodium chloride boundary as shown in the diagram below. At the boundary, part of the ray is reflected back into the air and part is refracted as it enters the sodium chloride.



Compared to the ray's angle of refraction in the sodium chloride, the ray's angle of reflection in the air is

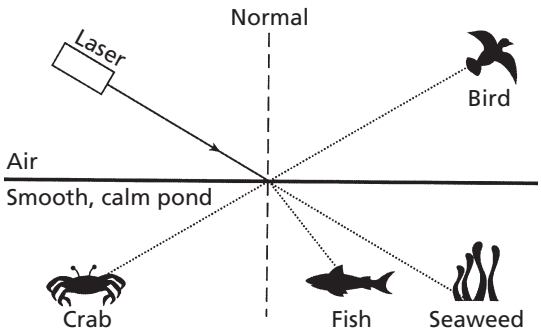
ANSWER: (2) larger

95. A ray of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) in air is incident at an angle of 30.° on a

boundary with corn oil. What is the angle of refraction, to the nearest degree, for this light ray in the corn oil?

ANSWER: (3) 20 degrees

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



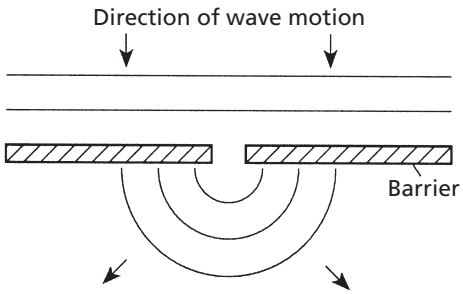
Which organisms could be illuminated by the laser light?

ANSWER: (1) the bird and the fish

97. 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

ANSWER: (2) 1.3

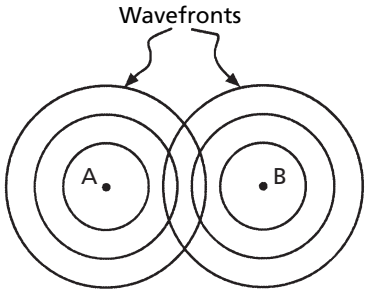
98. The diagram below shows wave fronts spreading into the region behind a barrier.



Which wave phenomenon is represented in the diagram?

ANSWER: (3) diffraction

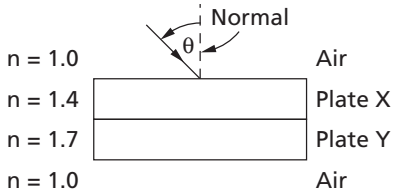
99. The diagram below represents the wave pattern produced by two sources located at points *A* and *B*.



Which phenomenon occurs at the intersections of the circular wave fronts?

ANSWER: (2) interference

Base your answers to questions 100 through 102 on the following diagram which represents a ray of monochromatic light incident upon the surface of plate X. *The values of* n *in the diagram represent absolute indices of refraction.*



100. The speed of the light ray in plate *X* is approximately

ANSWER: (2) 2.1×10^8 m/s

101. Compared with angle θ, the angle of refraction of the light ray in plate *X* is

ANSWER: (1) smaller

102. Compared with angle θ, the angle of refraction of the ray emerging from plate *Y* into the air will be

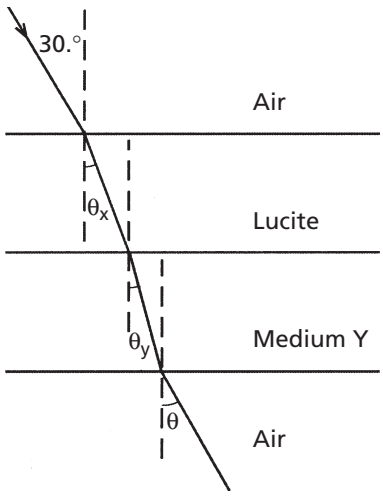
ANSWER: (3) the same

103. Which wave phenomenon could *not* be demonstrated with a single wave pulse?

ANSWER: (1) a standing wave

PART B-1: Page 155

Base your answers to questions 104 and 105 on the diagram below, which represents a light ray traveling from air to Lucite to medium Y *and back into air.*



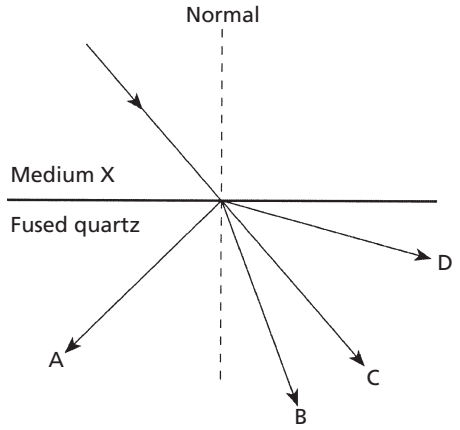
104. The sine of angle *x* is

ANSWER: (1) 0.333

105. Light travels *slowest* in

ANSWER: (3) medium *Y*, only

106. The diagram below represents a ray of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) passing from medium *X* ($n = 1.46$) into fused quartz.



Which path will the ray follow in the quartz?

ANSWER: (3) *C*

107. A monochromatic ray of light ($f = 5.09 \times 10^{14}$ hertz) traveling in air is incident upon medium *A* at an angle of 45°. If the angle of refraction is 29°, medium *A* could be

ANSWER: (2) fused quartz

PHYSICS IN YOUR LIFE—Seismic Waves

Page 156

1. Compare primary, secondary, and seismic waves.

Primary waves are longitudinal, secondary waves are transverse, and surface (seismic) waves are a combination of these.

2. A seismograph is a device that detects seismic waves. Explain what characteristic of the waves is related to the amount of energy carried by the wave.

The energy carried by a wave is related to its amplitude. The greater the amplitude, the greater the energy.

3. Which is the only type of seismic wave that can travel through Earth's core? Explain.

Only P waves, which are longitudinal, travel through the earth's liquid core.

4. In what order do the three different types of earthquake waves arrive at any point removed some distance from the center of the quake?

The first to arrive are the P waves, followed by the S waves and surface waves.

5. Which type of wave is the cause of the most severe shaking of buildings during an earthquake?

The surface waves.

Chapter Review Questions

PART A: Pages 156–157

1. If the frequency of a periodic wave is doubled, the period of the wave will be

ANSWER: (1) halved

2. How are electromagnetic waves that are produced by oscillating charges and sound waves that are produced by oscillating tuning forks similar?

ANSWER: (1) Both have the same frequency as their respective sources.

3. Wave motion in a medium transfers

ANSWER: (1) energy, only

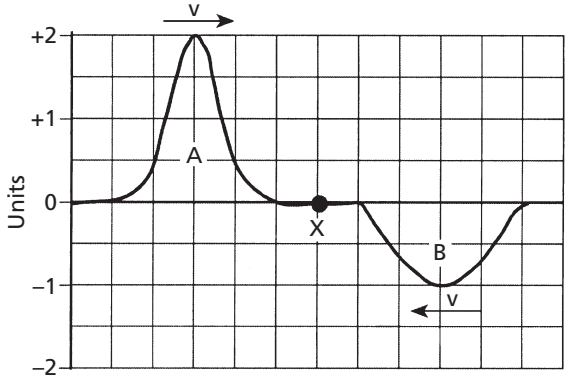
4. What happens to the frequency and the speed of an electromagnetic wave as it passes from air into glass?

ANSWER: (4) The frequency remains the same and the speed decreases.

5. When observed from Earth, the wavelengths of light emitted by a star are shifted toward the red end of the electromagnetic spectrum. This redshift occurs because the star is

ANSWER: (2) moving away from Earth

6. Two pulses, *A* and *B*, travel toward each other along the same rope, as shown below.



When the centers of the two pulses meet at point *X*, the amplitude at the center of the resultant pulse will be

ANSWER: (1) +1 unit

7. A single vibratory disturbance moving through a medium is called a (an)

ANSWER: (4) pulse

8. Radio waves and gamma rays traveling in space have the same

ANSWER: (4) speed

9. Which pair of terms best describes light waves traveling from the sun to Earth?

ANSWER: (1) electromagnetic and transverse

10. Which quantity is the product of the absolute index of refraction of water and the speed of light in water?

ANSWER: (4) speed of light in a vacuum

11. A sonar wave is reflected from the ocean floor. For which angles of incidence do the wave's angle of reflection equal its angle of incidence?

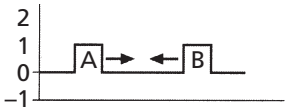
ANSWER: (4) all angles of incidence

12. A student in a band notices that a drum vibrates when another instrument emits a certain frequency note. This phenomenon illustrates

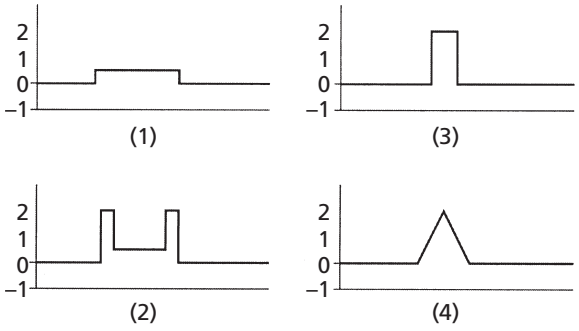
ANSWER: (2) resonance

PART B-1: Pages 157–158

13. The diagram below shows two pulses, *A* and *B*, approaching each other in a uniform medium.

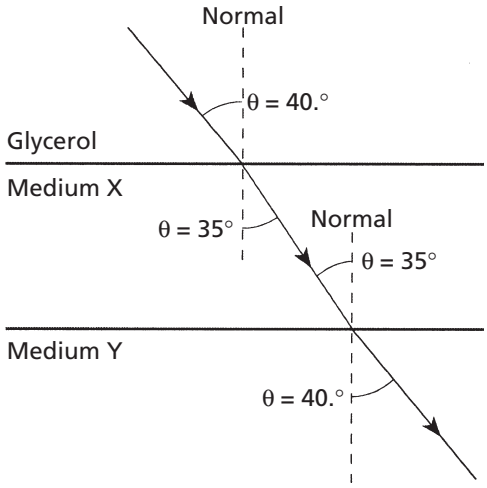


Which diagram best represents the superposition of the two pulses?



ANSWER: (3)

14. A beam of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) passes through parallel sections of glycerol, medium *X*, and medium *Y* as shown in the diagram below.



What could medium *X* and medium *Y* be?

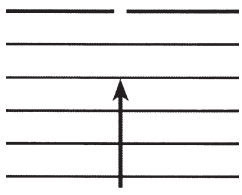
ANSWER: (1) *X* could be flint glass and *Y* could be corn oil.

15. A spaceship is moving away from Earth when a 2.00×10^6-hertz radio signal is received from Earth. Compared to the frequency of the signal sent from Earth, the frequency of the signal received by the spaceship is

ANSWER: (1) lower

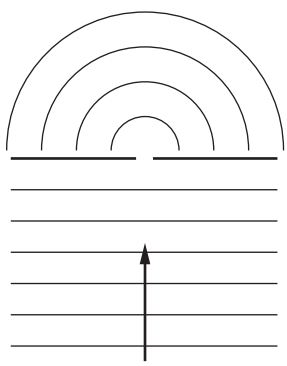
PART B-2: Pages 158–160

16. The diagram below shows a plane wave passing through a small opening in a barrier.



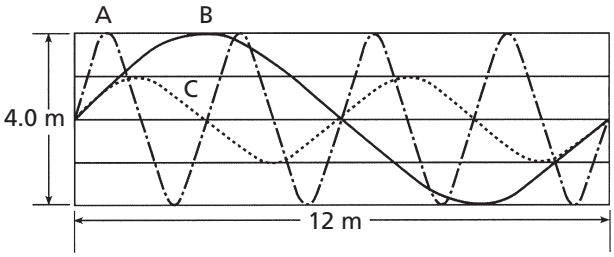
On a diagram *on a blank sheet of paper*, sketch four wave fronts after they have passed through the barrier.

ANSWER:



Base your answers to questions 17 through 19 on the information and diagram below in

which three waves, A, B, *and* C, *travel 12 meters in 2.0 seconds through the same medium.*



17. What is the amplitude of wave *C*?

ANSWER: 1.0 m

18. What is the period of wave *A*?

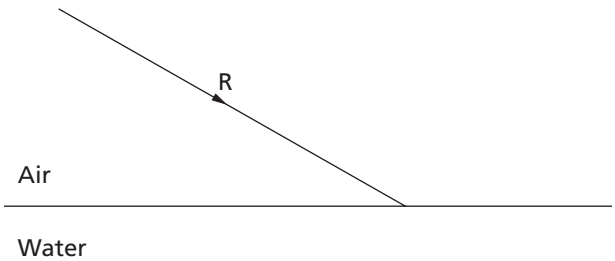
ANSWER: 0.50 s

19. What is the speed of wave *B*?

ANSWER: 6.0 m/s

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

In the diagram, a light ray, *R*, strikes the boundary of air and water.

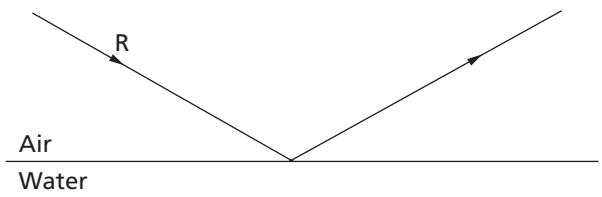


20. Using a protractor, determine the angle of incidence.

ANSWER: The angle of incidence is 61°

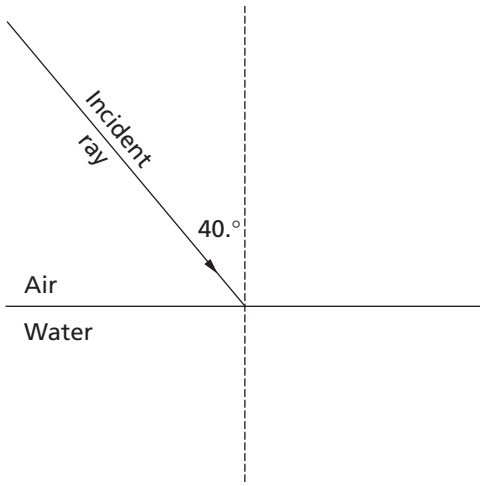
21. Using a protractor and straightedge, draw the reflected ray on a diagram on your own paper.

ANSWER: The reflected ray makes an angle of 61° with the normal.



Base your answers to questions 22 through 24 on the information and diagram below.

A light ray with a frequency of 5.09×10^{14} hertz traveling in air is incident at an angle of 40.° on an air-water interface as shown. At the interface, part of the ray is refracted as it enters the water and part of the ray is reflected from the interface.



22. Calculate the angle of refraction of the light ray as it enters the water. Show all work, including the equation and substitution with units.

ANSWER:

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

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

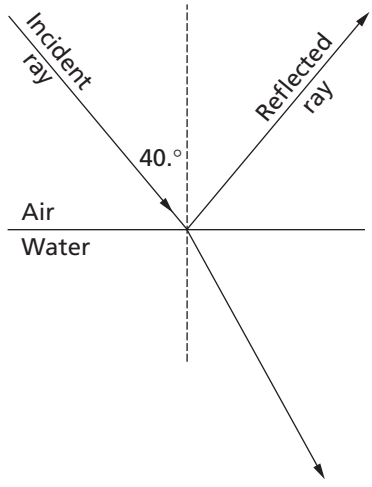
$$\sin \theta_2 = \frac{(1.00)(\sin 40.^\circ)}{1.33}$$

$$\sin \theta_2 = 0.483$$

$$\theta_2 = 28.9^\circ \text{ or } 29^\circ$$

23. On a diagram *on a blank sheet of paper*, using a protractor and straightedge, draw the refracted ray. Label this ray "Refracted ray."

ANSWER: The refracted ray makes an angle of 29° with the normal.

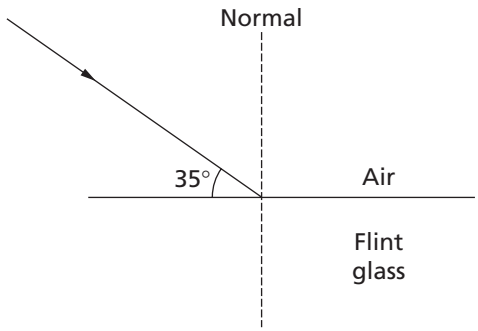


24. On a diagram *on a blank sheet of paper*, using a protractor and straightedge, draw the reflected ray. Label this ray "Reflected ray."

ANSWER: The reflected ray makes an angle of 40° with the normal.

See # 23, above.

Base your answers to questions 25 through 28 on the diagram below, which represents a ray of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) in air incident on flint glass.



25. Determine the angle of incidence of the light ray in air.

ANSWER: 55°

26. Calculate the angle of refraction of the light ray in the flint glass. Show all work, including the equation and substitution with units.

ANSWER:

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

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

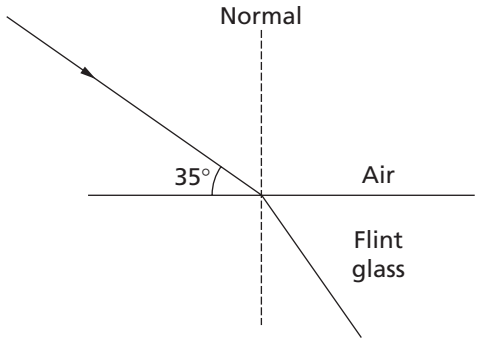
$$\sin \theta_2 = \frac{(1.00)(\sin 55°)}{1.66}$$

$$\sin \theta_2 = 0.493$$

$$\theta_2 = 29.6° \text{ or } 30.°$$

27. Using a protractor and straightedge, draw the refracted ray on a diagram *on your own paper*.

ANSWER: The refracted ray makes an angle of 30° with the normal.



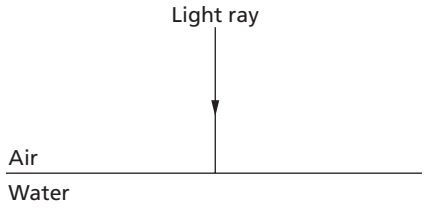
28. What happens to the light from the incident ray that is *not* refracted or absorbed?

ANSWER: It is reflected or scattered.

29. An FM radio station broadcasts its signal at a frequency of 9.15×10^7 hertz. Determine the wave-length of the signal in air.

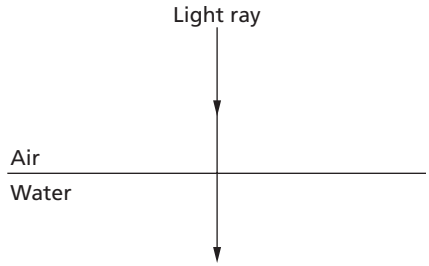
ANSWER: 3.28 m or 3.3 m

30. A ray of light traveling in air is incident on an air–water boundary as shown below.



On a diagram on *a blank sheet of paper*, draw the path of the ray in the water.

ANSWER: The line should extend straight into the water.



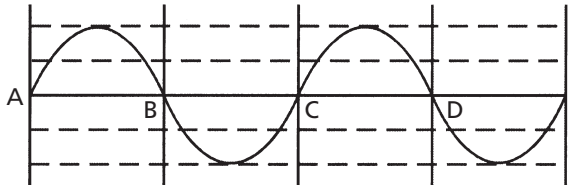
31. A ray of monochromatic light with a frequency of 5.09×10^{14} hertz is transmitted through four different media, listed below.

A. corn oil
B. ethyl alcohol
C. flint glass
D. water

Rank the four media from the one through which the light travels at the slowest speed to the one through which the light travels at the fastest speed. Use the letters in front of each medium to indicate your answer.

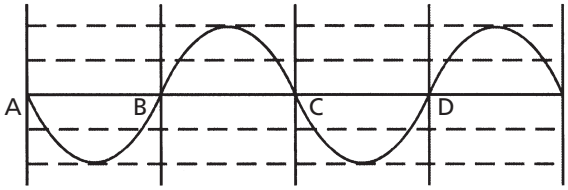
ANSWER: The correct order is *C A B D*.

32. The diagram below represents a transverse wave moving along a string.



On a diagram *on a blank sheet of paper*, draw a transverse wave that would produce complete destructive interference when superimposed with the original wave.

ANSWER:



33. A beam of light travels through medium *X* with a speed of 1.80×10^8 meters per second. Calculate the absolute index of refraction of medium *X*. Show all work, including the equation and substitution with units.

ANSWER:

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

$$n = \frac{3.00 \times 10^8 \text{ m/s}}{1.80 \times 10^8 \text{ m/s}}$$

$$n = 1.67 \text{ or } 1.7$$

Base your answers to questions 34 and 35 on the information below.

A student plucks a guitar string and the vibrations produce a sound wave with a frequency of 650 hertz.

34. The sound wave produced can best be described as a

ANSWER: (2) longitudinal wave of constant frequency

35. Calculate the wavelength of the sound wave in air at STP. Show all work, including the equation and substitution with units.

ANSWER:

$$v = f\lambda$$

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

$$\lambda = \frac{331 \text{ m/s}}{650 \text{ Hz}}$$

$$\lambda = 0.51 \text{ m} \text{ or } 0.509 \text{ m}$$

36. Rubbing a moistened finger around the rim of a water glass transfers energy to the glass at the natural frequency of the glass. Which wave phenomenon is responsible for this effect?

ANSWER: Resonance, standing waves *or* sympathetic vibration.

37. Calculate the wavelength in a vacuum of a radio wave having a frequency of 2.2×10^6 hertz. Show all work, including the equation and substitution with units.

ANSWER:

$$v = f\lambda$$

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

$$\lambda = \frac{3.00 \times 10^8 \text{ m/s}}{2.2 \times 10^6 \text{ Hz}}$$

$$\lambda = 1.4 \times 10^2 \text{ m} \text{ or } 140 \text{ m}$$

38. Two monochromatic, coherent light beams of the same wavelength converge on a screen. The point at which the beams converge appears dark. Which wave phenomenon best explains this effect?

ANSWER: destructive interference, principle of superposition

39. Exposure to ultraviolet radiation can damage skin. Exposure to visible light does not damage skin. State *one* possible reason for this difference.

Acceptable responses include but are not limited to:

Visible light has less energy.

Visible light has lower frequency.

Visible light has longer wavelength.

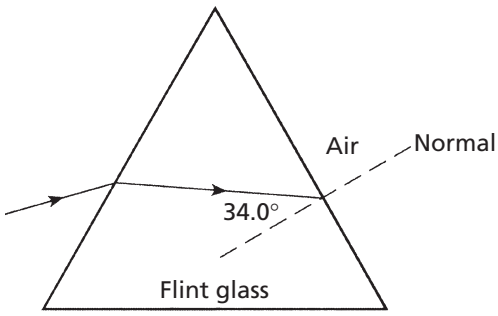
Ultraviolet has higher energy.

Ultraviolet has higher frequency.

Ultraviolet has shorter wavelength.

Ultraviolet radiation resonates with the cell membrane.

Base your answers to questions 40 through 42 on the diagram below which shows a ray of monochromatic light ($f = 5.09 \times 10^{14}$ hertz) passing through a flint glass prism.



40. Calculate the angle of refraction of the light ray as it enters the air from the flint glass prism. Show all calculations, including the equation and substitution with units.

ANSWER:

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

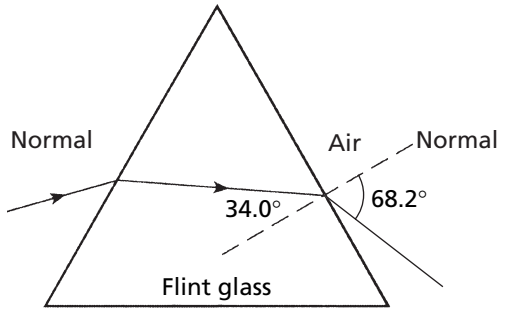
$$\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2}$$

$$\sin \theta_2 = \frac{1.66 \sin 34.0°}{1.00}$$

$$\theta_2 = 68.2° \text{ or } 68°$$

41. Using a protractor and a straightedge, construct the refracted light ray in the air on a diagram on your own paper.

ANSWER: The angle between the normal and the refracted ray is equal to 68 degrees.



42. What is the speed of the light ray in flint glass?

ANSWER: (2) 1.81×10^8 m/s

43. Determine the color of a ray of light with a wavelength of 6.21×10^{-7} meter.

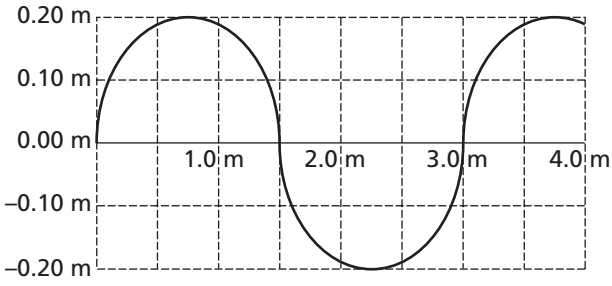
ANSWER: The color is orange.

Base your answers to questions 44 and 45 on the information below.

A periodic transverse wave has an amplitude of 0.20 meter and a wavelength of 3.0 meters.

44. On a grid, draw at least one cycle of this periodic wave.

ANSWER:



45. If the frequency of this wave is 12 Hz, what is its speed?

ANSWER: (3) 36 m/s

PART C: Pages 160–161

Base your answers to questions 46 and 47 on the passage below.

Shattering Glass

An old television commercial for audio recording tape showed a singer breaking a wine glass with her voice. The question was then asked if this was actually her voice or a recording. The inference is that the tape is of such high quality that the excellent reproduction of the sound is able to break glass. This is a demonstration of resonance. It is certainly possibly to break a wine glass with an amplified singing voice. If the frequency of the voice is the same as the natural frequency of the glass, and the sound is loud enough, the glass can be set into a resonant vibration whose amplitude is large enough to surpass the elastic limit of the glass. But the inference that high-quality reproduction is necessary is not justified. All that is important is that the frequency is recorded and played back correctly. The waveform of the sound can be altered as long as the frequency remains the same. Suppose, for example, that the singer sings a perfect sine wave, but the tape records it as a square wave. If the tape player plays the sound back at the right speed, the glass will still receive energy at the resonance frequency and will be set into vibration leading to breakage, even though the tape reproduction was terrible. Thus, this phenomenon does not require high-quality reproduction and, thus, does not demonstrate the quality of the recording tape. What it does demonstrate is the quality of the tape player, in that it played back the tape at an accurate speed!

46. List *two* properties that a singer's voice must have in order to shatter a glass.

ANSWER: Correct frequency, sufficient energy (amplitude or loudness)

47. Explain why the glass would not break if the tape player did not play back at an accurate speed.

ANSWER: The frequency of the sound is changed by variations in the speed of the tape.

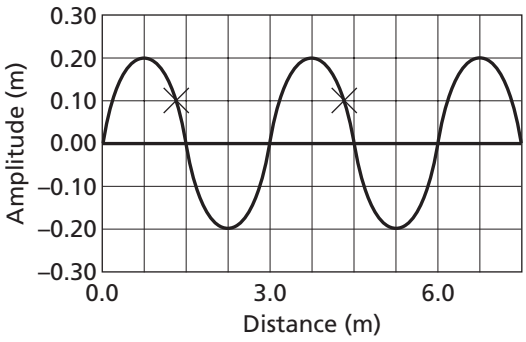
Base your answers to questions 48 and 49 on the information below.

A transverse wave with an amplitude of 0.20 meter and wavelength of 3.0 meters travels

toward the right in a medium with a speed of 4.0 meters per second.

48. On a copy of the diagram *on a blank sheet of paper*, place an **X** at each of *two* points that are in phase with each other.

Sample Correct Answer:



(Students may indicate any two points that are in phase.)

49. Calculate the period of the wave. Show all work, including the equation and substitution with units.

ANSWER:

$$v = f\lambda$$

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

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

$$T = \frac{3.0\text{ m}}{4.0\text{ m/s}}$$

$$T = 0.75\text{ s}$$

or

$$v = f\lambda$$

$$4.0\text{ m/s} = f(3.0\text{ m})$$

$$f = 1.3\text{ Hz}$$

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

$$T = \frac{1}{1.3\text{ Hz}}$$

$$T = 0.77\text{ s}$$

or

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

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

$$t = \frac{3.0\text{ m}}{4.0\text{ m/s}}$$

$$t = 0.75\text{ s}$$

Base your answers to questions 50 through 52 on the information below.

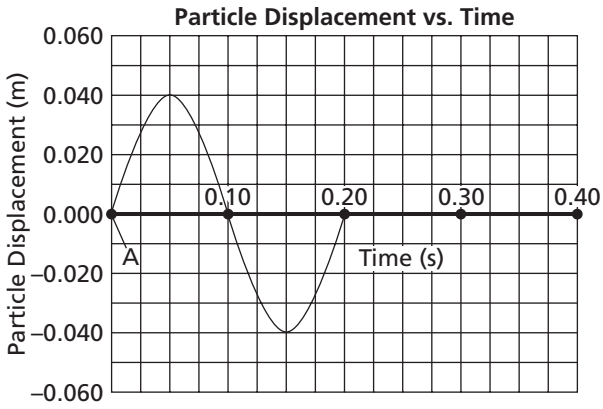
A periodic wave traveling in a uniform medium has a wavelength of 0.080 meter, an amplitude of 0.040 meter, and a frequency of 5.0 hertz.

50. Determine the period of the wave.

ANSWER: 0.20 s

51. On a grid *on a blank sheet of paper*, starting at point *A*, sketch a graph of *at least one* complete cycle of the wave showing its amplitude and period.

ANSWER:



52. Calculate the speed of the wave. Show all work, including the equation and substitution with units.

ANSWER:

$$v = f\lambda$$

$$v = (5.0\text{ Hz})(0.080\text{ m})$$

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

or

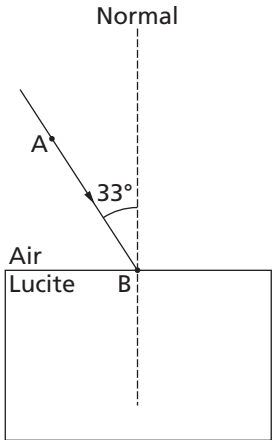
$$v = \frac{d}{t}$$

$$v = \frac{0.080\text{ m}}{0.2\text{ s}}$$

$$v = 0.4\text{ m/s}$$

Base your answers to questions 53 through 55 on the information and diagram below.

A monochromatic beam of yellow light, *AB*, is incident upon a Lucite block in air at an angle of 33°.



53. Calculate the angle of refraction for incident beam *AB*. Show all work, including the equation and substitution with units.

ANSWER:

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

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

$$\sin \theta_2 = \frac{1.00 \sin 33°}{1.50}$$

$$\sin \theta_2 = \frac{1.00\,(0.5446)}{1.50}$$

$$\sin \theta_2 = 0.363$$

$$\theta_2 = 21°$$

or

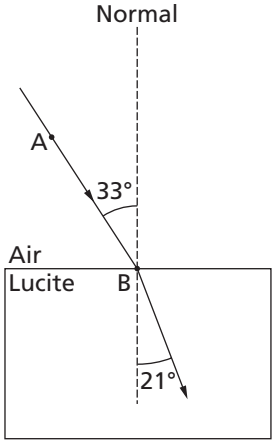
$$n_1 \sin i = n_2 \sin r$$

$$(1.00)(\sin 33°) = (1.50) \sin r$$

$$r = 21°$$

54. Using a straightedge, a protractor, and your answer from question 53, draw an arrow on a diagram on your own paper to represent the path of the refracted beam.

ANSWER:

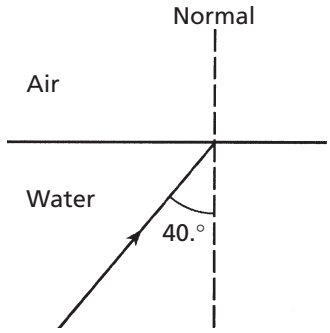


55. Compare the speed of the yellow light in air to the speed of the yellow light in Lucite.

ANSWER: Yellow light travels faster in air than in Lucite.

Base your answers to questions 56 and 57 on the information and diagram below.

A ray of light of frequency 5.09×10^{14} hertz is incident on a water-air interface as shown in the diagram below.



56. Calculate the angle of refraction of the light ray in air. Show all work, including the equation and substitution with units.

ANSWER:

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

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

$$\sin \theta_2 = \frac{(1.33)(\sin 40.°)}{1.00}$$

$$\sin \theta_2 = 0.855$$

$$\theta_2 = 58.7° \text{ or } 59°$$

57. Calculate the speed of the light while in the water. Show all work, including the equation and substitution with units.

ANSWER:

$$\frac{n_2}{n_1} = \frac{v_1}{v_2}$$

$$v_1 = \frac{n_2 v_2}{n_1}$$

$$v_1 = \frac{1.00\,(3.00 \times 10^8 \text{ m/s})}{1.33}$$

$$v_1 = 2.26 \times 10^8 \text{ m/s}$$

or

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

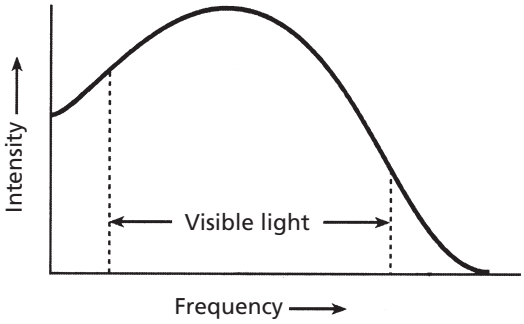
$$v = \frac{c}{n}$$

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

$$v = 2.26 \times 10^8 \text{ m/s}$$

Base your answers to questions 58 and 59 on the information and graph below.

Sunlight is composed of various intensities of all frequencies of visible light. The graph represents the relationship between light intensity and frequency.



58. Based on the graph, which color of visible light has the lowest intensity?

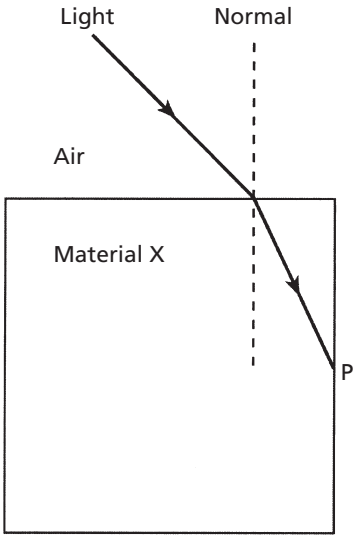
ANSWER: Violet, the one with the greatest frequency

59. It has been suggested that fire trucks be painted yellow-green instead of red. Using information from the graph, explain the advantage of using yellow-green paint.

ANSWER: Yellow-green has a higher intensity and is brighter than red

Base your answers to questions 60 through 62 on the information and diagram below.

A ray of light passes from air into a block of transparent material *X* as shown in the diagram below.



60. Measure the angles of incidence and refraction to the nearest degree for this light ray at the air-material *X* boundary

ANSWER: The angle of incidence is 45° (±2°) and the angle of refraction is 26° (±2°)

61. Calculate the absolute index of refraction of material *X*. Show all work, including the equation and substitution with units.

ANSWER:

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

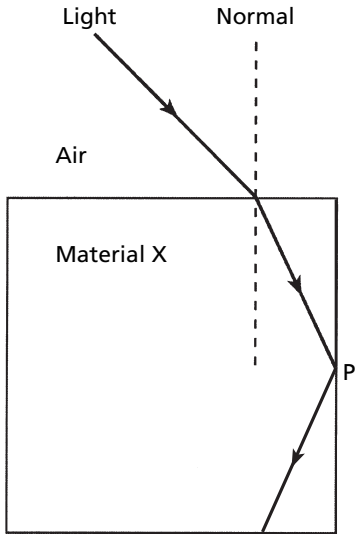
$$n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2}$$

$$n_2 = \frac{(1.00)(\sin 45°)}{\sin 26°}$$

$$n_2 = 1.61$$

62. The refracted light ray is reflected from the material *X*–air boundary at point *P*. Using a protractor and straightedge, draw the reflected ray from point *P* on your own paper.

ANSWER:



(The angle of reflection is 64 degrees.)

ENRICHMENT—Wave Phenomena

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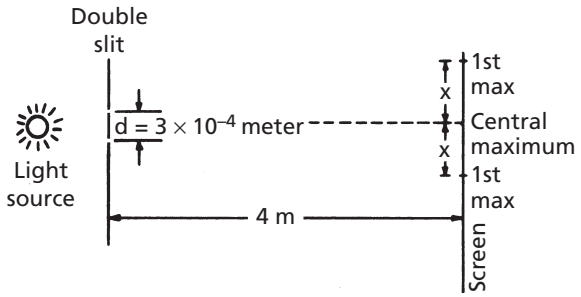
Base your answer to question E1 on the following diagram which shows light from a monochromatic source incident on a screen after passing through a double slit.

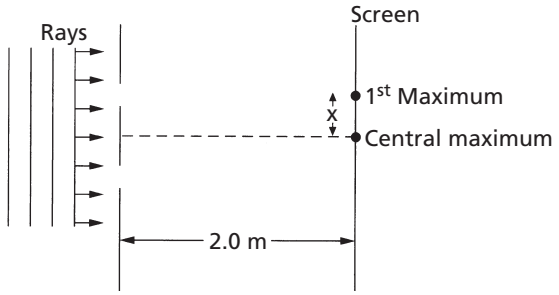


E1. What is the wavelength of the light source if the distance between the central light band and the next light band is 0.01 meter?

ANSWER: (4) 7.5×10^{-7} m

Base your answers to questions E2 through E6 on the following diagram.

The diagram represents two parallel slits 2.0×10^{-4} meter apart which are illuminated by parallel rays of monochromatic light of wavelength 6.0×10^{-7} meter. The interference pattern is formed on a screen 2.0 meters from the slits.



E2. Distance x is

ANSWER: (1) 6.0×10^{-3} m

E3. The difference in path length for the light from each of the two slits to the first maximum is

ANSWER: (1) λ

E4. If the wavelength of the light passing through the slits is doubled, the distance from the central maximum to the first maximum will

ANSWER: (2) increase

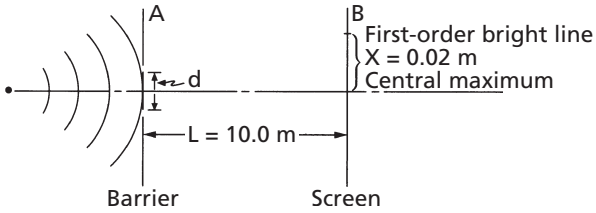
E5. If the screen is moved closer to the slits, the distance between the central maximum and the first maximum will

ANSWER: (1) decrease

E6. If the distance between the slits is decreased, the distance between the central maximum and the first maximum will

ANSWER: (2) increase

Base your answer to question E7 on the following diagram which represents monochromatic light incident upon a double slit in barrier A, *producing an interference pattern on screen* B.



E7. If $x = 0.02$ meter, $L = 10.0$ meters, and the wavelength of the incident light is 5.0×10^{-7} meter, the distance d between the slits is

ANSWER: (1) 2.5×10^{-4} m

E8. Light ($\lambda = 5.9 \times 10^{-7}$ meter) travels through a solution. If the absolute index of refraction of the solution is increased, the critical angle will

ANSWER: (1) decrease

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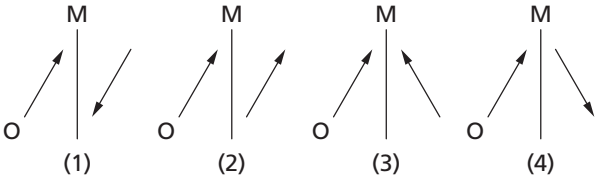
E9. As an object is moved closer to a plane mirror, the distance between the image and the mirror will

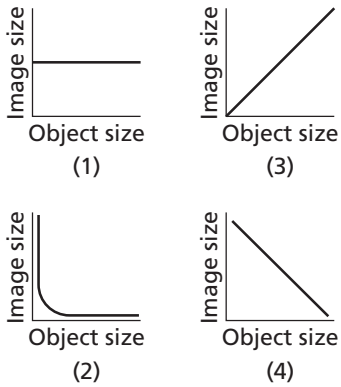
ANSWER: (1) decrease

E10. Which diagram best represents the reflection of an object O by plane mirror M?



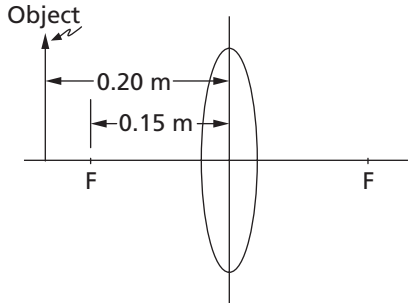
ANSWER: (3)

E11. Which graph best represents the relationship between the image size and the object size for an object reflected in a plane mirror?



ANSWER: (3)

Base your answers to questions E12 through E16 on the following diagram which represents an object placed 0.20 meter from a converging lens with a focal length of 0.15 meter.



E12. Which phenomenon best describes the image formation by the lens?

ANSWER: (4) refraction

E13. The image produced by the lens is

ANSWER: (1) enlarged and real

E14. If the object distance were increased, the image would become

ANSWER: (3) smaller, only

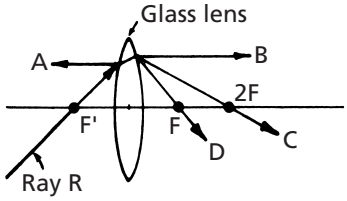
E15. If the object were placed 0.10 meter from the lens, the image would be

ANSWER: (4) virtual and erect

E16. Which monochromatic light, when used to illuminate the object, would produce the *smallest* image distance?

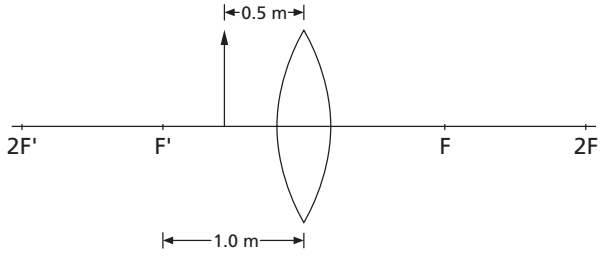
ANSWER: (4) blue

E17. In which direction does most of the light in ray *R* pass?



ANSWER: (2) *B*

Base your answers to questions E18 through E21 on the following diagram which represents an object that is 0.2 meter high. The object is located 0.5 meter from a converging lens with a focal length of 1.0 meter.



E18. The image would be described as

ANSWER: (4) virtual and erect

E19. The smallest image of the object would be produced by the lens when the object is located at

ANSWER: (4) 4*F*

E20. If the object were moved toward the lens from the position shown in the diagram, the distance from the lens to the image would

ANSWER: (1) decrease

E21. If the object were moved toward the lens from the position shown in the diagram, the size of the image would

ANSWER: (1) decrease

Base your answers to questions E22 through E26 on the following information and diagram. The diagram represents a converging lens made of Lucite, which is used to focus the parallel monochromatic yellow light rays shown. F *and* F' *are the principal foci.*

E22. The rays will pass through point

ANSWER: (3) *F*

E23. If an object is placed between *F'* and the lens, the image formed would be

ANSWER: (4) virtual and larger

E24. If an object that is placed 0.04 meter to the left of the lens will produce a real image at a distance of 0.08 meter to the right of the lens, the focal length of the lens is approximately

ANSWER: (2) 0.027 m

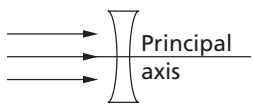
E25. As the light emerges from the lens, its speed will

ANSWER: (2) increase

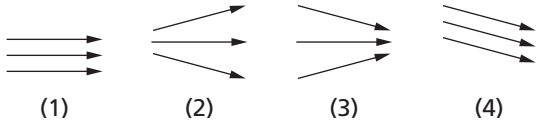
E26. The Lucite lens is replaced by a flint glass lens of identical shape. Compared with the focal length of the Lucite lens, the focal length of the flint glass lens will be

ANSWER: (1) smaller

E27. The diagram below represents light rays approaching a diverging lens parallel to the principal axis.

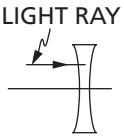


Which of the following diagrams best represents the light rays after they have passed through the diverging lens?

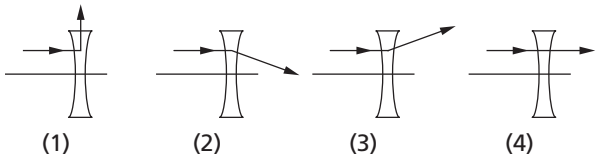


ANSWER: (2)

E28. A light ray is incident upon a diverging lens as shown in the diagram below.

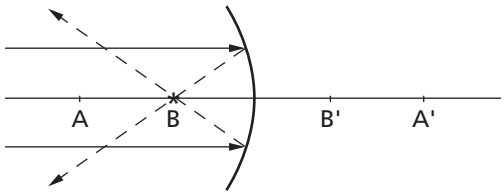


Which of the following diagrams best represents the path of the ray after it enters the lens?



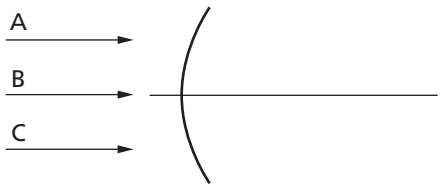
ANSWER: (3)

E29. In the following diagram of a concave mirror, which point represents the center of curvature?



ANSWER: (1) *A*

E30. The following diagram represents a spherical mirror with three parallel light rays approaching. Which light ray will be reflected normal to the surface of the mirror?



ANSWER: (2) *B*, only

E31. Which of the following are diverging instruments?

ANSWER: (2) concave lenses and convex mirrors

E32. The image created by a concave lens

ANSWER: (2) is always on the same side of the lens as the object

Base your answers to questions E33 through E36 on the following information.

A 10-centimeter tall arrow is situated 12 cm from a concave lens whose focal length is 6 cm.

E33. The image distance is closest to

ANSWER: (3) 4 cm

E34. The image length is closest to

ANSWER: (4) 3.33 cm

E35. The image is

ANSWER: (2) virtual and upright

E36. If the object is moved closer to the lens, the image

ANSWER: (3) moves closer to the lens

Base your answers to questions E37 through E42 on the following information.

A 10-centimeter tall arrow is situated in front of a concave mirror at the center of curvature of the mirror.

E37. The image distance will be

ANSWER: (2) equal to the object distance

E38. The height of the image will be closest to

ANSWER: (1) 10 cm

E39. The image will be

ANSWER: (4) real and inverted

E40. If the arrow is moved farther away from the mirror, the image

ANSWER: (3) moves closer to the mirror

E41. A source of light is placed at the focal point in front of a concave mirror. The reflected rays

ANSWER: (1) are parallel to one another

E42. An object is placed closer to a concave mirror than is the focal point. The image

ANSWER: (2) appears on the opposite side of the mirror as the object

CHAPTER 5 Modern Physics

PART A: Page 174

1. A photon of light carries

ANSWER: (3) both energy and momentum

2. Which characteristic of electromagnetic radiation is directly proportional to the energy of a photon?

ANSWER: (3) frequency

3. Light of wavelength 5.0×10^{-7} meter consists of photons having an energy of

ANSWER: (3) 4.0×10^{-19} J

4. Wave-particle duality is most apparent in analyzing the motion of

ANSWER: (4) an electron

5. The energy of a photon is inversely proportional to its

ANSWER: (1) wavelength

6. Which phenomenon best supports the theory that matter has a wave nature?

ANSWER: (2) electron diffraction

7. Which two characteristics of light can best be explained by the wave theory of light?

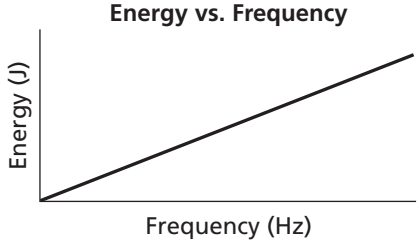
ANSWER: (4) interference and diffraction

PART B-1: Page 175

8. A photon of which electromagnetic radiation has the most energy?

ANSWER: (2) x-ray

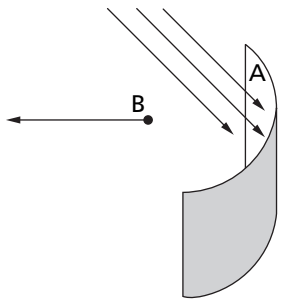
9. The graph below represents the relationship between the energy and the frequency of photons.



The slope of the graph would be

ANSWER: (1) 6.63×10^{-34} J • s

Base your answers to questions 10 and 11 on the following diagram, which represents monochromatic light hitting a photoemissive surface A. *Each photon has* 8.0×10^{-19} *J of energy.* B *represents the particle emitted when a photon strikes surface* A.



10. What is particle B?

ANSWER: (2) an electron

11. What is the frequency of the incident light?

ANSWER: (1) 1.2×10^{15} Hz

PART A: Page 179

12. White light is passed through a cloud of cool hydrogen gas and then examined with a spectroscope. The dark lines observed on a bright background are caused by

ANSWER: (2) the hydrogen absorbing certain frequencies of the white light

13. After electrons in hydrogen atoms are excited to the $n = 3$ energy state, how many different frequencies of radiation can be emitted as the electrons return to the ground state?

ANSWER: (3) 3

14. Which phenomenon provides evidence that the hydrogen atom has discrete energy levels?

ANSWER: (1) emission spectra

15. Compared with the amount of energy required to excite an atom, the amount of energy released by the atom when it returns to the ground state is

ANSWER: (3) the same

16. If an orbiting electron falls to a lower orbit, the total energy of that atom will

ANSWER: (1) decrease

PART B-1: Pages 179–180

17. An electron in a mercury atom drops from energy level i to the ground state by emitting a single photon. This photon has an energy of

ANSWER: (2) 8.82 eV

18. The bright-line emission spectrum of an element can best be explained by

ANSWER: (1) electrons transitioning between discrete energy levels in the atoms of that element

19. How much energy is required to move an electron in a mercury atom from the ground state to energy level h?

ANSWER: (2) 8.81 eV

20. What is the minimum energy needed to ionize a hydrogen atom in the $n = 2$ energy state?

ANSWER: (3) 3.40 eV

21. An atom changing from an energy state of -0.54 eV to an energy state of -0.85 eV will emit a photon whose energy is

ANSWER: (1) 0.31 eV

22. The lowest energy state of an atom is called its

ANSWER: (1) ground state

23. A hydrogen atom emits a photon with an energy of 1.63×10^{-18} J as it changes to the ground state. The radiation emitted by the atom would be classified as

ANSWER: (2) ultraviolet

24. How much energy is needed to raise a hydrogen atom from the $n = 2$ energy level to the $n = 4$ energy level?

ANSWER: (2) 2.55 eV

25. A hydrogen atom is excited to the $n = 3$ state. In returning to the ground state, the atom could *not* emit a photon with an energy of

ANSWER: (4) 12.75 eV

26. If a hydrogen atom absorbs 1.9 eV of energy, it could be excited from energy level

ANSWER: (3) $n = 2$ to $n = 3$

PART A: Pages 182–183

27. The force that holds protons and neutrons together is known as the

ANSWER: (2) strong force

28. A meson may *not* have a charge of

ANSWER: (2) $+2e$

29. The tau neutrino, the muon neutrino, and the electron neutrino are all

ANSWER: (1) leptons

30. The energy equivalent of the rest mass of an electron is approximately

ANSWER: (2) 8.2×10^{-14} J

31. The strong force is the force of

ANSWER: (4) attraction between nucleons

32. If a deuterium nucleus has a mass of 1.53×10^{-3} universal mass units less than its components, this mass represents an energy of

ANSWER: (2) 1.42 MeV

33. What type of nuclear force holds the protons and neutrons in an atom together?

ANSWER: (1) a strong force that acts over a short range

34. What type of particle has a charge of 1.6×10^{-19} C and a rest mass of 1.67×10^{-27} kg?

ANSWER: (1) proton

35. Which describes the nuclear forces that hold nucleons together?

ANSWER: (4) strong and short-range

36. What type of force holds the nucleons of an atom together?

ANSWER: (4) strong nuclear force

37. When compared with the total mass of its nucleons, the mass of the nucleus is

ANSWER: (1) less

38. How much energy would be produced if 1.0×10^{-3} kilogram of matter was entirely converted to energy?

ANSWER: (1) 9.0×10^{13} J

39. The positron can best be described as a

ANSWER: (1) positively charged electron

40. The mass of the neutrino is

ANSWER: (2) less than that of an electron

41. Particles with mass between that of an electron and a proton are called

ANSWER: (3) mesons

42. Particles with mass greater than that of a neutron are called

ANSWER: (4) hyperons

43. Which of the following are classified as baryons?

ANSWER: (4) protons, neutrons, and hyperons

PART B-1: Page 183

44. According to the Standard Model, a proton is constructed of two up quarks and one down quark (*uud*) and a neutron is constructed of one up quark and two down quarks (*udd*). During beta decay, a neutron decays into a proton, an electron, and an electron antineutrino. During this process there is a conversion of a

ANSWER: (3) baryon to another baryon

45. Which combination of quarks could produce a neutral baryon?

ANSWER: (3) *cdb*

PHYSICS IN YOUR LIFE— Production of Laser Light

Pages 183–184

1. How does laser light differ from ordinary light? How is it the same?

Laser light is monochromatic and coherent. Like ordinary light, laser light consists of photons.

2. Compare spontaneous emission to stimulated emission.

In spontaneous emission, an excited atom drops to a lower allowed energy level, thereby emitting a photon. In stimulated emission, a photon stimulates an excited atom to emit its photon sooner, so long as the photons are of equal energy.

3. Why do lasers contain mirrors on each end? How are the mirrors different from one another?

The mirrors contain the photons in order that they continue to stimulate more excited atoms. The mirror at one end is completely reflective, while at the other end the mirror is partially transparent to allow some light to escape. This escaped light forms the laser beam.

4. Suggest reasons why laser light is useful for a variety of applications where precision is essential.

Since laser light consists of a very narrow beam, it is useful where precision is important.

5. Some common lasers use a ruby rod consisting of Al_2O_3 with a small percentage of Al atoms replaced by chromium atoms. Other lasers use a mixture of helium and neon gases. How might the lasing material affect the properties of the resulting laser beam?

The lasing material affects the properties of the laser beam because the excited atoms of different elements emit photons with different energy and frequency.

Chapter Review Questions

PART A: Page 184

1. Which phenomenon best supports the theory that matter has a wave nature?

ANSWER: (2) electron diffraction

2. Compared to a photon of red light, a photon of blue light has a

ANSWER: (1) greater energy

3. Compared with the total energy of the hydrogen atom in the ground state, the total energy of the atom in an excited state is

ANSWER: (2) greater

4. Which statement is true of the strong nuclear force?

ANSWER: (2) It holds protons and neutrons together.

5. Protons and neutrons are examples of

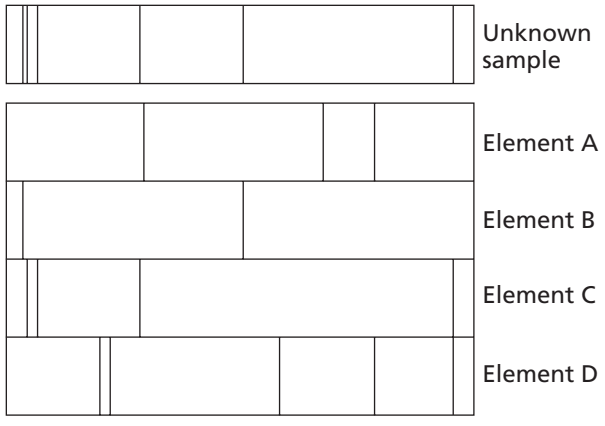
ANSWER: (2) baryons

PART B-1: Page 184

6. A photon of which electromagnetic radiation has the most energy?

ANSWER: (2) x-ray

7. The diagram below represents the bright-line spectra of four elements, *A*, *B*, *C*, and *D*, and the spectrum of an unknown gaseous sample.



Based on comparisons of these spectra, which two elements are found in the unknown sample?

ANSWER: (3) B and C

8. 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

ANSWER: (3) absorbed a 2.55-eV photon

9. According to the Standard Model of Particle Physics, a meson is composed of

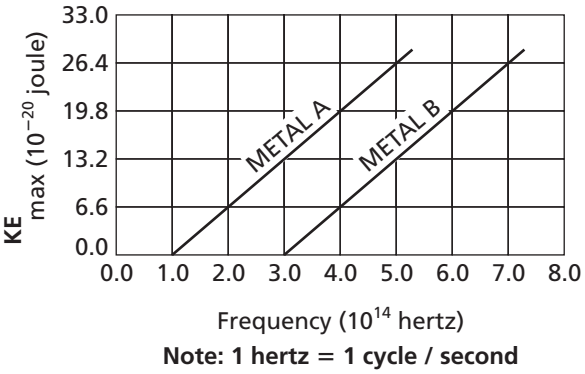
ANSWER: (2) a quark and an antiquark

PART B-2: Pages 184–185

10. What prevents the nucleus of a helium atom from flying apart?

ANSWER: The strong nuclear force prevents the nucleus of a helium atom from flying apart.

Base your answers to questions 11 and 12 on the following graph, which shows the maximum kinetic energy of photoelectrons as a function of the frequency of the incident electromagnetic waves for two photoemissive metals, A *and* B.



Note: 1 hertz = 1 cycle / second

11. Calculate the slope of the line for metal *B*.

ANSWER:

$$slope = \frac{\Delta y}{\Delta x}$$

$$slope = \frac{26.4 \times 10^{-20}\ \text{J} - 0.00\ \text{J}}{7.0 \times 10^{14}\ \text{s}^{-1} - 3.0 \times 10^{14}\ \text{s}^{-1}}$$

$$slope = \frac{26.4 \times 10^{-20}\ \text{J}}{4.0 \times 10^{14}\ \text{s}^{-1}}$$

$$slope = 6.6 \times 10^{-34}\ \text{J}$$

12. What is the meaning of the slope?

ANSWER: It is Planck's constant.

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

During the process of beta (β) emission, a neutron in the nucleus of an atom is converted into a proton, an electron, an electron antineutrino, and energy.

Neutron → proton + electron + electron antineutrino + energy

13. Based on conservation laws, how does the mass of the neutron compare to the mass of the proton?

ANSWER: The neutron is more massive.

14. Since charge must be conserved in the reaction shown, what charge must an electron antineutrino carry?

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

15. A photon has a wavelength of 9.00×10^{-10} meter. Calculate the energy of this photon in joules. Show all work, including the equation and substitution with units.

ANSWER:

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

$$E = \frac{(6.63 \times 10^{-34}\ \text{J} \cdot \text{s})(3.00 \times 10^{8}\ \text{m/s})}{9.00 \times 10^{-10}\ \text{m}}$$

$$E = 2.21 \times 10^{-16}\ \text{J}$$

16. After a uranium nucleus emits an alpha particle, the total mass of the new nucleus and the alpha particle is less than the mass of the original uranium nucleus. Explain what happens to the missing mass.

ANSWER: The mass is converted into energy.

Base your answers to questions 17 and 18 on the information below.

When an electron and its antiparticle (positron) combine, they annihilate each other and become energy in the form of gamma rays.

17. The positron has the same mass as the electron. Calculate how many joules of energy are released when they annihilate. Show all work, including the equation and substitution with units.

ANSWER:

$$E = mc^2$$

$$E = 2(9.11 \times 10^{-31}\ \text{kg})(3.00 \times 10^{8}\ \text{m/s})^2$$

$$E = 1.64 \times 10^{-13}\ \text{J}$$

18. What conservation law prevents this from happening with two electrons?

ANSWER: The law of conservation of charge.

19. What are the sign and charge, in coulombs, of an antiproton?

ANSWER: -1.6×10^{-19} C.

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

A lambda particle consists of an up, a down, and a strange quark.

20. A lambda particle can be classified as a

ANSWER: (1) baryon

21. What is the charge of a lambda particle in elementary charges?

ANSWER: Zero

22. How much energy, in megaelectronvolts, is produced when 0.250 universal mass unit of matter is completely converted into energy?

ANSWER: 233 MeV.

23. Explain why a hydrogen atom in the ground state can absorb a 10.2-electronvolt photon, but can *not* absorb an 11.0-electronvolt photon.

ANSWER: The photon's energy must match exactly an energy level transition for the photon to be absorbed.

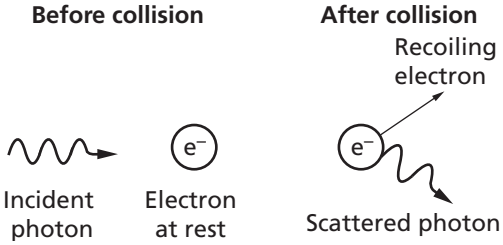
24. Exposure to ultraviolet radiation can damage skin. Exposure to visible light does not damage skin. State *one* possible reason for this difference.

Acceptable answers include but are not limited to:

Visible light has less energy.
Visible light has lower frequency.
Visible light has longer wavelength.
Ultraviolet has higher energy.
Ultraviolet has higher frequency.
Ultraviolet has shorter wavelength.
Ultraviolet radiation resonates with the cell membrane.

Base your answers to questions 25 and 26 on the information and diagram below.

The diagram shows the collision of an incident photon having a frequency of 2.00×10^{19} hertz with an electron initially at rest.



25. Calculate the initial energy of the photon. Show all calculations, including the equation and substitution with units.

ANSWER:

$E_{photon} = hf$

$E_{photon} = (6.63 \times 10^{-34}\ \text{J} \cdot \text{s})(2.00 \times 10^{19}\ \text{Hz})$

$E_{photon} = 1.33 \times 10^{-14}\ \text{J}$

26. What is the total energy of the two-particle system after the collision?

ANSWER: The energy of the system after the collision is 1.3×10^{-14} J, the same as the energy of the system before the collision.

PART C

Base your answers to questions 27 through 30 on the information below.

An electron in a hydrogen atom drops from the $n = 3$ energy level to the $n = 2$ energy level.

27. What is the energy, in electronvolts, of the emitted photon?

ANSWER: The energy is 1.89 eV.

28. What is the energy, in joules, of the emitted photon?

ANSWER: The energy is 3.02×10^{-19} J.

29. Calculate the frequency of the emitted radiation. Show all work, including the equation and substitution with units.

ANSWER:

$$E = hf$$

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

$$f = \frac{3.02 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}}$$

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

30. Calculate the wavelength of the emitted radiation. Show all work, including the equation and substitution with units.

ANSWER:

$$v = f\lambda$$

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

$$\lambda = \frac{3.00 \times 10^{8}\ \text{m/s}}{4.56 \times 10^{14}\ \text{Hz}}$$

$$\lambda = 6.58 \times 10^{-7}\ \text{m}$$

or

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

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

$$\lambda = \frac{(6.63 \times 10^{-34}\ \text{J} \cdot \text{s})(3.00 \times 10^{8}\ \text{m/s})}{3.02 \times 10^{-19}\ \text{J}}$$

$$\lambda = 6.59 \times 10^{-7}\ \text{m}$$

Base your answers to questions 31 through 33 on the information below.

The light of the "alpha line" in the Balmer series of the hydrogen spectrum has a wavelength of 6.58×10^{-7} meter.

31. Calculate the energy of an "alpha line" photon in joules. Show all work, including the equation and substitution with units.

ANSWER:

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

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

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

32. What is the energy of an "alpha line" photon in electronvolts?

ANSWER: 1.89 eV.

33. Using your answer to question 32, explain whether or not this result verifies that the "alpha line" corresponds to a transition from energy level $n = 3$ to energy level $n = 2$ in a hydrogen atom.

ANSWER: The $n = 3$ to $n = 2$ transition is also 1.89 eV.

Base your answers to questions 34 through 37 on the Energy Level Diagram for Hydrogen given in the Reference Tables.

34. Determine the energy, in electronvolts, of a photon emitted by an electron as it moves from the $n = 6$ to the $n = 2$ energy level in a hydrogen atom.

ANSWER: 3.02 eV

35. Convert the energy of the photon to joules.

ANSWER: 4.83×10^{-19} J

36. Calculate the frequency of the emitted photon. Show all work, including the equation and substitution with units.

ANSWER:

$$E = hf$$

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

$$f = \frac{4.83 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J} \cdot \text{s}}$$

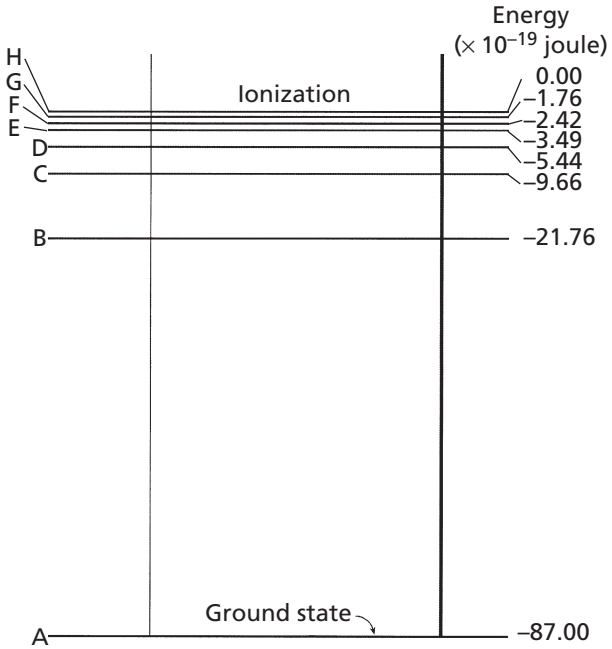
$$f = 7.29 \times 10^{14}\ \text{Hz}$$

37. Is this the only energy and/or frequency that an electron in the $n = 6$ energy level of a hydrogen atom could emit? Explain your answer.

Acceptable responses include:

No, the $n = 6$ level can return to any of the five lower energy levels.
No, the electron can drop to many different energy levels.
The electron can fall from $n = 6$ to any other level between $n = 5$ and $n = 1$.

Base your answers to questions 38 and 39 on the diagram below, which shows some energy levels for an atom of an unknown substance.



38. Determine the minimum energy necessary for an electron to change from the *B* energy level to the *F* energy level.

ANSWER: 19.34×10^{-19} J or 1.934×10^{-18} J

39. Calculate the frequency of the photon emitted when an electron in this atom changes from the *F* energy level to the *B* energy level. Show all work, including the equation and substitution with units.

ANSWER:

$$E = hf$$

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

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

$$f = 2.92 \times 10^{15}\ \text{Hz} \quad \text{or} \quad 2.92 \times 10^{15}\,\frac{1}{\text{s}}$$

Base your answers to questions 40 and 41 on the information below.

Louis de Broglie extended the idea of wave-particle duality to all of nature with his matter-wave equation, $\lambda = h/mv$, where λ is the particle's wavelength, m is its mass, v is its velocity, and h is Planck's constant.

40. Using this equation, calculate the de Broglie wavelength of a helium nucleus (mass = 6.7×10^{-27} kg) moving with a speed of 2.0×10^6 meters per second. Show all work, including the equation and substitution with units.

ANSWER:

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

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

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

41. The wavelength of this particle is of the same order of magnitude as which type of electromagnetic radiation?

ANSWER: The wavelength of this particle is of the same order of magnitude as gamma rays.

ENRICHMENT—Modern Physics

Pages 189–190

E1. A monochromatic light incident upon a photoemissive surface emits electrons. If the intensity of the incident light is increased, the rate of electron emission will

ANSWER: (2) increase

E2. When incident on a given photoemissive surface, which color of light will produce photoelectrons with the greatest energy?

ANSWER: (3) violet

E3. The threshold frequency of a metal surface is in the violet light region. What type of radiation will cause photoelectrons to be emitted from the metal's surface?

ANSWER: (3) ultraviolet light

E4. The work function of a photoelectric material can be found by determining the minimum frequency of light that will cause electron emission and then

ANSWER: (4) multiplying it by Planck's constant

E5. The work function of a metal is 4.2 eV. If photons with an energy of 5.0 eV strike the metal, the maximum kinetic energy of the emitted photoelectrons will be

ANSWER: (2) 0.80 eV

E6. The threshold frequency for a photoemissive surface is 6.4×10^{14} Hz. Which color light, if incident upon the surface, may produce photoelectrons?

ANSWER: (1) blue

E7. Compared with the energy of the photons of blue light, the energy of the photons of red light is

ANSWER: (1) less

E8. The energy of a photon varies

ANSWER: (2) directly as the frequency

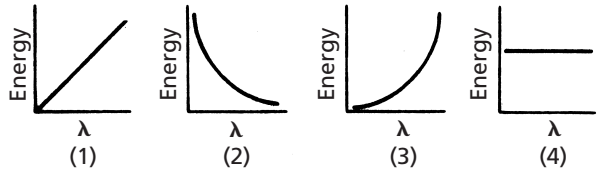
E9. All of the following particles are traveling at the same speed. Which has the greatest wavelength?

ANSWER: (4) electron

E10. If the wave properties of a particle are difficult to observe, it is probably due to the particle's

ANSWER: (2) large mass

E11. Which graph best represents the relationship between the energy of a photon and its wavelength?



ANSWER: (2)

E12. As the wavelength of a ray of light increases, the momentum of the photons

ANSWER: (1) decreases

E13. Compared with the photon momentum of blue light, the photon momentum of red light is

ANSWER: (1) less

E14. Which is conserved when a photon collides with an electron?

ANSWER: (4) momentum and energy

Base your answers to questions E15 through E19 on the following information.

Photons with an energy of 3.0 eV strike a metal surface and eject electrons with a maximum kinetic energy of 2.0 eV.

E15. The work function of the metal is

ANSWER: (1) 1.0 eV

E16. If the photons had a higher frequency, what would remain constant?

ANSWER: (2) the speed of the photons

E17. If the photon intensity were decreased, there would be

ANSWER: (4) a decrease in the rate of electron emission

E18. Compared with the frequency of the 3.0-eV photons, the threshold frequency for the metal is

ANSWER: (1) lower

E19. If a metal with a greater work function were used and the photon energy remained constant, the maximum energy of the ejected electrons would

ANSWER: (1) decrease

Base your answers to questions E20 through E24 on the following information.

Photons of wavelength 2×10^{-7} meter are incident upon a photoemissive surface whose work function is 6.6×10^{-19} joule.

E20. The speed of the incident photons is approximately

ANSWER: (4) 3.0×10^{8} m/s

E21. The maximum kinetic energy of the photoelectrons is approximately

ANSWER: (2) 3.3×10^{-19} J

E22. If the frequency of the incident photons is increased, the kinetic energy of the emitted photoelectrons will

ANSWER: (2) increase

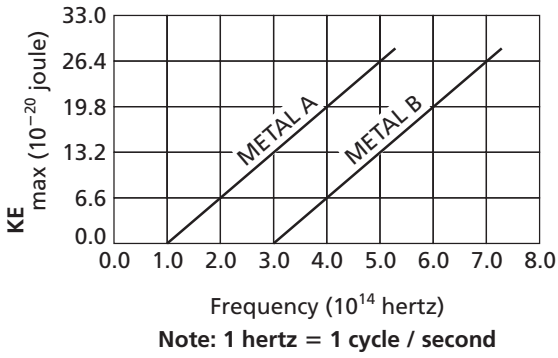
E23. If the intensity of the incident photons is decreased, the rate of emission of photoelectrons will

ANSWER: (1) decrease

E24. Photons of the same wavelength are incident upon a photoemissive surface with a lower work function. Compared with the original situation, the maximum kinetic energy of the photoelectrons emitted from the new surface would be

ANSWER: (2) greater

Base your answers to questions E25 through E29 on the following graph which represents the maximum kinetic energy of photoelectrons as a function of incident electromagnetic frequencies for two different photoemissive metals, A and B.



Note: 1 hertz = 1 cycle / second

E25. The slope of each line is equal to

ANSWER: (4) Planck's constant

E26. The threshold frequency for metal *A* is

ANSWER: (1) 1.0×10^{14} Hz

E27. The work function for metal *B* is closest to

ANSWER: (2) 2.0×10^{-19} J

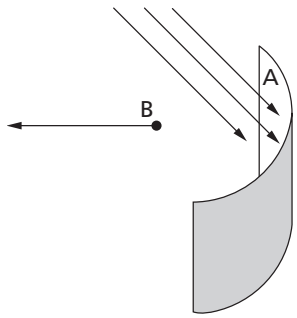
E28. Compared with the work function for metal *B*, the work function for metal *A* is

ANSWER: (1) less

E29. Monochromatic light with a period of 2.0×10^{-15} second is incident on both of the metals. Compared with the energy of the photoelectrons emitted by metal *A*, the energy of the photoelectrons emitted by metal *B* is

ANSWER: (1) less

Base your answers to questions E30 through E32 on the following diagram which represents monochromatic light incident upon photoemissive surface A. *Each photon has 8.0 $\times$ 10^{-19} joule of energy.* B *represents the particle emitted when a photon strikes surface* A.



E30. What is particle *B*?

ANSWER: (2) an electron

E31. If the work function of metal *A* is 3.2×10^{-19} J, the energy of particle *B* is

ANSWER: (2) 4.8×10^{-19} J

E32. The frequency of the incident light is approximately

ANSWER: (1) 1.2×10^{15} Hz

Pages 195–198

E33. The nucleus of isotope *A* of an element has a larger mass than the nucleus of isotope *B* of the same element. Compared with the number of protons in the nucleus of isotope *A*, the number of protons in the nucleus of isotope *B* is

ANSWER: (3) the same

E34. Which is an isotope of $^{44}_{21}$Sc

ANSWER: (3) $^{46}_{21}$Sc

E35. An atom consists of 9 protons, 9 electrons, and 10 neutrons. The number of nucleons in this atom is

ANSWER: (3) 19

E36. The total number of neutrons in the nucleus of any atom is equal to the

ANSWER: (4) mass number minus the atomic number

E37. A pair of isotopes is

ANSWER: (1) $^{238}_{92}$U and $^{239}_{92}$U

E38. Which device makes visual observation of the path of a charged particle possible?

ANSWER: (4) cloud chamber

E39. Which device could be used to give a positively charged particle sufficient kinetic energy to penetrate the nucleus of an atom?

ANSWER: (4) Van de Graaff generator

E40. Which of the following is used to accelerate a charged particle?

ANSWER: (3) a cyclotron

E41. Of the following particles the one that can not be accelerated in an atom-smashing machine is the

ANSWER: (2) neutron

E42. Which group of particles can *all* be accelerated by a cyclotron?

ANSWER: (3) protons, alpha particles, and electrons

Base your answers to questions E43 and E44 on the following nuclear equation.

$$^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$$

E43. What is represented by $^{4}_{2}$He?

ANSWER: (1) an alpha particle

E44. This equation represents the process of

ANSWER: (1) alpha decay

E45. In which reaction does *X* represent a beta particle?

ANSWER: (4) $^{214}_{82}\text{Ra} \rightarrow {}^{214}_{83}\text{Bi} + X$

E46. In the decay series of U-238, the change from Th-234 to U-234 involves the emission of

ANSWER: (4) beta particles

E47. How many beta particles are given off when one atom of U-238 completely disintegrates to Pb-206?

ANSWER: (1) 6

Base your answers to questions E48 through E50 on the following information.

$^{131}_{53}$I initially decays by emission of beta particles.

E48. Beta particles are

ANSWER: (2) electrons

E49. When $^{131}_{53}$I decays by beta emission, it becomes

ANSWER: (3) $^{131}_{54}$Xe

E50. The half-life of $^{131}_{53}$I is 8 days. After 24 days, how much of a 100.-gram sample of $^{131}_{53}$I would remain?

ANSWER: (2) 12.5 g

Base your answers to questions E51 through E55 on Figure 5-E2.

E51. Which change is the result of the loss of two negative beta particles?

ANSWER: (2) Th to U

E52. Which of the following pairs of isotopes is found in the Uranium Disintegration Series?

ANSWER: (3) $^{214}_{83}$Bi and $^{210}_{83}$Bi

E53. Which particle is emitted as $^{234}_{90}$Th changes to $^{234}_{91}$Pa?

ANSWER: (4) a negative beta particle

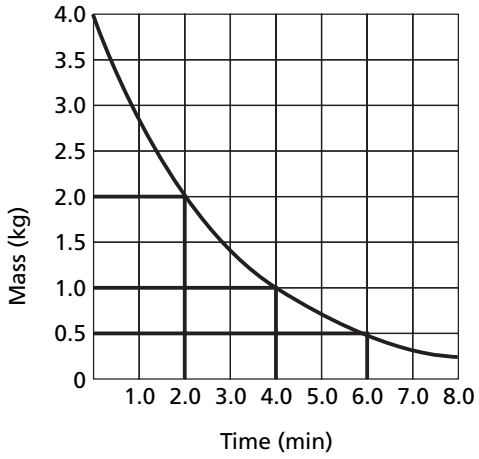
E54. When a nucleus emits an alpha particle, the mass number of the nucleus

ANSWER: (1) decreases

E55. As a sample of uranium disintegrates, the half-life of the remaining uranium

ANSWER: (3) remains the same

Base your answers to questions E56 through E60 on the following graph which represents the disintegration of a sample of a radioactive element. At time $t = 0$ the sample has a mass of 4.0 kilograms.



E56. What mass of the material remains at 4.0 minutes?

ANSWER: (1) 1 kg

E57. What is the half-life of the isotope?

ANSWER: (2) 2.0 min

E58. How many half-lives of the isotope occurred during 8.0 minutes?

ANSWER: (4) 4

E59. How long did it take for the mass of the sample to reach 0.25 kilogram?

ANSWER: (4) 8 min

E60. If the mass of this material had been 8.0 kilograms at time $t = 0$, its half-life would have been

ANSWER: (3) the same

Base your answers to questions E61 through E65 on the following information.

In the equation ${}^{221}_{87}\mathrm{Fr} \rightarrow X + \gamma + Q$ the letter X represents the nucleus produced by the reaction, γ represents a gamma photon, and Q represents additional energy released in the reaction.

E61. Which nucleus is represented by X?

ANSWER: (4) ${}^{221}_{87}X$

E62. The rest mass of the gamma ray photon is approximately

ANSWER: (4) zero

E63. If the energy Q equals 9.9×10^{-13} joule, the mass equivalent of this energy is

ANSWER: (3) 1.1×10^{-29} kg

E64. The sample of ${}^{221}_{87}\mathrm{Fr}$ (half-life = 4.8 minutes) will decay to one-fourth of its original amount in

ANSWER: (2) 9.6 min

E65. The gamma photon makes a collision with an electron at rest. During the interaction, the momentum of the photon will

ANSWER: (1) decrease

E66. A certain radioactive isotope has a half-life of 2 days. If 8 kilograms of the isotope is placed in a sealed container, how much of the isotope will be left after 6 days?

ANSWER: (1) 1 kg

Base your answers to questions E67 through E71 on the following information and nuclear equations.

When nitrogen is bombarded with protons, the first reaction that occurs is ${}^{14}_{7}\mathrm{N} + {}^{1}_{1}\mathrm{H} \rightarrow {}^{15}_{8}\mathrm{O} + X$. The oxygen produced is radioactive with a half-life of 0.10 second, and decays in the following manner: ${}^{15}_{8}\mathrm{O} \rightarrow {}^{15}_{7}\mathrm{N} + Y$.

E67. The first reaction is an example of

ANSWER: (3) induced transmutation

E68. In the first reaction, X represents

ANSWER: (4) a gamma photon

E69. In the second reaction, Y represents

ANSWER: (3) a positron

E70. If a 4.0-kilogram sample of ${}^{15}_{8}\mathrm{O}$ decays for 0.40 second, the mass of ${}^{15}_{8}\mathrm{O}$ remaining will be **ANSWER:** (4) 0.25 kg

E71. As the amount of ${}^{15}_{8}\mathrm{O}$ decreases, the half-life

ANSWER: (3) remains the same

Base your answers to questions E72 through E75 on the following nuclear equations.

$${}^{27}_{13}\mathrm{Al} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{30}_{15}\mathrm{P} + X + \text{energy}$$

$${}^{30}_{15}\mathrm{P} \rightarrow {}^{30}_{14}\mathrm{Si} + Y + \text{energy}$$

E72. The first equation indicates that the radioactive phosphorus is produced by bombarding ${}^{27}_{13}\mathrm{Al}$ with

ANSWER: (3) alpha particles

E73. In the first equation, particle X is

ANSWER: (1) a neutron

E74. In the second equation, particle Y is

ANSWER: (4) a positron

E75. The number of neutrons in the nucleus of ${}^{27}_{13}\mathrm{Al}$ is

ANSWER: (2) 14

Base your answers to questions E76 through E79 on the following nuclear equation.

$$^{30}_{15}\mathrm{P} \rightarrow {}^{A}_{Z}\mathrm{Si} + {}^{0}_{+1}X$$

E76. In the equation, X represents

ANSWER: (1) a positron

E77. What is the value of A in the equation?

ANSWER: (3) 30

E78. What is the value of Z in the equation?

ANSWER: (1) 14

E79. The nucleus of $^{30}_{15}\mathrm{P}$ has

ANSWER: (4) 15 neutrons

E80. The function of the moderator in a nuclear reactor is to

ANSWER: (2) slow down neutrons

E81. An atom of U-235 splits into two nearly equal parts. This is an example of

ANSWER: (4) fission

E82. When a nucleus captures an electron, the atomic number of the nucleus

ANSWER: (1) decreases

E83. In a nuclear reactor, control rods are used to

ANSWER: (3) absorb neutrons

E84. During nuclear fusion, energy is released as a result of the

ANSWER: (3) combining of light nuclei

E85. When a neutron is emitted from a nucleus

ANSWER: (4) both (2) and (3)

E86. When a beta particle is emitted from a nucleus

ANSWER: (2) the atomic number increases

E87. In the nuclear reaction $^{9}_{4}\mathrm{Be} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{12}_{6}\mathrm{C} + W$ the symbol W represents

ANSWER: (3) a neutron

E88. In the nuclear reaction $^{239}_{92}\mathrm{U} \rightarrow {}^{239}_{93}\mathrm{Np} + X$, the symbol X represents

ANSWER: (2) an electron

E89. In the nuclear reaction $^{4}_{2}\mathrm{He} + {}^{14}_{7}\mathrm{N} \rightarrow {}^{17}_{8}\mathrm{O} + Z$, the symbol Z represents

ANSWER: (1) a proton

E90. When fission occurs

ANSWER: (4) all of these

E91. Fusion is produced by

ANSWER: (3) intense heat

E92. The process of fusion is accompanied by

ANSWER: (2) a loss in mass

E93. The nuclear reaction believed to be taking place in the sun and to be responsible for its release of energy is known as

ANSWER: (3) fusion

E94. An element suitable for fusion is

ANSWER: (3) hydrogen

E95. The nuclear raw materials for a fusion reaction have a total mass of 3.0067 g. The products of this reaction may have a mass of approximately

ANSWER: (1) 3.0065 g

E96. An atom that undergoes electron capture emits

ANSWER: (3) a gamma photon

E97. Air can be used in a nuclear reactor as a

ANSWER: (1) coolant

E98. In some reactors the coolant also serves as the

ANSWER: (1) moderator

E99. Steel and concrete can be used in nuclear reactors as

ANSWER: (3) shields

E100. Which of the following does not undergo fission?

ANSWER: (2) U-238

E101. Some reactors breed plutonium by bombarding which of the following with neutrons?

ANSWER: (2) U-238

E102. Fusion requires a high temperature to initiate because

ANSWER: (1) atomic nuclei repel each other

E103. Which of the following nuclei would be most difficult to get to "fuse" together?

ANSWER: (2) carbon-12 ($^{12}_{6}\mathrm{C}$)

Laboratory Skills

PART B-1: Page 206

1. The mass of a high school football player is approximately

ANSWER: (3) 10^2 kg

2. A high school physics student is sitting in a seat reading this question. The magnitude of the force with which the seat is pushing up on the student to support the student is closest to

ANSWER: (3) 600 N

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

ANSWER: (2) 10^1 m

4. What is the approximate mass of an automobile?

ANSWER: (3) 10^3 kg

5. What is the approximate mass of a pencil?

ANSWER: (1) 5.0×10^{-3} kg

6. The approximate height of a 12-ounce can of root beer is

ANSWER: (2) 1.3×10^{-1} m

7. The diameter of a United States penny is closest to

ANSWER: (3) 10^{-2} m

8. What is the approximate width of a person's little finger?

ANSWER: (3) 0.01 m

PART B-2: Page 206

Base your answers to questions 9 through 12 on the information and table below.

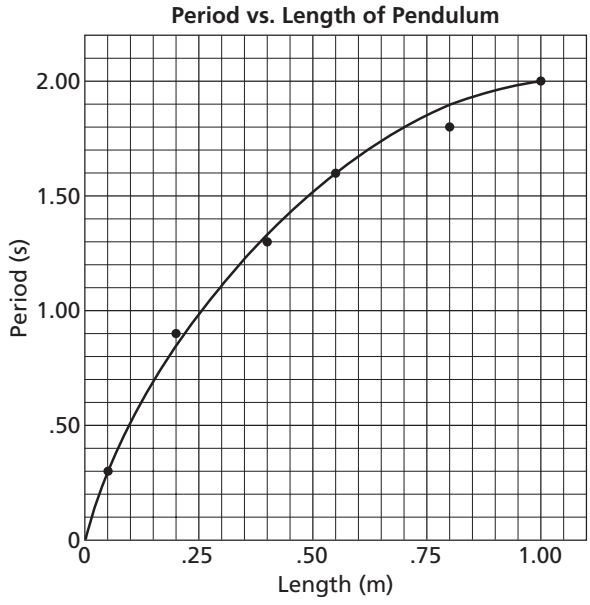
In a laboratory exercise, a student kept the mass and amplitude of swing of a simple pendulum constant. The length of the pendulum was increased and the period of the pendulum was measured. The student recorded the data in the table below.

Length (m)	Period (s)
0.05	0.30
0.20	0.90
0.40	1.30
0.60	1.60
0.80	1.80
1.00	2.00

Directions: Using the information in the table, construct a graph on a grid, following the directions given.

9. Label each axis with the appropriate physical quantity and unit. Mark an appropriate scale on each axis.

ANSWER:



10. Plot the data points for period versus pendulum length.

ANSWER: See #9, above.

11. Draw the best-fit line or curve for the data graphed.

ANSWER: See #9, above.

12. Using your graph, determine the period of a pendulum whose length is 0.25 meter.

ANSWER: The period of the pendulum is 1.0 s (±0.03 s).

Base your answers to questions 13 through 16 on the information and data table below.

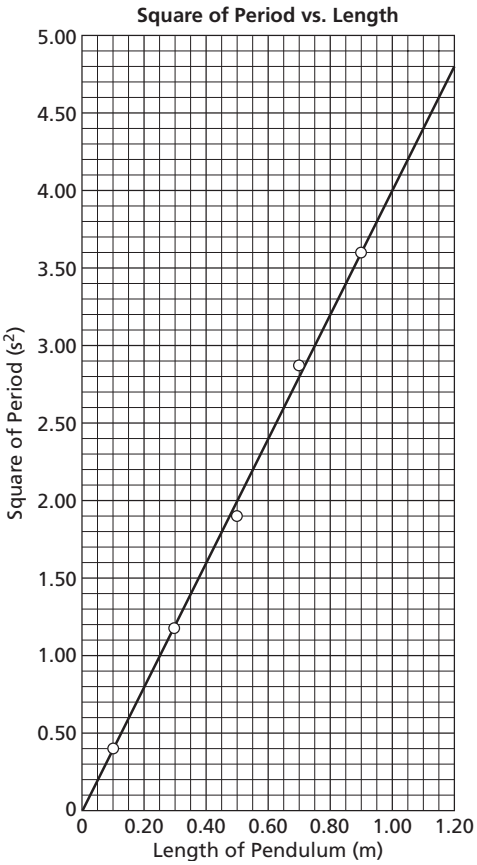
In an experiment, a student measured the length and period of a simple pendulum. The data table lists the length (l) of the pendulum in meters and the square of the period (T^2) of the pendulum in seconds^2.

Length (l) (m)	Square of Period (T^2) (s^2)
0.100	0.410
0.300	1.18
0.500	1.91
0.700	2.87
0.900	3.60

Directions: Using the information in the data table, construct a graph on a grid, following the directions below.

13. Plot the data points for the square of period versus length.

ANSWER:



14. Draw the best-fit straight line.

ANSWER: See #13, above.

15. Using your graph, determine the time in seconds it would take this pendulum to make one complete swing if it were 0.200 meter long.

ANSWER: 0.89 s (±0.1 s)

16. The period of a pendulum is related to its length by the formula $T^2 = 4\pi^2 l / g$, where g represents the acceleration due to gravity. Explain how the graph you have drawn could be used to calculate the value of g. You do *not* need to perform any actual calculations.

ANSWER: Find the coordinates of a point on the best-fit line and substitute into $T^2 = 4\pi^2 l / g$, then solve for g. Or, find the slope and divide it into $4\pi^2$.

PART C: Page 206

17. Explain how you would experimentally determine the spring constant of a particular spring. Your explanation must include: (a) Measurements required (b) Equipment needed (c) Any equation(s) needed.

Sample answer: You would use a balance or scale to determine the mass, m, of an object, in kg. Then suspend the object at equilibrium from the spring and, using a ruler, determine the elongation, x, in meters. Then using the equation $F_s = kx$, substitute the weight of the object, W, obtained from the mass via $W = mg$, into F and substitute the elongation into x, and solve for k, the spring constant.

Science, Technology, and Society

Page 209: The Physics of Baseball

1. Why would a ball thrown on the moon travel faster than a ball thrown with the same force on Earth?

   ANSWER: There is no air to provide drag.

2. What factors determine the magnitude of the Magnus force on a baseball?

   ANSWER: The rate at which the ball spins and the forward speed of the ball determine the strength of the Magnus force.

3. Why don't baseballs curve as much in Denver as they do in New York?

   ANSWER: Because of the high elevation of Denver, the air is less dense than in New York. This results in less drag on the ball and therefore a smaller Magnus force.

4. What is the shape of the path through which a baseball travels after being hit? Why?

   ANSWER: The ball follows a parabolic path. As the ball moves forward, it is acted upon by drag and gravity.

5. What type of interference occurs at the sweet spot of a baseball bat?

   ANSWER: Destructive interference occurs, thereby canceling out the oscillations of the bat at that point.

Page 211: Solar Explosions

1. Why do radio and power blackouts from a solar flare occur only during the day?

   ANSWER: Radiation from the sun reaches only the half of Earth facing the sun. This side of Earth has day. The side of Earth facing away from the sun, which has night, does not receive the radiation.

2. How is the energy released during a solar flare similar to that released by a twisted rubber band?

   ANSWER: When a rubber band is twisted repeatedly, it stores potential energy. When the rubber band is released, it unwinds. In the process, stored potential energy is converted to kinetic energy of motion. During a solar flare, energy stored by twisted magnetic fields is released and converted into radiation and the motion of charged particles.

3. Why don't people on Earth experience the effects of most solar flares?

   ANSWER: Earth's magnetic field and atmosphere prevent most of the radiation and particles of solar flares from reaching Earth's surface.

4. Why are instruments used to measure solar flares located in space?

   ANSWER: X-rays used to measure solar flares do not penetrate Earth's atmosphere.

5. How can a solar flare change the orbit of a satellite?

   ANSWER: The extra energy of charged particles and ionizing radiation causes the atmosphere to expand. This produces more drag on satellites, thereby changing their orbits.

Page 213: Now You See It, Now You Don't

1. How is the amount of refraction related to the refractive indices of the materials?

   ANSWER: The greater the difference between the refractive indices of the materials, the greater the refraction of the light beam.

2. Why are metamaterials sometimes called left-handed materials?

   ANSWER: Metamaterials refract light on the left side of the incident beam rather than the right side as natural materials do.

3. What are two possible applications of negatively refracting materials?

ANSWER: They may be used to produce superlenses as well as cloaking devices.

4. How does the fact that visible light is made up of many different wavelengths pose an obstacle to the applications of metamaterials?

   ANSWER: Existing metamaterials are designed to respond to specific wavelengths. Researchers have yet to design a material that can interact with several wavelengths at the same time.

5. Why might researchers have to use many different metamaterials to construct a sphere in which to cloak an object?

   ANSWER: Each piece of metamaterial will refract light in a specific direction. Because the direction will need to vary to move light around the sphere, the pieces of metamaterials will need to vary as well.

Page 215: Reversal of Fortune

1. What is the source of Earth's magnetism?

   ANSWER: The complex motion of the inner and outer core gives rise to Earth's magnetic field.

2. What evidence has led some scientists to predict that Earth may experience a magnetic reversal within the next 2000 years?

   ANSWER: Earth's magnetic field has experienced a decrease in strength.

3. How might animals be affected by a magnetic reversal?

   ANSWER: Many animals rely on Earth's magnetic field to navigate. Animals that cannot adjust to the reversal may not be able to survive.

4. How might the SAA be related to current observations about Earth's magnetic field?

   ANSWER: The SAA is a region of weakening.

Page 217: Tracking a Storm

1. What is the source of energy for a tropical cyclone?

   ANSWER: Heat from the warm tropical water provides energy to a tropical cyclone.

2. In what direction does a tropical cyclone spin?

   ANSWER: It spins in a counterclockwise direction.

3. How is the TRMM different from other rain radar instruments?

   ANSWER: The TRMM is the first rain radar in space. This makes it possible to look directly into storms.

4. What advantage does ground radar have over the TRMM in tracking a hurricane?

   ANSWER: Ground radar can track a storm continuously whereas the TRMM can gather information only when its orbit takes it over the storm.

5. What does a sequence of tall hot towers indicate about a hurricane?

   ANSWER: Hot towers indicate that the storm in intensifying.

6. How does the arsenal of modern tools help modern forecasters study hurricanes?

   ANSWER: Modern tools give forecasters the ability to collect data about storms long before they make landfall.

Page 219: It Takes Guts

1. Which were the first two forces combined by physicists?

   ANSWER: electricity and magnetism

2. How does the electroweak theory depend on mediator particles?

   ANSWER: According to the theory, forces are carried between particles by bosons. Each force has a distinct type of boson.

3. How would a TOE differ from the Standard Model of Matter?

   ANSWER: It would account for gravity.

4. What happened to Einstein as a result of his quest to unify the forces?

   ANSWER: He became isolated by the scientific community.

Page 221: Are We There Yet?

1. How does the thrust of a chemical engine compare to that of an ion engine?

   ANSWER: The thrust of a chemical engine is much greater.

2. Why doesn't an ion engine spacecraft accelerate at the same rate as the ions that are emitted from its exhaust?

   ANSWER: The mass of the spacecraft is much greater than that of the ions.

3. Why does an ion engine need to neutralize its exhaust?

   ANSWER: If the exhaust were positive, it might be attracted back to the positive surfaces of the engine. This would cancel out the thrust.

4. What is one important way that reducing the mass of a spacecraft reduces cost?

ANSWER: The vehicle required to launch a lightweight craft is less expensive than it would be to launch a heavier craft.

5. Why are ion propulsion engines an important option for deep space exploration?

ANSWER: They can attain much higher speeds than chemical propulsion engines and they require a smaller amount of propellant.

Answer Key

ANSWER KEY
PHYSICAL SETTING/PHYSICS — JUNE 2005 (1)

Part A

Allow 1 credit for each correct response.

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

Part B–1

Allow 1 credit for each correct response.

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

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

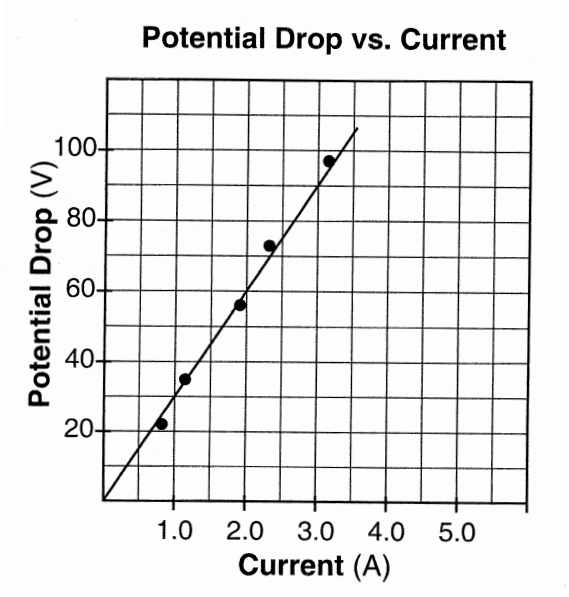
48. Allow 1 credit for marking an appropriate scale on the axis labeled "Potential Drop (V)."

49. Allow 1 credit for plotting all points accurately (±0.3 grid space).

50. Allow 1 credit for drawing the line of best fit. Allow credit for an answer that is consistent with the student's response to questions 48 and/or 49.

48–50.

Example of a 3-Credit Graph



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

Example of an Acceptable Response

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{\Delta V}{\Delta A}$$

$$\text{slope} = \frac{90.\ V - 30.\ V}{3.0\ A - 1.0\ A}$$

$$\text{slope} = 30.\ \frac{V}{A} \quad \textit{or} \quad 30\Omega$$

Allow credit for an answer that is consistent with the student's graph.

Note: The slope may be determined by substitution of data points only if the data values are on the best-fit line or if the student failed to draw a best-fit line.

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

Example of an Acceptable Response

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

$W = qV$

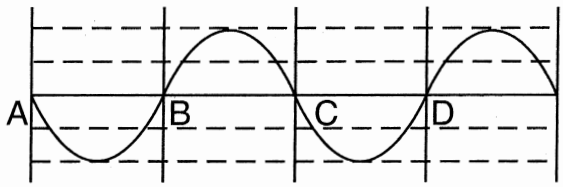
$W = (1.60 \times 10^{-19}\ \text{C})(2.5 \times 10^{4}\ V)$

$W = 4.0 \times 10^{-15}\ \text{J}$

53. Allow 1 credit for the correct order: *C A B D*. Allow credit even if the student writes the list of materials instead of the letters.

54. Allow 1 credit for drawing a transverse wave that would produce complete destructive interference when superimposed with the original wave.

Example of an Acceptable Response



55. Allow 1 credit for 233 MeV.

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

Example of an Acceptable Response

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

$a = \frac{25\ \text{m/s} - 13\ \text{m/s}}{5.0\ \text{s}}$

$a = 2.4\ \text{m/s}^2$

57. Allow 1 credit for 19 m/s.

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

Example of an Acceptable Response

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

$m_2 = \frac{Fr^2}{Gm_1}$

$m_2 = \frac{(3.52 \times 10^{22}\ \text{N})(1.50 \times 10^{11}\ \text{m})^2}{\left(6.67 \times 10^{-11}\ \frac{\text{N} \bullet \text{m}^2}{\text{kg}^2}\right)\left(5.98 \times 10^{24}\ \text{kg}\right)}$

$m_2 = 1.99 \times 10^{30}\ \text{kg}$

59. Allow 1 credit for -1.6×10^{-19} C.

60. Allow 1 credit for 1.

61. Allow 1 credit for 0e.

Note: Allow credit if the student writes "neutral."

Part C

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

Example of an Acceptable Response

$\Delta PE = mg\Delta h$

$\Delta PE = (250.\ \text{kg} + 75\ \text{kg})(9.81\ \text{m/s}^2)(20.\ \text{m})$

$\Delta PE = 6.4 \times 10^4\ \text{J}$

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

Examples of Acceptable Responses

$\Delta PE = KE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2\Delta PE}{m}}$

$v = \sqrt{\frac{2(6.4 \times 10^4\ \text{J})}{325\ \text{kg}}}$

$v = 20.\ \text{m/s}$

or

$\Delta PE = KE = \frac{1}{2}mv^2$

$6.4 \times 10^4\ \text{J} = \frac{1}{2}(250.\ \text{kg} + 75\ \text{kg})v^2$

$v^2 = 394$

$v = 20.\ \text{m/s}$

Allow credit for an answer that is consistent with the student's response to question 62.

64. Allow 1 credit for indicating that the total mechanical energy is the same at all three points.

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

Example of an Acceptable Response

$a = \frac{F_{net}}{m}$

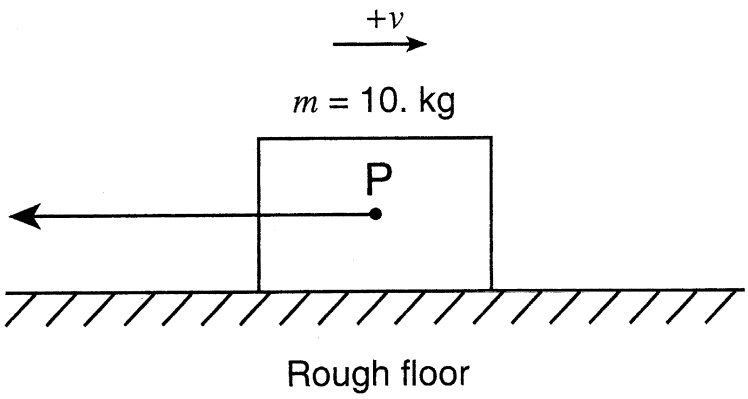
$F_{net} = ma$

$F_{net} = (10.\text{ kg})(-2.0\text{ m/s}^2)$

$F_{net} = -20.\text{ N}$ *or* 20 N

66. Allow a maximum of 2 credits. Allow 1 credit for a length of 4.0 cm (±0.2 cm). Allow 1 credit for drawing a vector directed to the left. Allow credit even if the vector does not begin at point *P*.

Example of a 2-Credit Response



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

Example of an Acceptable Response

$F_f = \mu F_N$

$\mu = \frac{F_f}{F_N}$

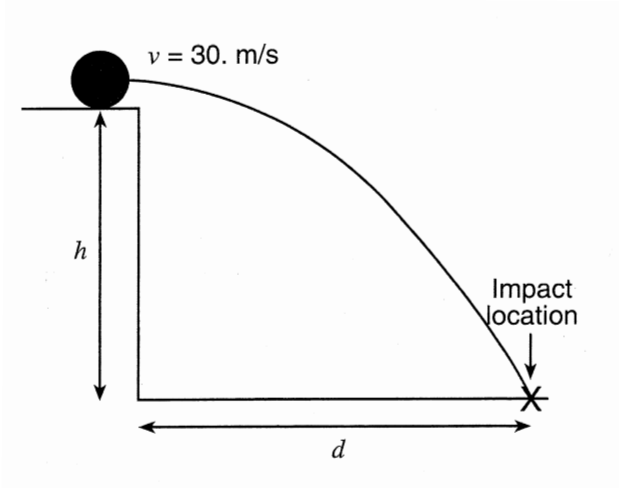
$\mu = \frac{20.\text{ N}}{98.1\text{ N}}$

$\mu = 0.20$

Allow credit for an answer that is consistent with the student's response to question 65.

68. Allow 1 credit for sketching the theoretical path of the projectile.

Example of an Acceptable Response



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

Examples of Acceptable Responses

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

$d = (30.\ \text{m/s})(2.5\ \text{s}) + \frac{1}{2}(0\ \text{m/s}^2)(2.5\ \text{s})^2$

$d = 75\ \text{m}$

or

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

$d = \overline{v}t$

$d = (30.\ \text{m/s})(2.5\ \text{s})$

$d = 75\ \text{m}$

70. Allow a maximum of 2 credits, 1 credit for a correct equation with substitution and 1 credit for solving for t (not t^2).

Examples of Acceptable Responses

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

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

$t = \sqrt{\frac{2h}{g}}$

or

$h = v_i t + \frac{1}{2}gt^2$

$h = \frac{1}{2}gt^2$

$t = \sqrt{\frac{2h}{g}}$

or

$t = \sqrt{\frac{2h}{g}}$

Note: Allow full credit if d_y or s_y are used in place of h. Allow 1 credit if d is used in place of h.

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

Example of an Acceptable Response

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

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

$$\sin \theta_2 = \frac{(1.33)(\sin 40.^\circ)}{1.00}$$

$$\sin \theta_2 = 0.855$$

$$\theta_2 = 59^\circ \quad or \quad 58.7^\circ$$

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

Examples of Acceptable Responses

$$\frac{n_2}{n_1} = \frac{v_1}{v_2}$$

$$v_1 = \frac{n_2 v_2}{n_1}$$

$$v_1 = \frac{1.00(3.00 \times 10^8 \text{ m/s})}{1.33}$$

$$v_1 = 2.26 \times 10^8 \text{ m/s}$$

or

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

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

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

$$v = 2.26 \times 10^8 \text{ m/s}$$

Regents Examination in Physical Setting / Physics
June 2005

Chart for Converting Total Test Raw Scores to Final Examination Scores (Scaled Scores)

Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score	Raw Score	Scale Score
85	100	63	80	41	60	19	34
84	99	62	79	40	59	18	33
83	98	61	78	39	58	17	31
82	97	60	78	38	57	16	30
81	96	59	77	37	56	15	28
80	95	58	76	36	55	14	27
79	94	57	75	35	54	13	25
78	93	56	74	34	53	12	24
77	92	55	73	33	52	11	22
76	91	54	72	32	50	10	20
75	90	53	72	31	49	9	19
74	89	52	71	30	48	8	17
73	89	51	70	29	47	7	15
72	88	50	69	28	46	6	13
71	87	49	68	27	45	5	11
70	86	48	67	26	43	4	9
69	85	47	66	25	42	3	7
68	84	46	65	24	41	2	5
67	83	45	64	23	40	1	3
66	83	44	63	22	38	0	0
65	82	43	62	21	37		
64	81	42	61	20	35		

To determine the student's final examination score, find the student's total test raw score in the column labeled "Raw Score" and then locate the scaled score that corresponds to that raw score. The scaled score is the student's final examination score. Enter this score in the space labeled "Final Score" on the student's answer sheet.

All student answer papers that receive a scaled score of 60 through 64 **must** be scored a second time. For the second scoring, a different committee of teachers may score the student's paper or the original committee may score the paper, except that no teacher may score the same open-ended questions that he/she scored in the first rating of the paper. The school principal is responsible for assuring that the student's final examination score is based on a fair, accurate and reliable scoring of the student's answer paper.

Because scaled scores corresponding to raw scores in the conversion chart may change from one examination to another, it is crucial that for each administration, the conversion chart provided for that administration be used to determine the student's final score. The chart above is usable only for this administration of the physical setting / physics examination.

ANSWER KEY
PHYSICAL SETTING/PHYSICS — JANUARY 2006 (1)

Part A

Allow 1 credit for each correct response.

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

Part B–1

Allow 1 credit for each correct response.

36. 3	**39.** 2	**42.** 2	**45.** 4
37. 1	**40.** 1	**43.** 2	**46.** 3
38. 3	**41.** 1	**44.** 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. Allow 1 credit for 55 J.

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

Examples of 2-credit responses:

$PE = mgh$

$m = \dfrac{PE}{gh}$

$m = \dfrac{25\ \text{J}}{(9.81\ \text{m/s}^2)(1.0\ \text{m})}$

$m = 2.5\ \text{kg}$ *or* $2.55\ \text{kg}$

or

$PE = mgh$

$m = \dfrac{55\ \text{J}}{(2.25\ \text{m})(9.81\ \text{m/s}^2)}$

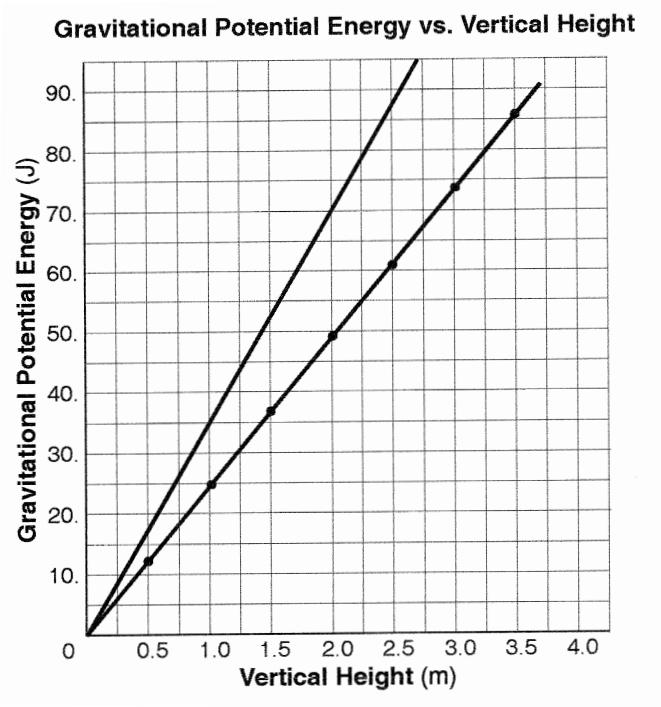
$m = 2.5\ \text{kg}$

Allow credit for an answer that is consistent with the student's response to question 48.

50. Allow 1 credit. Acceptable responses include, but are not limited to:
— weight of object *or* weight
— mg
— force
— F_g

51. Allow 1 credit for drawing a line that would represent the relationship between gravitational potential energy and vertical height for an object having a greater mass. The line must be straight, with a slope steeper than that of the given line.

Example of a 1-credit response:



52. Allow 1 credit for 55° (±2°).

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

Example of a 2-credit response:

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

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

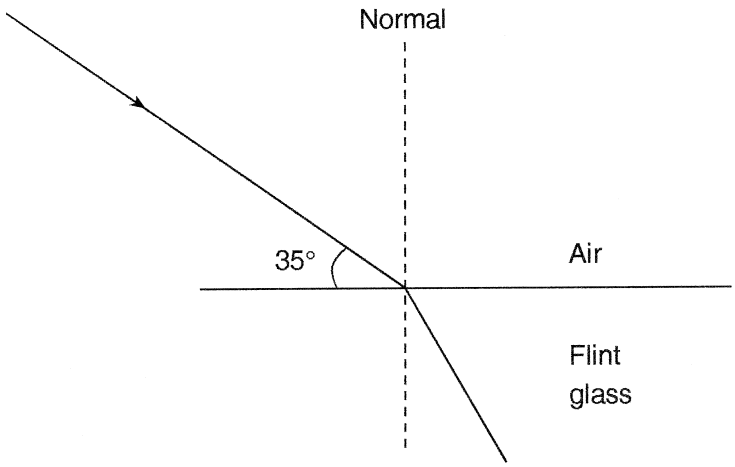
$$\sin \theta_2 = \frac{(1.00)(\sin 55°)}{1.66} = 0.493$$

$$\theta_2 = 29.6° \quad or \quad 30.°$$

Allow credit for an answer that is consistent with the student's response to question 52.

54. Allow 1 credit for drawing the refracted ray at an angle of 30.° (±2°).

Example of a 1-credit response:



Allow credit for an answer that is consistent with the student's response to question 53.

55. Allow 1 credit for stating what would happen to light from the incident ray that is not refracted or absorbed. Acceptable responses include, but are not limited to:
— reflected
— scattered

56. Allow 1 credit for indicating that a feather does not accelerate at 9.81 meters per second^2 when dropped near the surface of Earth because the net force is less than F_g. Acceptable responses include, but are not limited to:
— Air friction acts on the feather.
— The feather is not in free fall.

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

Example of a 2-credit response:

$F_f = \mu F_N$

$F_N = \frac{F_f}{\mu}$

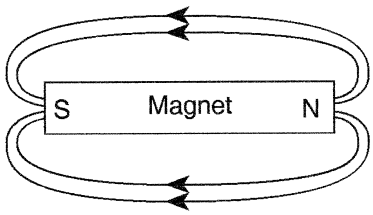
$F_N = \frac{39\ \text{N}}{.05}$

$F_N = 780\ \text{N}$

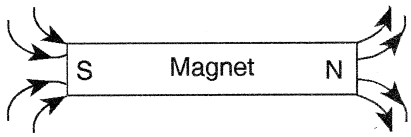
58. Allow 1 credit for 6000 $\frac{\text{kg} \bullet \text{m}}{\text{s}}$.

59. Allow a maximum of 2 credits, allocated as follows:
- Allow 1 credit for drawing four field lines that do *not* cross and are closest together at the poles.
- Allow 1 credit for four field lines drawn from N to S.

Examples of 2-credit responses:



or



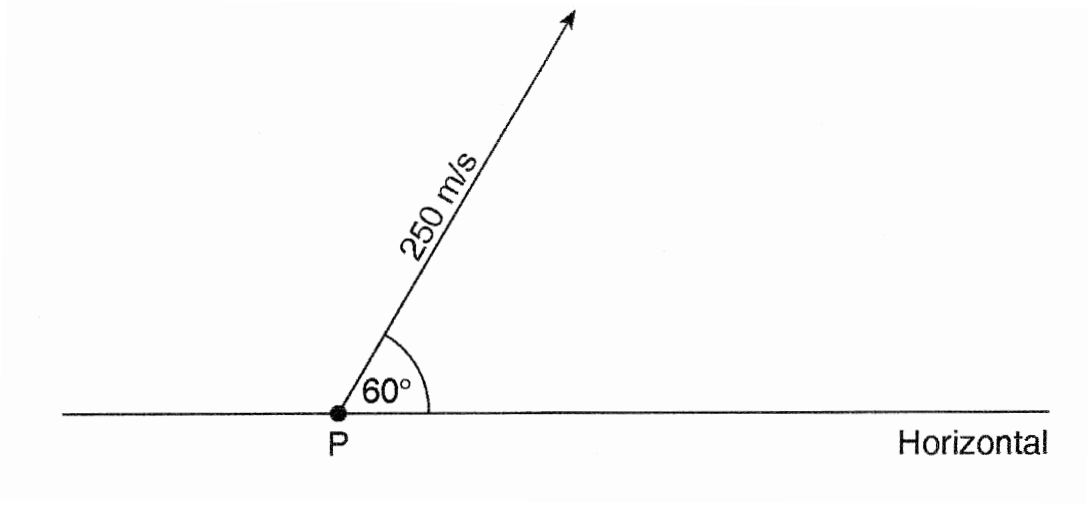
60. Allow 1 credit for indicating that mass is converted into energy.

61. Allow 1 credit for 3.28 m *or* 3.3 m.

Part C

62. Allow a maximum of 2 credits, allocated as follows:
- Allow 1 credit for a length of 5.0 cm (±0.2 cm) and an arrow.
- Allow 1 credit for an angle above the horizontal of 60.° (±2°).

Example of a 2-credit response:



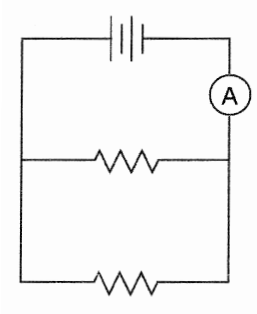
63. Allow 1 credit for 125 m/s (±10 m/s).

Allow credit for an answer that is consistent with the student's response to question 62.

64. Allow 1 credit for explaining why the projectile has no acceleration in the horizontal direction. Acceptable responses include, but are not limited to:
— no force on object in horizontal direction
— The only force is vertical.
— Gravity acts only vertically.

65. Allow a maximum of 2 credits, allocated as follows:
- Allow 1 credit for drawing a parallel circuit containing two resistors and a battery.
  Note: Do *not* allow this credit if the student draws a cell instead of a battery.
- Allow 1 credit for a correct placement of the ammeter.

Example of a 2-credit response:



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

Example of a 2-credit response:

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

$$\frac{1}{R_{eq}} = \frac{1}{18\ \Omega} + \frac{1}{36\ \Omega}$$

$$R_{eq} = 12\ \Omega$$

Allow credit for an answer that is consistent with the student's response to question 65.

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

Examples of 2-credit responses:

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

$$P = \frac{(24\ V)^2}{12\ \Omega}$$

$$P = 48\ W$$

or

$$I = \frac{V}{R} = \frac{24\ V}{12\ \Omega} = 2A$$

and

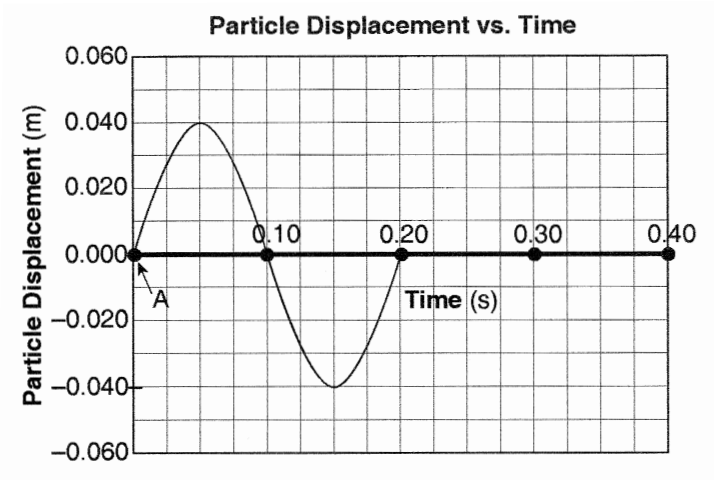
$$P = VI$$
$$P = (24\ V)(2\ A)$$
$$P = 48\ W$$

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

68. Allow 1 credit for 0.20 s *or* $\frac{1}{5}$ s.

69. Allow a maximum of 2 credits, allocated as follows:
- Allow 1 credit for correct amplitude ±0.3 grid space.
- Allow 1 credit for correct period ±0.3 grid space.

Example of a 2-credit response:



Note: Allow credit for any periodic wave form (e.g., square or triangular) that meets these criteria.

Allow credit for an answer that is consistent with the student's response to question 68.

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

Examples of 2-credit responses:

$v = f\lambda$		$v = \frac{d}{t}$
v = (5.0 Hz)(0.080 m)	*or*	$v = \frac{0.080 \text{ m}}{0.2 \text{ s}}$
v = 0.40 m/s		v = .4 m/s

71. Allow 1 credit for 3.02 eV.

72. Allow 1 credit for 4.83×10^{-19} J.

Allow 1 credit for a response that is consistent with the student's response to question 71.

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

Example of a 2-credit response:

$E = hf$

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

$f = \frac{4.83 \times 10^{-19}\ \text{J}}{6.63 \times 10^{-34}\ \text{J•s}}$

$f = 7.29 \times 10^{14}\ \text{Hz}$

Allow credit for an answer that is consistent with the student's response to question 72.

74. Allow 1 credit for explaining why this is not the only energy and/or frequency that an electron in the $n = 6$ energy level of a hydrogen atom could emit. Acceptable responses include, but are not limited to:
— No, the $n = 6$ level can return to any of the 5 lower energy levels.
— No, the electron can drop to many different energy levels.
— The electron can fall from $n = 6$ to any other level between $n = 5$ and $n = 1$.
— $6 \rightarrow 5$ $6 \rightarrow 4$ $6 \rightarrow 3$ $6 \rightarrow 1$

Note: Do *not* allow credit for "no" without a correct explanation.

Regents Examination in Physical Setting / Physics
January 2006

Chart for Converting Total Test Raw Scores to Final Examination Scores (Scaled Scores)

Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score
85	100	63	79	41	56	19	30
84	99	62	78	40	55	18	28
83	98	61	77	39	54	17	27
82	97	60	76	38	53	16	25
81	96	59	75	37	52	15	24
80	95	58	74	36	51	14	22
79	94	57	73	35	50	13	21
78	93	56	72	34	49	12	20
77	92	55	71	33	48	11	18
76	91	54	70	32	46	10	16
75	90	53	69	31	45	9	15
74	89	52	68	30	44	8	13
73	88	51	67	29	43	7	12
72	87	50	66	28	41	6	10
71	86	49	65	27	40	5	8
70	85	48	64	26	39	4	7
69	84	47	63	25	38	3	5
68	83	46	62	24	36	2	4
67	82	45	61	23	35	1	2
66	81	44	60	22	34	0	0
65	80	43	59	21	32		
64	79	42	58	20	31		

To determine the student's final examination score, find the student's total test raw score in the column labeled "Raw Score" and then locate the scaled score that corresponds to that raw score. The scaled score is the student's final examination score. Enter this score in the space labeled "Final Score" on the student's answer sheet.

All student answer papers that receive a scaled score of 60 through 64 **must** be scored a second time. For the second scoring, a different committee of teachers may score the student's paper or the original committee may score the paper, except that no teacher may score the same open-ended questions that he/she scored in the first rating of the paper. The school principal is responsible for assuring that the student's final examination score is based on a fair, accurate and reliable scoring of the student's answer paper.

Because scaled scores corresponding to raw scores in the conversion chart may change from one examination to another, it is crucial that for each administration, the conversion chart provided for that administration be used to determine the student's final score. The chart above is usable only for this administration of the physical setting / physics examination.

ANSWER KEY
PHYSICAL SETTING/PHYSICS — JUNE 2006 (1)

Part A

Allow 1 credit for each correct response.

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

Part B–1

Allow 1 credit for each correct response.

36. 2	**40.** 1	**43.** 4	**46.** 2	**49.** 3
37. 1	**41.** 4	**44.** 1	**47.** 3	**50.** 1
38. 4	**42.** 2	**45.** 3	**48.** 2	**51.** 4
39. 1				

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

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

Example of a 2-credit response:

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

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

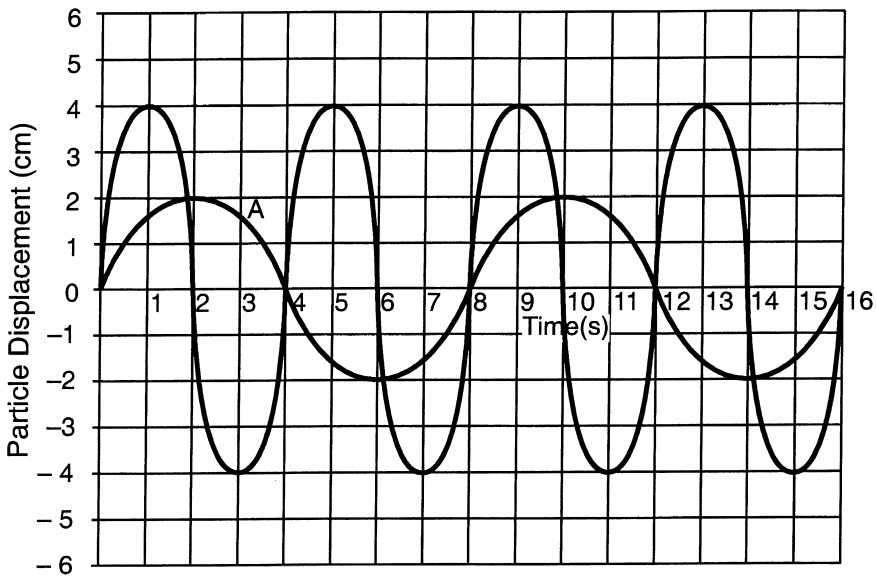
$$n_2 = \frac{1.33 \sin 45°}{\sin 29°}$$

$n_2 = 1.94$

53. Allow 1 credit for zircon. Allow credit for an answer that is consistent with the student's response to question 52.

54. Allow a maximum of 2 credits, 1 credit for correct amplitude and 1 credit for correct frequency.

Example of a 2-credit response:



Note: If more than one cycle is drawn, rate only the first cycle.

55. Allow 1 credit for explaining the difference between a scalar and a vector quantity. Acceptable responses include, but are not limited to:
— A scalar quantity has magnitude only. A vector quantity has both magnitude and direction.
— A vector quantity has direction.
— A scalar quantity has no direction.

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

Example of a 2-credit response:

$F_f = \mu F_N$

$F_f = (.15)(10.\text{ kg})(9.81\text{ m/s}^2)$

$F_f = 15\text{ N}$ *or* 14.7 N

57. Allow 1 credit for 4.52×10^{14} Hz.

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

Examples of 2-credit responses:

$E = mc^2$

$E = 2(1.67 \times 10^{-27}\text{ kg})(3.00 \times 10^8\text{ m/s})^2$ *or* $\dfrac{1\text{ u}}{931\text{ MeV}} = \dfrac{2\text{ u}}{x\text{ MeV}}$

$E = 3.01 \times 10^{-10}\text{ J}$ $x = 1860\text{ MeV}$

59. Allow 1 credit for 8.0 m ± 0.2 m.

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

Example of a 2-credit response:

$P = \dfrac{Fd}{t}$

$P = \dfrac{(50.\text{ N})(8.0\text{ m})}{3.0\text{ s}}$

$P = 130\text{ W}$ *or* 133 W

Allow credit for an answer that is consistent with the student's response to question 59.

Part C

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

Example of a 2-credit response:

$\Delta PE = mg\Delta h$
$\Delta PE = (3.0 \text{ kg})(9.81 \text{ m/s}^2)(3.0 \text{ m})$
$\Delta PE = 88 \text{ J}$ *or* $88.3 \text{ kg} \bullet \text{m}^2/\text{s}^2$

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

Example of a 2-credit response:

$E_T = PE + KE + Q$
$KE = mg\Delta h$
$KE = (3.0 \text{ kg})(9.81 \text{ m/s}^2)(3.0 \text{ m} - 1.0 \text{ m})$
$KE = 59 \text{ J}$ *or* 58.9 J

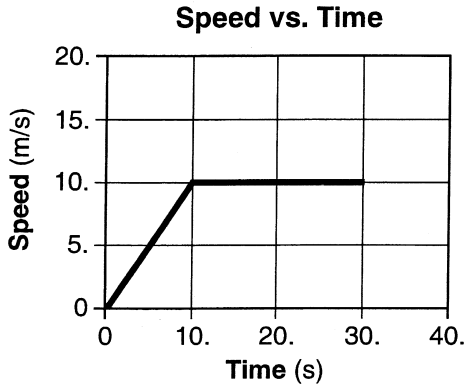
63. Allow 1 credit for G.

64. Allow 1 credit for 10. m/s.

65. Allow a maximum of 2 credits, allocated as follows:
- Allow 1 credit for the line segment from 0 to 10. s.
- Allow 1 credit for the line segment from 10. to 30. s.

Note: Do *not* penalize the student for extending the line past 30. s.

Example of a 2-credit response:



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

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

Examples of 2-credit responses:

$d = v_i t + \frac{1}{2}at^2$ $\qquad$ $d = \text{area} = \frac{1}{2}bh$

$d = 0 + \frac{1}{2}(1.0\ \text{m/s}^2)(10.\ \text{s})^2$ $\qquad$ *or* $\qquad$ $d = \frac{1}{2}(10.\ \text{s})(10.\ \text{m/s})$

$d = 50.\ \text{m}$ $\qquad$ $d = 50.\ \text{m}$

67. Allow 1 credit for indicating that gravity is the fundamental force to which the author is referring.

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

Example of a 2-credit response:

$$F = \frac{G\, m_1 m_2}{r^2}$$

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

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

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

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

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

Example of a 2-credit response:

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

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

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

$$f = 0.20\ \text{Hz}$$

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

Examples of 2-credit responses:

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

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

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

Allow credit for an answer that is consistent with the student's response to question 70.

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

Example of a 2-credit response:

$I = \frac{\Delta q}{t}$

$\Delta q = It$
$\Delta q = (0.50\text{ A})(60.\text{ s})$
$\Delta q = 30.\text{ C}$

Regents Examination in Physical Setting/Physics
June 2006

Chart for Converting Total Test Raw Scores to Final Examination Scores (Scaled Scores)

Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score	Raw Score	Scaled Score
85	100	63	80	41	58	19	32
84	99	62	79	40	57	18	30
83	98	61	78	39	56	17	29
82	97	60	77	38	55	16	28
81	96	59	76	37	54	15	26
80	95	58	75	36	53	14	25
79	94	57	74	35	52	13	23
78	93	56	73	34	51	12	22
77	92	55	72	33	49	11	20
76	91	54	71	32	48	10	19
75	90	53	70	31	47	9	17
74	89	52	69	30	46	8	15
73	89	51	68	29	45	7	14
72	88	50	67	28	43	6	12
71	87	49	66	27	42	5	10
70	86	48	66	26	41	4	8
69	85	47	65	25	40	3	6
68	84	46	63	24	39	2	4
67	83	45	62	23	37	1	2
66	82	44	61	22	36	0	0
65	81	43	60	21	35		
64	81	42	59	20	33		

To determine the student's final examination score, find the student's total test raw score in the column labeled "Raw Score" and then locate the scaled score that corresponds to that raw score. The scaled score is the student's final examination score. Enter this score in the space labeled "Final Score" on the student's answer sheet.

All student answer papers that receive a scaled score of 60 through 64 **must** be scored a second time. For the second scoring, a different committee of teachers may score the student's paper or the original committee may score the paper, except that no teacher may score the same open-ended questions that he/she scored in the first rating of the paper. The school principal is responsible for assuring that the student's final examination score is based on a fair, accurate and reliable scoring of the student's answer paper.

Because scaled scores corresponding to raw scores in the conversion chart may change from one examination to another, it is crucial that for each administration, the conversion chart provided for that administration be used to determine the student's final score. The chart above is usable only for this administration of the Physical Setting/Physics Examination.

ANSWER KEY
PHYSICAL SETTING/PHYSICS — JANUARY 2007 (1)

Part A

Allow 1 credit for each correct response.

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

Part B–1

Allow 1 credit for each correct response.

36. 1	**40.** 1	**43.** 4	**46.** 1	**49.** 2
37. 4	**41.** 2	**44.** 3	**47.** 4	**50.** 1
38. 2	**42.** 3	**45.** 3	**48.** 4	**51.** 2
39. 1				

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:

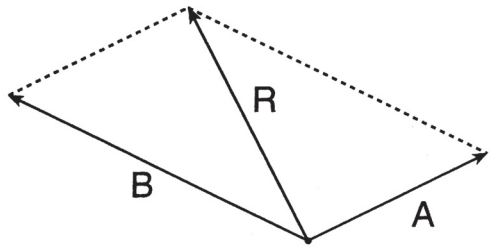
- Allow 1 credit for the equation and substitution of values with units. If the equation and/or substitution with units is not shown, do *not* allow this credit.
- Allow 1 credit for the correct answer (number and unit). If the number is given without the unit, do *not* allow this credit.
- Penalize 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

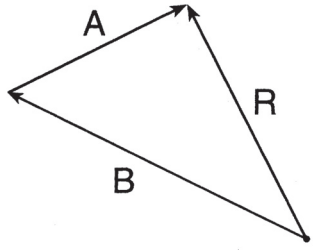
52. [1] Allow 1 credit for 2.0 N ± 0.2 N.

53. [1] Allow 1 credit for constructing the resultant 3.7 cm ± 0.2 cm long, at an angle of 36° ± 2° from vector *B*.

Examples of 1-credit responses:



or



Note: Do *not* deduct credit if the resultant vector is not labeled.

54. [1] Allow 1 credit for 7.4 N ± 0.4 N *or* an answer that is consistent with the student's responses to questions 52 and 53.

55. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

$$R = 429\ \Omega$$

56. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

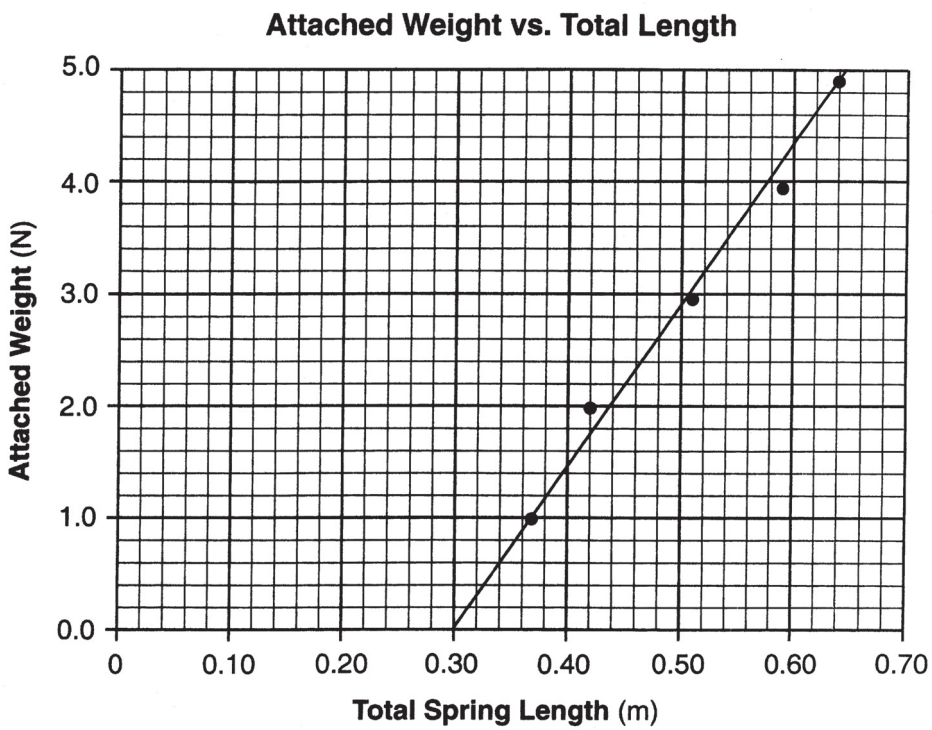
Example of a 2-credit response:

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

57. [1] Allow 1 credit for correctly plotting all the data points ± 0.3 grid space.

58. [1] Allow 1 credit for drawing the line or curve of best fit.

Examples of a 2-credit graph for questions 57 and 58:



59. [1] Allow 1 credit for 0.30 m ± 0.01 m *or* an answer that is consistent with the student's graph.

60. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

$v = f\lambda$
$v = (5.0\text{ Hz})(1.0\text{ m})$
$v = 5.0\text{ m/s}$

or

$v = f\lambda$
$v = (2.0\text{ Hz})(2.5\text{ m})$
$v = 5.0\text{ m/s}$

61. [1] 2 **62.** [1] 4

Part C

63. [1] Allow 1 credit for 5.4 cm ± 0.2 cm

64. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

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

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

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

65. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

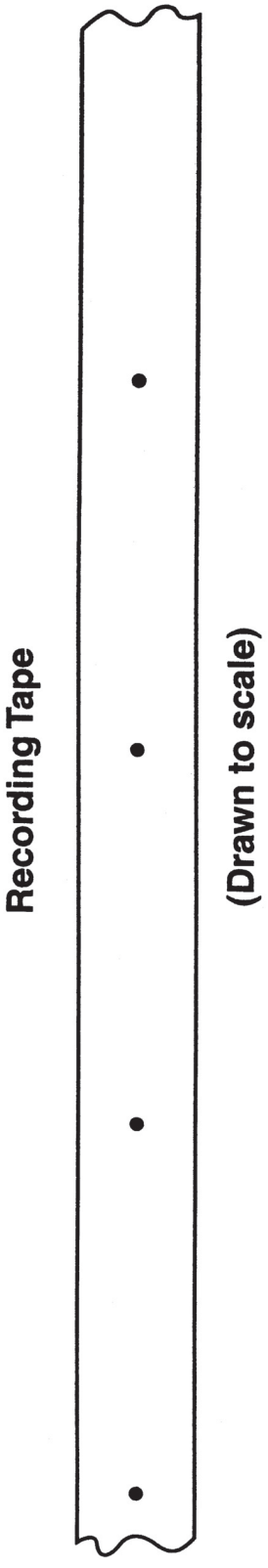
$\bar{v} = \frac{5.4\text{ cm}}{0.30\text{ s}}$

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

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

66. [1] Allow 1 credit for *at least four* dots that are equally spaced ± 0.2 cm.

Example of a 1-credit response:



67. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

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

$R = 240\ \Omega$

68. [1] Allow 1 credit for 190 Ω *or* an answer that is consistent with the student's response to question 67.

69. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Example of a 2-credit response:

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

70. [1] Allow 1 credit for flint glass.

71. [1] Allow 1 credit for 1.81×10^8 m/s.

72. [2] Allow a maximum of 2 credits. Refer to *Scoring Criteria for Calculations* in this rating guide.

Examples of 2-credit responses:

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

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

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

$\sin\theta_2 = 0.493$

$\theta_2 = 30.°$ *or* $29.6°$

or

$n = \frac{\sin i}{\sin r}$

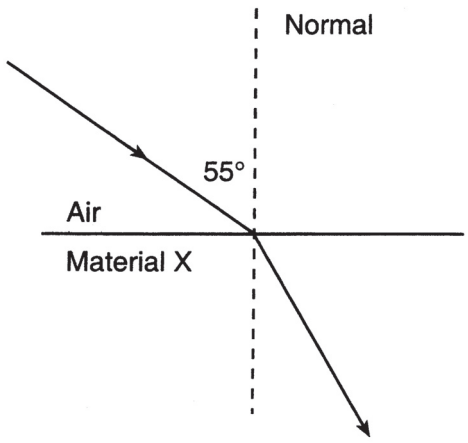
$r = \sin^{-1}\left(\frac{\sin i}{n}\right)$

$r = \sin^{-1}\left(\frac{\sin 55°}{1.66}\right)$

$r = 30.°$

73. [1] Allow 1 credit for drawing a ray in material *X* at an angle of 30.° ± 2° to the right of the normal. Allow this credit even if an arrowhead is *not* drawn on the ray.

Example of a 1-credit response:



Note: Allow credit for an answer that is consistent with the student's response to question 72.

74. [1] Allow 1 credit for antiproton.

75. [1] Allow 1 credit for stating how the emission spectrum of antihydrogen should compare to the emission spectrum of hydrogen. Acceptable responses include, but are not limited to:

— identical
— the same

76. [1] Allow 1 credit for identifying charge as one characteristic that antimatter particles must possess.

77. [1] Allow 1 credit for explaining why it is a mystery that "the universe seems to be overwhelmingly composed of normal matter." Acceptable responses include, but are not limited to:

— Although matter is only created in matter-antimatter pairs, most matter is normal.
— matter, not ½ antimatter
— It should be balanced by antimatter.
— Matter can only be created in particle-antiparticle pairs.

Regents Examination in Physical Setting/Physics
January 2007

Chart for Converting Total Test Raw Scores to Final Examination Scores (Scaled Scores)

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85	100	63	81	41	60	19	33
84	99	62	80	40	59	18	31
83	98	61	79	39	58	17	30
82	97	60	78	38	57	16	28
81	96	59	77	37	56	15	27
80	95	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	49	9	17
74	90	52	71	30	47	8	15
73	90	51	70	29	46	7	13
72	89	50	69	28	45	6	12
71	88	49	68	27	44	5	10
70	87	48	67	26	42	4	8
69	86	47	66	25	41	3	6
68	85	46	65	24	40	2	4
67	84	45	64	23	38	1	2
66	84	44	63	22	37	0	0
65	83	43	62	21	36		
64	82	42	61	20	34		

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