Chapter 1

Physics and Measurement

Conceptual Problems

1. The standard kilogram is a platinum-iridium cylinder 39 mm in height and 39 mm in diameter. What is the density of the material?

2. A 2.00 m by 3.00 m plate of aluminum has a mass of 324 kg. What is the thickness of the plate? (The density of aluminum is $2.70 \times 10^3\ \text{kg/m}^3$).

3. What is the mass of air in a room that measures $5.0\ \text{m} \times 8.0\ \text{m} \times 3.0\ \text{m}$? (The density of air is 1/800 that of water).

4. The basic function of a carburetor of an automobile is to atomize the gasoline and mix it with air to promote rapid combustion. As an example, assume that $30\ \text{cm}^3$ of gasoline is atomized into N spherical droplets, each with a radius of 2.0×10^{-5} m. What is the total surface area of these N spherical droplets?

5. Which of the following products of ratios gives the conversion factor to convert miles per hour $\left(\frac{\text{mi}}{\text{h}}\right)$ to meters per second $\left(\frac{\text{m}}{\text{s}}\right)$?

a. $\frac{5280\ \text{f}}{\text{mi}} \cdot \frac{12\ \text{in}}{\text{f}} \cdot \frac{1\ \text{in}}{2.54\ \text{cm}} \cdot \frac{1\ \text{m}}{100\ \text{cm}} \cdot \frac{1\ \text{h}}{3600\ \text{s}}$

b. $\frac{5280\ \text{f}}{\text{mi}} \cdot \frac{12\ \text{in}}{\text{f}} \cdot \frac{2.54\ \text{cm}}{1\ \text{in}} \cdot \frac{100\ \text{cm}}{1\ \text{m}} \cdot \frac{1\ \text{h}}{3600\ \text{s}}$

c. $\frac{1\ \text{mi}}{5280\ \text{f}} \cdot \frac{1\ \text{f}}{12\ \text{in}} \cdot \frac{1\ \text{in}}{2.54\ \text{cm}} \cdot \frac{100\ \text{cm}}{1\ \text{m}} \cdot \frac{3600\ \text{s}}{1\ \text{h}}$

d. $\frac{5280\ \text{f}}{\text{mi}} \cdot \frac{12\ \text{in}}{\text{f}} \cdot \frac{2.54\ \text{cm}}{1\ \text{in}} \cdot \frac{1\ \text{m}}{100\ \text{cm}} \cdot \frac{1\ \text{h}}{3600\ \text{s}}$

e. $\frac{5280\ \text{f}}{\text{mi}} \cdot \frac{12\ \text{in}}{\text{f}} \cdot \frac{2.54\ \text{cm}}{1\ \text{in}} \cdot \frac{1\ \text{m}}{100\ \text{cm}} \cdot \frac{3600\ \text{s}}{1\ \text{h}}$

6. The density of an object is defined as:

a. the volume occupied by each unit of mass.

b. the amount of mass for each unit of volume.

c. the weight of each unit of volume.

d. the amount of the substance that has unit volume and unit mass.

e. the amount of the substance that contains as many particles as 12 grams of the carbon-12 isotope.

7. If you drove day and night without stopping for one year without exceeding the legal speed limit in the United States, the maximum number of miles you could drive would be closest to:

a. 8700.

b. 300, 000.

c. 500,000.

d. 1,000,000.

e. 32,000,000.

Chapter 1

Physics and Measurement

1. Answer: $21,475\ kg/m^3$

2. Answer: 2.00 cm

3. Answer: 150 kg

4. Answer: $45,000\ cm^2$

5. Answer: d

6. Answer: b

7. Answer: c

Chapter 2

Motion in One Dimension

Multiple Choice

1. The position of a particle moving along the x axis is given by $x = (21 + 22t - 6.0t^2)$ m, where t is in s. What is the average velocity during the time interval $t = 1.0$ s to $t = 3.0$ s?

a. –6.0 m / s
b. –4.0 m / s
c. –2.0 m / s
d. –8.0 m / s
e. 8.0 m / s

2. A bullet is fired through a board, 14.0 cm thick, with its line of motion perpendicular to the face of the board. If it enters with a speed of 450 m / s and emerges with a speed of 220 m / s, what is the bullet's acceleration as it passes through the board?

a. –500 km / s^2
b. –550 km / s^2
c. –360 km / s^2
d. –520 km / s^2
e. –275 km / s^2

3. The position of a particle moving along the x axis is given by $x = 6.0t^2 - 1.0t^3$, where x is in meters and t in seconds. What is the position of the particle when it achieves its maximum speed in the positive x direction?

a. 24 m
b. 12 m
c. 32 m
d. 16 m
e. 2.0 m

4. The velocity of a particle moving along the x axis is given for $t > 0$ by $v_x = (32.0t - 2.00t^3)$ m / s, where t is in s. What is the acceleration of the particle when (after $t = 0$) it achieves its maximum displacement in the positive x direction?

a. –64.0 m / s^2
b. zero
c. 128 m / s^2
d. 32.0 m / s^2
e. –32.0 m / s^2

5. The position of a particle as it moves along the x axis is given for $t > 0$ by $x = (t^3 - 3t^2 + 6t)$m, where t is in s. Where is the particle when it achieves its minimum speed (after $t = 0$)?

a. 3 m
b. 4 m
c. 8 m
d. 2 m
e. 7 m

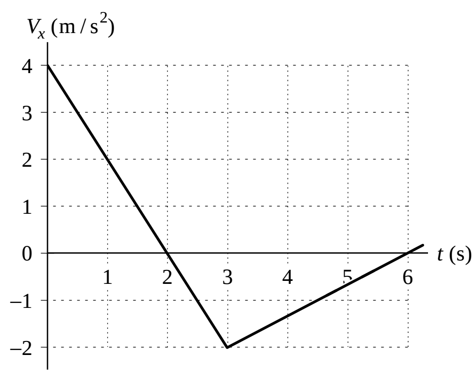
6. The position of a particle as it moves along the x axis is given by $x = 15\,e^{-2t}$ m, where t is in s. What is the acceleration of the particle at $t = 1$ s?

a. 22 m/s
b. 60 m/s
c. 8.1 m/s
d. 15 m/s
e. 35 m/s

7. The position of a particle moving along the x axis is given by $x = 4.0te^{-t}$, where x is in m and t is in s. What is the position of the particle when its acceleration is zero?

a. 1.1 m
b. 3.8 m
c. 1.8 m
d. 2.7 m
e. 6.2 m

8. V_x is the velocity of a particle moving along the x axis as shown. If $x = 2.0$ m at $t = 1.0$ s, what is the position of the particle at $t = 6.0$ s?



a. –2.0 m
b. +2.0 m
c. +1.0 m
d. –1.0 m
e. 6.0 m

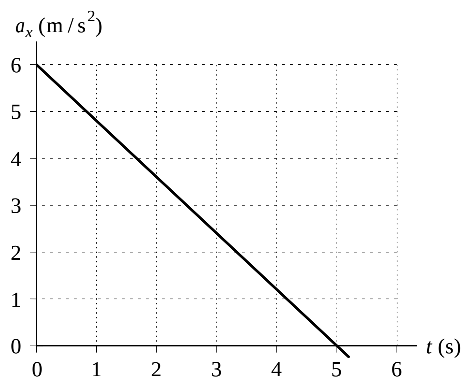
9. A particle moving along the *x* axis has a position given by $x = (24t - 2.0t^3)$ m, where *t* is measured in s. How far is the particle from the origin ($x = 0$) when the particle is not moving?

a. 23 m
b. No distance. The particle is always moving.
c. 32 m
d. 40 m
e. 17m

10. A particle moving along the x axis has a position given by $x = (24t - 2.0t^3)$ m, where *t* is measured in s. What is the magnitude of the acceleration of the particle when the particle is not moving?

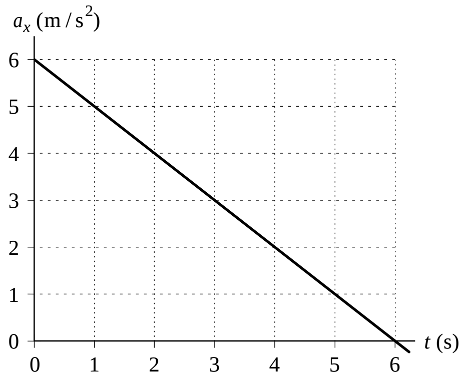
a. 24 m/s^2
b. zero
c. 12 m/s^2
d. 48 m/s^2
e. 36 m/s^2

11. At $t = 0$, a particle is located at $x = 25$ m and has a velocity of 15 m/s in the positive *x* direction. The acceleration of the particle varies with time as shown in the diagram. What is the velocity of the particle at $t = 5.0$ s?



a. +15 m/s
b. –15 m/s
c. +30 m/s
d. 0
e. –1.2 m/s

12. At $t = 0$, a particle is located at $x = 25$ m and has a velocity of 15 m / s in the positive x direction. The acceleration of the particle varies with time as shown in the diagram. What is the position of the particle at $t = 5.0$ s?



a. 175 m
b. 125 m
c. 138 m
d. 154 m
e. 165 m

13. A particle confined to motion along the x axis moves with constant acceleration from $x = 2.0$ m to $x = 8.0$ m during a 2.5-s time interval. The velocity of the particle at $x = 8.0$ m is 2.8 m / s. What is the acceleration during this time interval?

a. 0.48 m / s^2
b. 0.32 m / s^2
c. 0.64 m / s^2
d. 0.80 m / s^2
e. 0.57 m / s^2

14. A proton moving along the x axis has an initial velocity of 4.0×10^6 m / s and a constant acceleration of 6.0×10^{12} m / s^2. What is the velocity of the proton after it has traveled a distance of 80 cm?

a. 5.1×10 m / s
b. 6.3×10 m / s
c. 4.8×10 m / s
d. 3.9×10 m / s
e. 2.9×10 m / s

15. A particle moving with a constant acceleration has a velocity of 20 cm / s when its position is $x = 10$ cm. Its position 7.0 s later is $x = -30$ cm. What is the acceleration of the particle?

a. –7.3 cm / s^2
b. –8.9 cm / s^2
c. –11 cm / s^2
d. –15 cm / s^2
e. –13 cm / s^2

16. An automobile moving along a straight track changes its velocity from 40 m/s to 80 m/s in a distance of 200 m. What is the (constant) acceleration of the vehicle during this time?

a. 8.0 m/s
b. 9.6 m/s
c. 12 m/s
d. 6.9 m/s
e. 0.20 m/s

17. In 2.0 s, a particle moving with constant acceleration along the x axis goes from $x = 10$ m to $x = 50$ m. The velocity at the end of this time interval is 10 m/s. What is the acceleration of the particle?

a. +15 m/s^2
b. +20 m/s^2
c. –20 m/s^2
d. –10 m/s^2
e. –15 m/s^2

18. An automobile manufacturer claims that its product will, starting from rest, travel 0.40 km in 9.0 s. What is the magnitude of the constant acceleration required to do this?

a. 9.9 m/s^2
b. 8.9 m/s^2
c. 6.6 m/s^2
d. 5.6 m/s^2
e. 4.6 m/s^2

19. An automobile traveling along a straight road increases its speed from 30.0 m/s to 50.0 m/s in a distance of 180 m. If the acceleration is constant, how much time elapses while the auto moves this distance?

a. 6.00 s
b. 4.50 s
c. 3.60 s
d. 4.00 s
e. 9.00 s

20. An object moving on the x axis with a constant acceleration increases its x coordinate by 80 m in a time of 5.0 s and has a velocity of +20 m/s at the end of this time. Determine the acceleration of the object during this motion.

a. –1.6 m/s^2
b. +6.4 m/s^2
c. +1.6 m/s^2
d. –2.0 m/s^2
e. –6.4 m/s^2

21. An electron, starting from rest and moving with a constant acceleration, travels 2.0 cm in 5.0 ms. What is the magnitude of this acceleration?

a. 2.5 km/s^2
b. 0.80 km/s^2
c. 1.6 km/s^2
d. 1.3 km/s^2
e. 3.2 km/s^2

22. A particle starts from rest at $x = 0$ and moves for 10 s with an acceleration of +2.0 cm/s^2. For the next 20 s, the acceleration of the particle is –1.0 cm/s^2. What is the position of the particle at the end of this motion?

a. zero
b. +3.0 m
c. –1.0 m
d. +2.0 m
e. –3.0 m

23. A rocket, initially at rest, is fired vertically with an upward acceleration of 10 m/s^2. At an altitude of 0.50 km, the engine of the rocket cuts off. What is the maximum altitude it achieves?

a. 1.9 km
b. 1.3 km
c. 1.6 km
d. 1.0 km
e. 2.1 km

24. A ball is thrown vertically upward with an initial speed of 20 m/s. Two seconds later, a stone is thrown vertically (from the same initial height as the ball) with an initial speed of 24 m/s. At what height above the release point will the ball and stone pass each other?

a. 17 m
b. 21 m
c. 18 m
d. 27 m
e. 31 m

25. An object is thrown vertically and has an upward velocity of 18 m/s when it reaches one fourth of its maximum height above its launch point. What is the initial (launch) speed of the object?

a. 35 m/s
b. 25 m/s
c. 30 m/s
d. 21 m/s
e. 17 m/s

26. A stone is thrown from the top of a building with an initial velocity of 20 m/s downward. The top of the building is 60 m above the ground. How much time elapses between the instant of release and the instant of impact with the ground?

a. 2.0 s
b. 6.1 s
c. 3.5 s
d. 1.6 s
e. 1.0 s

27. An object is thrown downward with an initial (t = 0) speed of 10 m/s from a height of 60 m above the ground. At the same instant (t = 0), a second object is propelled vertically upward from ground level with a speed of 40 m/s. At what height above the ground will the two objects pass each other?

a. 53 m
b. 41 m
c. 57 m
d. 46 m
e. 37 m

28. A toy rocket, launched from the ground, rises vertically with an acceleration of 20 m/s^2 for 6.0 s until its motor stops. Disregarding any air resistance, what maximum height above the ground will the rocket achieve?

a. 1.1 km
b. 0.73 km
c. 1.9 km
d. 0.39 km
e. 1.5 km

29. A rock is thrown downward from an unknown height above the ground with an initial speed of 10 m/s. It strikes the ground 3.0 s later. Determine the initial height of the rock above the ground.

a. 44 m
b. 14 m
c. 74 m
d. 30 m
e. 60 m

30. A ball thrown vertically from ground level is caught 3.0 s later by a person on a balcony which is 14 m above the ground. Determine the initial speed of the ball.

a. 19 m/s
b. 4.7 m/s
c. 10 m/s
d. 34 m/s
e. 17 m/s

31. An object is thrown vertically upward such that it has a speed of 25 m/s when it reaches two thirds of its maximum height above the launch point. Determine this maximum height.

a. 64 m
b. 48 m
c. 32 m
d. 96 m
e. 75 m

Conceptual Problems

32. A 50-gram superball traveling at 25 m/s is bounced off a brick wall and rebounds at 22 m/s. A high-speed camera records this event. If the ball is in contact with the wall for 3.5 ms, what is the average acceleration of the ball during this time interval?

33. A boat moves at 10 m/s relative to the water. If the boat is in a river where the current is 2.0 m/s, how long does it take the boat to make a complete round trip of 1.0 km upstream followed by a 1.0 km trip downstream?

34. A bicyclist starts down a hill with an initial speed of 2.0 m/s. She moves down the hill with a constant acceleration, arriving at the bottom of the hill with a speed of 8.0 m/s. If the hill is 12 m long, how long did it take the bicyclist to travel down the hill?

35. An advertisement claims that a certain brand of disc brake can stop a car going 88 km/h in 5.0 s. Determine the alleged acceleration and compare this to the acceleration of gravity.

36. A helicopter descends from a height of 600 m with uniform negative acceleration, reaching the ground at rest in 5.00 minutes. Determine the acceleration of the helicopter and its initial downward velocity.

37. A modern Galileo throws a bowling ball downward off the Leaning Tower with an initial velocity of 3.0 m/s. What is the ball's velocity after 2.0 s?

38. A speedy tortoise can run with a velocity of 10 cm/s and a hare can run 20 times as fast. In a race, they both start at the same time, but the hare stops to rest for 2.0 minutes. The tortoise wins by a shell (20 cm). What was the length of the race?

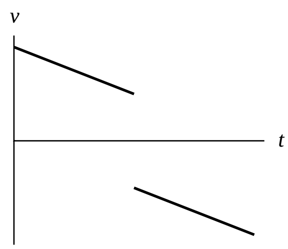
39. A peregrine falcon dives at a pigeon. The falcon starts with zero downward velocity and falls with the acceleration of gravity. If the pigeon is 76.0 m below the initial height of the falcon, how long does it take the falcon to intercept the pigeon?

Conceptual Multiple Choice

40. Two identical balls are at rest and side by side at the top of a hill. You let one ball, A, start rolling down the hill. A little later you start the second ball, B, down the hill by giving it a shove. The second ball rolls down the hill along a line parallel to the path of the first ball and passes it. At the instant ball B passes ball A:

a. it has the same position and the same velocity as A.
b. it has the same position and the same acceleration as A.
c. it has the same velocity and the same acceleration as A.
d. it has the same displacement and the same velocity as A.
e. it has the same displacement and the same acceleration as A.

41. The graph below shows the velocity versus time graph for a ball. Which explanation best fits the motion of the ball as shown by the graph?

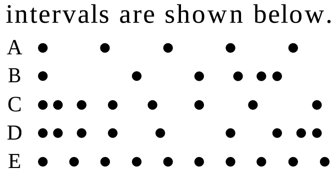


a. The ball is falling, is caught, and is thrown down with greater velocity.
b. The ball is rolling, stops, and then continues rolling.
c. The ball is rising, hits the ceiling, and falls down.
d. The ball is falling, hits the floor, and bounces up.
e. The ball is rising, is caught, and then is thrown down.

42. A boy on a skate board skates off a horizontal bench at a velocity of 10 m/s. One tenth of a second after he leaves the bench to two significant figures the magnitudes of his velocity and acceleration are:

a. 10 m/s; 9.8 m/s^2.
b. 9.0 m/s; 9.8 m/s^2.
c. 9.0 m/s; 9.0 m/s^2.
d. 1.0 m/s; 9.0 m/s^2.
e. 1.0 m/s; 9.8 m/s^2.

43. Five motion diagrams in which points represent the positions of an object at equal time intervals are shown below. Which statement is correct?



a. A has the greatest speed and the greatest acceleration.
b. C has decreasing speed.
c. D slows down and then speeds up.
d. D speeds up and then slows down.
e. E has a greater speed than A.

44. Two children start at one end of a street, the origin, run to the other end, then head back. On the way back Joan is ahead of Mike. Which statement is correct about the distances run and the displacements from the origin?

a. Joan has run a greater distance and her displacement is greater than Mike's.
b. Mike has run a greater distance and his displacement is greater than Joan's.
c. Joan has run a greater distance, but her displacement is less than Mike's.
d. Mike has run a greater distance, but his displacement is less than Joan's.
e. Mike has run a shorter distance, and his displacement is less than Joan's.

45. A juggler throws two balls to the same height so that one is at the halfway point going up when the other is at the halfway point coming down. At that point:

a. Their velocities and accelerations are equal.
b. Their velocities are equal but their accelerations are equal and opposite.
c. Their acclerations are equal but their velocities are equal and opposite.
d. Their velocities and accelerations are both equal and opposite.
e. Their velocities are equal to their accelerations.

Calculation and Concept

46. A car travels north at 30 m/s for one half hour. It then travels south at 40 m/s for 15 minutes. The total distance the car has traveled and its displacement are:

a. 18 km; 18 km S.
b. 36 km; 36 km S.
c. 36 km; 36 km N.
d. 90 km; 18 km N.
e. 90 km; 36 km N.

47. A skier leaves a ski jump with a horizontal velocity of 29.4 m/s. The instant before she lands three seconds later, the magnitudes of the horizontal and vertical components of her velocity are:

a. 0; 29.4 m/s.
b. 29.4 m/s; 0.
c. 29.4 m/s; 29.4 m/s.
d. 29.4 m/s; 41.6 m/s.
e. 41.6 m/s; 41.6 m/s.

Calculation

48. The velocity at the midway point of a ball able to reach a height y when thrown with velocity v_o at the origin is:

a. $\frac{v_0}{2}$ **b.** $\sqrt{v_o^2 - 2gy}$ **c.** $\sqrt{\frac{v_o^2}{2}}$ **d.** $\sqrt{v_o^2+2gy}$ **e.** gy

Chapter 2

Motion in One Dimension

1. Answer: c

2. Answer: b

3. Answer: d

4. Answer: a

5. Answer: b

6. Answer: c

7. Answer: a

8. Answer: d

9. Answer: c

10. Answer: a

11. Answer: c

12. Answer: d

13. Answer: b

14. Answer: a

15. Answer: a

16. Answer: c

17. Answer: d

18. Answer: a

19. Answer: b

20. Answer: c

21. Answer: c

22. Answer: b

23. Answer: d

24. Answer: a

25. Answer: d

26. Answer: a

27. Answer: b

28. Answer: a

29. Answer: c

30. Answer: a

31. Answer: d

32. Answer: 13,430 m/s^2

33. Answer: 208.3 s

34. Answer: 2.4 s

35. Answer: 0.5 g

36. Answer: –0.0133 m/s^2, 4.0 m / s

37. Answer: 22.6 m / s

38. Answer: 12.62 m

39. Answer: 3.94 s

40. Answer: e

41. Answer: c

42. Answer: a

43. Answer: d

44. Answer: c

45. Answer: c

46. Answer: d

47. Answer: c

48. Answer: c

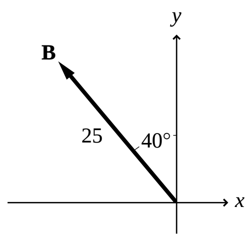
Chapter 3

Vectors

Multiple Choice

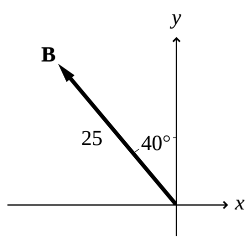
The notation $A = [A, \theta]$ will be a shorthand notation for $A = A \cos\theta\,\mathbf{i} + A \sin\theta\,\mathbf{j}$.

1. If $A = 28\mathbf{i} + 11\mathbf{j}$ and **B** is as shown, what is the magnitude of the sum of these two vectors?



a. 45
b. 35
c. 39
d. 32
e. 64

2. If $A = 30\mathbf{i} + 11\mathbf{j}$ and **B** is as shown, what is the direction of the sum of these two vectors?

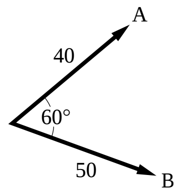


a. 65°
b. 59°
c. 73°
d. 55°
e. 42°

3. If $\mathbf{A} = [15, 80°]$ and $\mathbf{B} = 12\mathbf{i} - 16\mathbf{j}$, what is the magnitude of $\mathbf{A} - \mathbf{B}$?

a. 15
b. 35
c. 32
d. 5.0
e. 23

4. Vectors **A** and **B** are shown. What is the magnitude of a vector **C** if **C** = **A** – **B**?



a. 46
b. 10
c. 30
d. 78
e. 90

5. If **A** = 12**i** – 16**j** and **B** = –24**i** + 10**j**, what is the magnitude of the vector **C** = 2**A** – **B**?

a. 42
b. 22
c. 64
d. 90
e. 13

6. If **A** = 12**i** – 16**j** and **B** = –24**i** + 10**j**, what is the direction of the vector **C** = 2**A** – **B**?

a. –49°
b. –41°
c. –90°
d. +49°
e. +21°

7. If **C** = [10 m, 30°] and **D** = [25 m, 130°], what is the magnitude of the sum of these two vectors?

a. 20 m
b. 35 m
c. 15 m
d. 25 m
e. 50 m

8. If **C** = [10 m, 30°] and **D** = [25 m, 130°], what is the direction of the sum of these two vectors?

a. 17°
b. 73°
c. 107°
d. 163°
e. 100°

9. A vector, **B**, when added to the vector **C** = 3**i** + 4**j** yields a resultant vector which is in the positive *y* direction and has a magnitude equal to that of **C**. What is the magnitude of **B**?

a. 3.2
b. 6.3
c. 9.5
d. 18
e. 5

10. If vector **B** is added to vector **A**, the result is 6**i** + **j**. If **B** is subtracted from **A**, the result is –4**i** + 7**j**. What is the magnitude of **A**?

a. 5.1
b. 4.1
c. 5.4
d. 5.8
e. 8.2

11. If **C** = [2.5 cm, 80°], i.e., the magnitude and direction of **C** are 2.5 cm and 80°, **D** = [3.5 cm, 120°], and **E** = **D** – 2**C**, then what is the direction of **E** (to the nearest degree)?

a. 247°
b. 235°
c. 243°
d. 216°
e. 144°

12. If vector **C** is added to vector **B**, the result is –9**i** – 8**j**. If **B** is subtracted from **C**, the result is 5**i** + 4 **j**. What is the direction of **B** (to the nearest degree)?

a. 225°
b. 221°
c. 230°
d. 236°
e. 206°

13. A vector **A** is added to **B** = 6**i** – 8**j**. The resultant vector is in the positive *x* direction and has a magnitude equal to **A**. What is the magnitude of **A**?

a. 11
b. 5.1
c. 7.1
d. 8.3
e. 12.2

14. A vector **A** is added to **B** = 6**i** – 8**j**. The resultant vector is in the positive *x* direction and has a magnitude equal to that of **A**. What is the direction of **A**?

a. 74°
b. 100°
c. –81°
d. –62°
e. 106°

15. If vectors **A** and **B** are added, the resultant has a magnitude equal to 4.0. If the two are subtracted, the resultant has a magnitude equal to 8.0. What is the magnitude of **B**?

a. 6.1
b. 4.9
c. 8.6
d. 9.8
e. 7.6

16. If vector **A** is added to vector **B** which has a magnitude of 5.0, a third vector results that is perpendicular to **A** and has a magnitude that is twice that of **A**. What is the magnitude of **A**?

a. 2.2
b. 2.5
c. 4.5
d. 5.0
e. 7.0

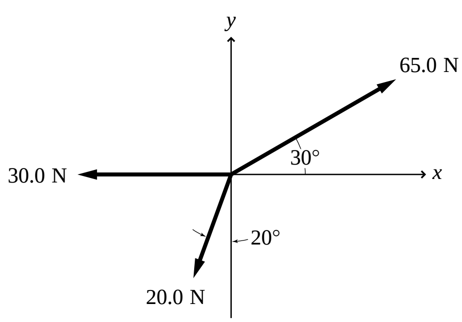
17. Starting from one oasis, a camel walks 25 km in a direction 30° south of west and then walks 30 km toward the north to a second oasis. What distance separates the two oases?

a. 15 km
b. 48 km
c. 28 km
d. 53 km
e. 55 km

18. Starting from one oasis, a camel walks 25 km in direction 30° south of west and then walks 30 km toward the north to a second oasis. What is the direction from the first oasis to the second oasis?

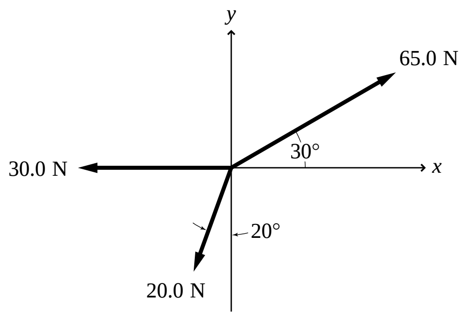
a. 21° N of W
b. 39° W of N
c. 69° N of W
d. 51° W of N
e. 42° W of N

19. The three forces shown act on a particle. What is the magnitude of the resultant of these three forces?



a. 27.0 N **b.** 33.0 N **c.** 36.0 N
d. 24.0 N **e.** 105 N

20. The three forces shown act on a particle. What is the direction of the resultant of these three forces?



a. 35°
b. 45°
c. 65°
d. 55°
e. 85°

21. If vector **C** is added to vector **D**, the result is a third vector that is perpendicular to **D** and has a magnitude equal to 3**D**. What is the ratio of the magnitude of **C** to that of **D**?

a. 1.8
b. 2.2
c. 3.2
d. 1.3
e. 1.6

Conceptual Problems

22. A hunter wishes to cross a river that is 1.5 km wide and flows with a velocity of 5.0 km/h parallel to its banks. The hunter uses a small powerboat that moves at a maximum speed of 12 km/h with respect to the water. What is the minimum time for crossing?

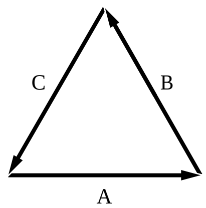
23. Raindrops are falling straight downward. When observed from a car traveling at 55 mi/h, the drops streak the side window at an angle of 60 with the vertical. Find the speed with which the drops are falling.

24. A fast duck is flying (20**i** + 40**j**) mi/h at the same altitude as a slow airplane flying with a velocity of (–80**i** + 40**j**) mi/h. How fast and in what direction is the duck moving relative to the airplane?

25. Two vectors starting at the same origin have equal and opposite *x*-components. Is it possible for the two vectors to be perpendicular to each other? Justify your answer.

Conceptual Multiple Choice

26. The diagram below shows 3 vectors which sum to zero, all of equal length. Which statement below is true?



a. **A** + **B** = **A** – **C**
b. **A** + **B** = **B** – **C**
c. **A** – **B** = 2**A** – **C**
d. **A – B** = 2**A** + **C**
e. 2**A** + 2**B** = 2**C**

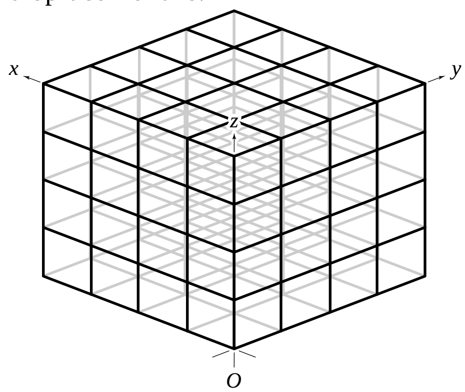
27. Which statement is true about the unit vectors **i**, **j** and **k**?

a. Their directions are defined by a left-handed coordinate system.
b. The angle between any two is 90 degrees.
c. Each has a length of 1 m.
d. If **i** is directed east and **j** is directed south, **k** points up out of the surface.
e. All of the above.

28. We know the signs of the components of two vectors, **A** and **B**, which have equal magnitudes. The signs are: A_x negative; A_y positive; B_x negative; B_y negative. Which statement is always true?

a. **A** + **B** = 0.
b. **A** – **B** = 0.
c. **A** – **B** is perpendicular to **A** + **B**.
d. **B** – **A** is perpendicular to **A** – **B**.
e. The magnitude of **A** – **B** equals the magnitude of **A** + **B**.

29. A child starts at one corner of a cubical jungle gym in a playground and climbs up to the diagonally opposite corner. The original corner is the coordinate origin, and the *x*-, *y*- and *z*-axes are oriented along the jungle gym edges. The length of each side is 2m. The child's displacement is:



a. 2**i** + 2**j** + 2**k**.
b. 2.8**i** + 2.8**j** + 2**k**
c. 2**i** + 2**j** + 2.8**k**
d. 2**i** + 2**j** + 3.5**k**
e. 3.5**i** + 3.5**j** + 3.5**k**

30. The displacement of the tip of the 10 cm long minute hand of a clock between 12:15 A.M. and 12:45 P.M. is:

a. 10 cm, 90°
b. 10 cm, + 180°
c. 10 cm, 4500°
d. 20 cm, 180°
e. 20 cm, 540°

31. A student decides to spend spring break by driving 50 miles due east, then 50 miles 30 degrees south of east, then 50 miles 30 degrees south of that direction, and to continue to drive 50 miles deviating by 30 degrees each time until he returns to his original position. How far will he drive, and how many vectors must he sum to calculate his displacement?

a. 0, 0
b. 0, 8
c. 0, 12
d. 400 mi, 8
e. 600 mi, 12

32. Jane plans to fly from Binghampton, New York, to Springfield, Massachusetts, about 280 km due east of Binghampton. She heads due east for one hour but finds herself at Keene, which is 294 miles from Binghampton in a direction 17.8 degrees north of due east. What was the wind velocity?

a. 14 mph, E
b. 14 mph, W
c. 14 mph, N
d. 90 mph, S
e. 90 mph, N

Chapter 3

Vectors

1. Answer: d

2. Answer: a

3. Answer: c

4. Answer: a

5. Answer: c

6. Answer: b

7. Answer: d

8. Answer: c

9. Answer: a

10. Answer: b

11. Answer: d

12. Answer: b

13. Answer: d

14. Answer: a

15. Answer: b

16. Answer: a

17. Answer: c

18. Answer: d

19. Answer: d

20. Answer: a

21. Answer: c

22. Answer: 0.13 h

23. Answer: 31.7 mi/h

24. Answer: 100 mi/h, along +*i*

25. Answer: Yes. If the *y*-components are of the right magnitudes, the angle can be 90 degrees. (This will occur if $\theta_2 = \theta_1 + \frac{\pi}{2}$ and $B = A \tan \theta_1$.)

26. Answer: d

27. Answer: b

28. Answer: c

29. Answer: a

30. Answer: d

31. Answer: e

32. Answer: e

Chapter 4

Motion in Two Dimensions

Multiple Choice

1. A particle starts from the origin at $t = 0$ with a velocity of 8.0**j** m/s and moves in the xy plane with a constant acceleration of (4.0i + 2.0**j**) m/s^2. At the instant the x coordinate of the particle is 29 m, what is the value of its y coordinate?

a. 35 m
b. 39 m
c. 45 m
d. 42 m
e. 29 m

2. At $t = 0$, a particle leaves the origin with a velocity of 9.0 m/s in the positive y direction and moves in the xy plane with a constant acceleration of (2.0**i** – 4.0**j**) m/s^2. At the instant the x coordinate of the particle is 15 m, what is the speed of the particle?

a. 10 m/s
b. 16 m/s
c. 12 m/s
d. 14 m/s
e. 26 m/s

3. A particle starts from the origin at $t = 0$ with a velocity of 6.0**i** m/s and moves in the xy plane with a constant acceleration of (–2.0**i** + 4.0**j**) m/s^2. At the instant the particle achieves its maximum positive x coordinate, how far is it from the origin?

a. 36 m
b. 20 m
c. 45 m
d. 27 m
e. 37 m

4. A particle leaves the origin with a velocity of 7.2 m/s in the positive y direction and moves in the xy plane with a constant acceleration of (3.0**i** – 2.0**j**) m/s^2. At the instant the particle moves back across the x axis ($y = 0$), what is the value of its x coordinate?

a. 65 m
b. 91 m
c. 54 m
d. 78 m
e. 86 m

5. At $t = 0$ a particle leaves the origin with a velocity of 5.0 m/s in the positive y direction. Its acceleration is given by $\mathbf{a} = (3.0\mathbf{i} - 2.0\mathbf{j})$ m/s^2. At the instant the particle reaches its maximum y coordinate how far is the particle from the origin?

a. 11 m
b. 16 m
c. 22 m
d. 29 m
e. 19 m

6. A particle moves in the xy plane with a constant acceleration given by $\mathbf{a} = -4.0\mathbf{j}$ m/s^2. At $t = 0$ its position and velocity are $10\mathbf{i}$ m and $(-2.0\mathbf{i} + 8.0\mathbf{j})$ m/s, respectively. What is the distance from the origin to the particle at $t = 2.0$ s?

a. 6.4 m
b. 10 m
c. 8.9 m
d. 2.0 m
e. 6.2 m

7. A particle starts from the origin at $t = 0$ with a velocity of $(16\mathbf{i} - 12\mathbf{j})$ m/s and moves in the xy plane with a constant acceleration of $\mathbf{a} = (3.0\mathbf{i} - 6.0\mathbf{j})$ m/s^2. What is the speed of the particle at $t = 2.0$ s?

a. 52 m/s
b. 39 m/s
c. 46 m/s
d. 33 m/s
e. 43 m/s

8. At $t = 0$, a particle leaves the origin with a velocity of 12 m/s in the positive x direction and moves in the xy plane with a constant acceleration of $(-2.0\mathbf{i} + 4.0\mathbf{j})$ m/s^2. At the instant the y coordinate of the particle is 18 m, what is the x coordinate of the particle?

a. 30 m
b. 21 m
c. 27 m
d. 24 m
e. 45 m

9. At $t = 0$, a particle leaves the origin with a velocity of 12 m/s in the positive y direction and moves in the xy plane with a constant acceleration of $(2.0\mathbf{i} - 4.0\mathbf{j})$ m/s^2. At the instant the particle moves back across the x axis ($y = 0$), what is the speed of the particle?

a. 16 m/s
b. 17 m/s
c. 18 m/s
d. 14 m/s
e. 22 m/s

10. The initial speed of a cannon ball is 0.20 km/s. If the ball is to strike a target that is at a horizontal distance of 3.0 km from the cannon, what is the minimum time of flight for the ball?

a. 16 s
b. 21 s
c. 24 s
d. 14 s
e. 19 s

11. A ball is thrown horizontally from the top of a building 0.10 km high. The ball strikes the ground at a point 65 m horizontally away from and below the point of release. What is the speed of the ball just before it strikes the ground?

a. 43 m/s
b. 47 m/s
c. 39 m/s
d. 36 m/s
e. 14 m/s

12. A baseball is hit at ground level. The ball is observed to reach its maximum height above ground level 3.0 s after being hit. And 2.5 s after reaching this maximum height, the ball is observed to barely clear a fence that is 97.5 m from where it was hit. How high is the fence?

a. 8.2 m
b. 15.8 m
c. 13.4 m
d. 11.0 m
e. 4.9 m

13. A rock is projected from the edge of the top of a building with an initial velocity of 12.2 m/s at an angle of 53° above the horizontal. The rock strikes the ground a horizontal distance of 25 m from the base of the building. Assume that the ground is level and that the side of the building is vertical. How tall is the building?

a. 25.3 m
b. 29.6 m
c. 27.4 m
d. 23.5 m
e. 18.9 m

14. A rock is projected from ground level. Later, 4.0 s after being projected, the rock is observed to strike the top of a 9.75 m tall fence that is a horizontal distance of 240 ft from the point of projection. Determine the speed with which the rock was projected.

a. 27.7 m/s
b. 29.6 m/s
c. 28.7 m/s
d. 26.8 m/s
e. 25.8 m/s

15. A projectile is thrown from the top of a building with an initial velocity of 30 m/s in the horizontal direction. If the top of the building is 30 m above the ground, how fast will the projectile be moving just before it strikes the ground?

a. 35 m/s
b. 39 m/s
c. 31 m/s
d. 43 m/s
e. 54 m/s

16. The initial speed of a projectile is 80 m/s. If the projectile is to strike a target that is a horizontal distance of 0.45 km away, what is the minimum time of flight?

a. 9.0 s
b. 6.9 s
c. 7.8 s
d. 6.1 s
e. 5.6 s

17. A rifle is aimed horizontally at the center of a large target 60 m away. The initial speed of the bullet is 240 m/s. What is the distance from the center of the target to the point where the bullet strikes the target?

a. 48 cm
b. 17 cm
c. 31 cm
d. 69 cm
e. 52 cm

18. A rock is projected from the edge of the top of a 100-ft tall building at some unknown angle above the horizontal. The rock strikes the ground a horizontal distance of 160 ft from the base of the building 5.0 s after being projected. Assume that the ground is level and that the side of the building is vertical. Determine the speed with which the rock was projected.

a. 72 ft/s
b. 77 ft/s
c. 68 ft/s
d. 82 ft/s
e. 87 ft/s

19. An airplane flies horizontally with a speed of 300 m/s at an altitude of 400 m. Assume that the ground is level. What horizontal distance from a target must the pilot release a bomb so as to hit the target?

a. 3.0 km
b. 2.4 km
c. 3.3 km
d. 2.7 km
e. 1.7 km

20. An object moving at a constant speed requires 6.0 s to go once around a circle with a diameter of 4.0 m. What is the magnitude of the instantaneous acceleration of the particle during this time?

a. 2.2 m/s^2
b. 2.7 m/s^2
c. 3.3 m/s^2
d. 3.8 m/s^2
e. 2.9 m/s^2

21. A particle moves at a constant speed in a circular path with a radius of 2.0 cm. If the particle makes four revolutions each second, what is the magnitude of its acceleration?

a. 20 m/s^2
b. 18 m/s^2
c. 13 m/s^2
d. 15 m/s^2
e. 24 m/s^2

22. A race car moving with a constant speed of 60 m/s completes one lap around a circular track in 50 s. What is the magnitude of the acceleration of the race car?

a. 8.8 m/s^2
b. 7.5 m/s^2
c. 9.4 m/s^2
d. 6.3 m/s^2
e. 5.3 m/s^2

23. At the lowest point in a vertical dive (radius = 0.60 km), an airplane has a speed of 300 km/h which is not changing. Determine the magnitude of the acceleration of the pilot at this lowest point.

a. 26 m/s^2
b. 21 m/s^2
c. 16 m/s^2
d. 12 m/s^2
e. 8.8 m/s^2

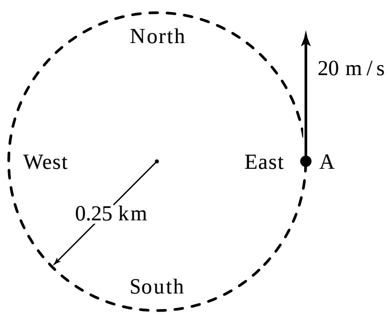
24. A carnival Ferris wheel has a 15-m radius and completes five turns about its horizontal axis every minute. What is the acceleration of a passenger at his lowest point during the ride?

a. 5.7 m/s^2 downward
b. 4.1 m/s^2 upward
c. 14 m/s^2 downward
d. 4.1 m/s^2 downward
e. 19 m/s^2 downward

25. A space station of diameter 80 m is turning about its axis at a constant rate. If the acceleration of the outer rim of the station is 2.5 m/s^2, what is the period of revolution of the space station?

a. 22 s
b. 19 s
c. 25 s
d. 28 s
e. 40 s

26. A car travels counterclockwise around a flat circle of radius 0.25 km at a constant speed of 20 m/s. When the car is at point A as shown in the figure, what is the car's acceleration?



a. 1.6 m/s^2, east
b. Zero
c. 1.6 m/s^2, east
d. 1.6 m/s^2, north
e. 1.6 m/s^2, west

27. A particle moves along a circular path having a radius of 2.0 m. At an instant when the speed of the particle is equal to 3.0 m/s and changing at the rate of 5.0 m/s^2, what is the magnitude of the total acceleration of the particle?

a. 7.5 m/s^2
b. 6.0 m/s^2
c. 5.4 m/s^2
d. 6.7 m/s^2
e. 4.5 m/s^2

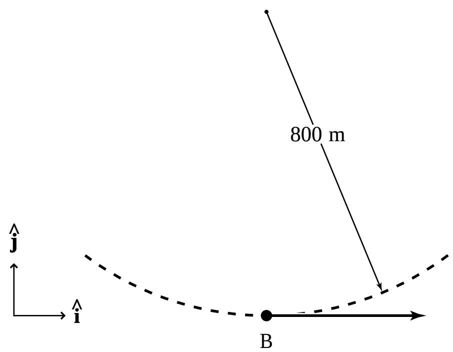
28. A car travels in a flat circle of radius R. At a certain instant the velocity of the car is 20 m/s north, and the total acceleration of the car is 2.5 m/s^2 37° south of west. Which of the following is correct?

a. R = 0.40 km, and the car's speed is decreasing.
b. R = 0.20 km, and the car's speed is decreasing.
c. R = 0.20 km, and the car's speed is increasing.
d. R = 0.16 km, and the car's speed is increasing.
e. R = 0.16 km, and the car's speed is decreasing.

29. A car travels in a flat circle of radius R. At a certain instant the velocity of the car is 24 m / s west, and the total acceleration of the car is 2.5 m / s^2 53° north of west. Which of the following is correct?

a. R = 0.29 km, and the car's speed is increasing.
b. R = 0.23 km, and the car's speed is decreasing.
c. R = 0.23 km, and the car's speed is increasing.
d. R = 0.29 km, and the car's speed is decreasing
e. R = 0.29 km, and the car's speed is constant.

30. A stunt pilot performs a circular dive of radius 800 m. At the bottom of the dive (point B in the figure) the pilot has a speed of 200 m / s which at that instant is increasing at a rate of 20 m / s^2. What acceleration does the pilot have at point B?



a. (50**i** + 20**j**) m / s^2
b. (20**i** – 50**j**) m / s^2
c. (20**i** + 50**j**) m / s^2
d. (–20**i** + 50**j**) m / s^2
e. (–50**i** + 20**j**) m / s^2

31. The speed of a particle moving in a circle 2.0 m in radius increases at the constant rate of 4.4 m / s^2. At an instant when the magnitude of the total acceleration is 6.0 m / s^2, what is the speed of the particle?

a. 3.9 m / s
b. 2.9 m / s
c. 3.5 m / s
d. 3.0 m / s
e. 1.4 m / s

32. A car travels in a flat circle of radius *R*. At a certain instant the velocity of the car is 24 m / s, west and the acceleration of the car has components of 2.4 m / s^2 east and 1.8 m / s^2 south. What is the radius of the circle?

a. 0.24 km
b. 0.19 km
c. 0.32 km
d. 0.14 km
e. 0.27 km

33. A particle moves in the *xy* plane in a circle centered on the origin. At a certain instant the velocity and acceleration of the particle are 6.0**i** m/s and (3.0**i** + 4.0**j**) m/s^2. What are the *x* and *y* coordinates of the particle at this moment?

a. $x = 0$, $y = -9.0$ m
b. $x = 0$, $y = +7.2$ m
c. $x = 0$, $y = +9.0$ m
d. $x = 0$, $y = -7.2$ m
e. $x = 6.0$, $y = -9.0$ m

34. A particle moves in the *xy* plane in a circle centered on the origin. At a certain instant the velocity and acceleration of the particle are 4.0**j** m/s, and (–3.0**i** – 2.0**j**) m/s^2. What are the *x* and *y* coordinates of the particle at this moment?

a. $x = -4.4$ m, $y = 0$
b. $x = +5.3$ m, $y = 0$
c. $x = -5.3$ m, $y = 0$
d. $x = +4.4$ m, $y = 0$
e. $x = -1.8$ m, $y = 0$

35. A 0.14-km wide river flows with a uniform speed of 4.0 m/s toward the east. It takes 20 s for a boat to cross the river to a point directly north of its departure point on the south bank. What is the speed of the boat relative to the water?

a. 5.7 m/s
b. 8.5 m/s
c. 8.1 m/s
d. 7.0 m/s
e. 6.4 m/s

36. A 0.20-km wide river has a uniform flow speed of 4.0 m/s toward the east. It takes 20 s for a boat to cross the river to a point directly north of its departure point on the south bank. In what direction must the boat be pointed so as to accomplish this?

a. 23° west of north
b. 21° west of north
c. 24° west of north
d. 22° west of north
e. 17° west of north

37. A 0.20-km wide river has a uniform flow speed of 3.0 m/s toward the east. A boat with a speed of 8.0 m/s relative to the water leaves the south bank and heads in such a way that it crosses to a point directly north of its departure point. How long does it take the boat to cross the river?

a. 29 s
b. 23 s
c. 25 s
d. 27 s
e. 17 s

38. A river has a steady speed of 0.30 m / s. A student swims downstream a distance of 1.2 km and returns to the starting point. If the student swims with respect to the water at a constant speed and the downstream portion of the swim requires 20 minutes, how much time is required for the entire swim?

a. 50 minutes
b. 80 minutes
c. 90 minutes
d. 70 minutes
e. 60 minutes

39. The pilot of an aircraft flies due north relative to the ground in a wind blowing 40 km / h toward the east. If his speed relative to the ground is 80 km / h, what is the speed of his airplane relative to the air?

a. 89 km / h
b. 85 km / h
c. 81 km / h
d. 76 km / h
e. 72 km / h

40. A car travels in a due northerly direction at a speed of 55 km / h. The traces of rain on the side windows of the car make an angle of 60 degrees with respect to the horizontal. If the rain is falling vertically with respect to the earth, what is the speed of the rain with respect to the earth?

a. 48 km / h
b. 95 km / h
c. 58 km / h
d. 32 km / h
e. 80 km / h

Conceptual Problems

41. Wiley Coyote has missed the elusive roadrunner once again. This time, he leaves the edge of the cliff at 50 m / s horizontal velocity. If the canyon is 100 m deep, how far from the edge of the cliff does the coyote land?

42. A track star in the broad jump goes into the jump at 12 m / s and launches himself at 20° above the horizontal. How long is he in the air before returning to Earth?

43. An artillery shell is fired with an initial velocity of 300 m / s at 55° above the horizontal. It explodes on a mountainside 42 s after firing. If x is horizontal and y vertical, find the (x, y) coordinates where the shell explodes.

44. In a TV set, an electron beam moves horizontally at 3.0×10^7 m / s across the cathode ray tube and strikes the screen, 42 cm away. How far does the electron beam fall while traversing this distance?

45. A football is thrown upward at a 30° angle to the horizontal. To throw a 40.0-m pass, what must be the initial speed of the ball?

46. A satellite is in a circular orbit 600 km above the Earth's surface. The acceleration of gravity is 8.21 m/s^2 at this altitude. The radius of the Earth is 6400 km. Determine the speed of the satellite, and the time to complete one orbit around the Earth.

47. A tennis player standing 12.6 m from the net hits the ball at 3.0° above the horizontal. To clear the net, the ball must rise at least 0.33 m. If the ball just clears the net at the apex of its trajectory, how fast was the ball moving when it left the racket?

48. A rifle is aimed horizontally toward the center of a target 0.10 km away, but the bullet strikes 10 cm below the center. Calculate the velocity of the bullet just as it emerges from the rifle.

Multiple Choice Conceptual Problems

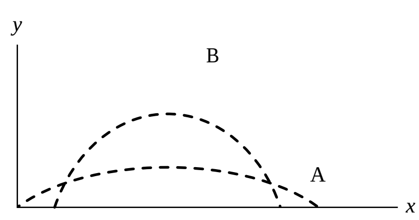
49. Two cars are traveling around identical circular racetracks. Car A travels at a constant speed of 20 m/s. Car B starts at rest and speeds up with constant tangential acceleration until its speed is 40 m/s. When car B has the same (tangential) velocity as car A, it is always true that:

a. it is passing car A.
b. it has the same linear (tangential) acceleration as car A.
c. it has the same centripetal acceleration as car A.
d. it has the same total acceleration as car A.
e. it has traveled farther than car A since starting.

50. A student in the front of a school bus tosses a ball to another student in the back of the bus while the bus is moving forward at constant velocity. The *speed* of the ball as seen by a stationary observer in the street:

a. is less than that observed inside the bus.
b. is the same as that observed inside the bus.
c. is greater than that observed inside the bus.
d. may be either greater or smaller than that observed inside the bus.
e. cannot be determined without knowing the magnitudes of the velocities.

51. Two balls, projected at different times so they don't collide, have trajectories A and B, as shown below.



Which statement is correct?

a. v_{oB} must be greater than v_{oA}.
b. Ball A is in the air for a longer time than ball B.
c. Ball B is in the air for a longer time than ball A.
d. Ball B has a greater acceleration than ball A.
e. Ball A has a greater acceleration than ball B.

52. The vector **r** indicates the instantaneous displacement of a projectile from the origin. **v** is the instantaneous velocity of the projectile and **a** its acceleration when at **r**. Which statement is correct?

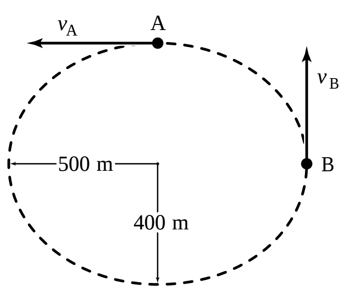
a. **v** is always perpendicular to **r**.
b. **a** is always perpendicular to **r.**
c. **a** is always perpendicular to **v**.
d. **a** is always perpendicular to $\mathbf{v}_x$.
e. **a** is always perpendicular to $\mathbf{v}_y$.

53. A projectile starts at the coordinate origin, where the displacement vector also originates. The initial velocity, $\mathbf{v}_0$, makes an angle θ_0 with the horizontal where $0 < \theta < 90°$. At the instant when the projectile is at the highest point of its trajectory, the displacement, velocity and acceleration vectors are **r**, **v** and **a**. Which statement is true?

a. **r** is parallel to **v**.
b. **r** is perpendicular to **v**.
c. **v** is parallel to **a**.
d. **v** is perpendicular to **a**.
e. **r** is perpendicular to **a**.

Conceptual and Calculation

54. A car travels in an oval path as shown below. $\mathbf{v}_A$ = 25 m/s, West, and $\mathbf{v}_B$ = 20 m/s, North. The ratio of the magnitude of the acceleration at B to that at A, $\dfrac{a_B}{a_A}$ is:



a. 0.512 **b.** 0.64 **c.** 0.8 **d.** 1.25 **e.** 1.56

55. Two cooks standing side by side in a restaurant pull their beaters out of the dough at the same instant. A glob of dough flies off each beater. Each glob lands on the top of a tin the same horizontal distance away and at its initial height. However, one lands later than the other. The explanation is that they left the beaters at angles θ_1 and θ_2 such that:

a. $\theta_2 = -\theta_1$.
b. $\theta_1 + \theta_2 = \dfrac{\pi}{4}$.
c. $\theta_1 + \theta_2 = \dfrac{\pi}{2}$.
d. $\theta_1 + \theta_2 = \pi$.
e. $\theta_1 - \theta_2 = \pi$.

Chapter 4

Motion in Two Dimensions

1. Answer: c

2. Answer: a

3. Answer: b

4. Answer: d

5. Answer: a

6. Answer: b

7. Answer: d

8. Answer: c

9. Answer: b

10. Answer: a

11. Answer: b

12. Answer: c

13. Answer: d

14. Answer: c

15. Answer: b

16. Answer: d

17. Answer: c

18. Answer: c

19. Answer: d

20. Answer: a

21. Answer: c

22. Answer: b

23. Answer: d

24. Answer: a

25. Answer: c

26. Answer: e

27. Answer: d

28. Answer: b

29. Answer: a

30. Answer: c

31. Answer: b

32. Answer: c

33. Answer: a

34. Answer: b

35. Answer: c

36. Answer: d

37. Answer: d

38. Answer: d

39. Answer: a

40. Answer: b

41. Answer: 225 m

42. Answer: 0.83 s

43. Answer: 7227 m, 1678 m

44. Answer: 9.6×10^{-16} m

45. Answer: 21.3 m / s

46. Answer: 7580 m / s, 5800 s

47. Answer: 48.6 m / s

48. Answer: 700 m / s

49. Answer: c

50. Answer: d

51. Answer: c

52. Answer: d

53. Answer: d

54. Answer: a

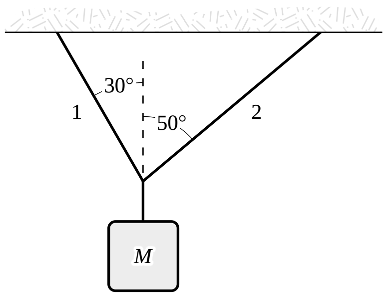
55. Answer: c

Chapter 5A

The Laws of Motion

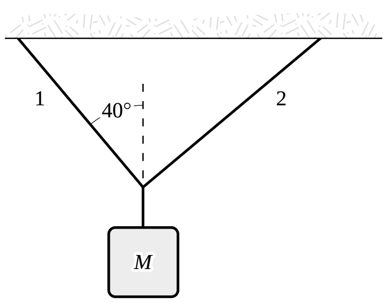
Multiple Choice

1. In the figure, if the tension in string 1 is 23 N, what is the mass of the object shown?



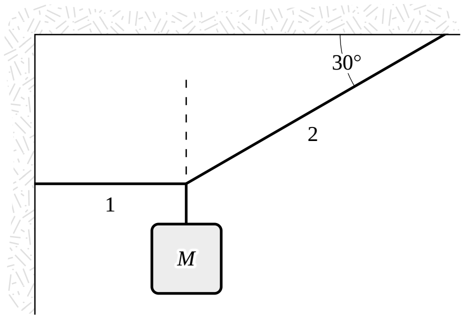
a. 3.8 kg
b. 3.4 kg
c. 3.0 kg
d. 4.2 kg
e. 5.0 kg

2. In the figure, if the tension in string 1 is 34 N and the tension in string 2 is 24 N, what is the mass of the object shown?



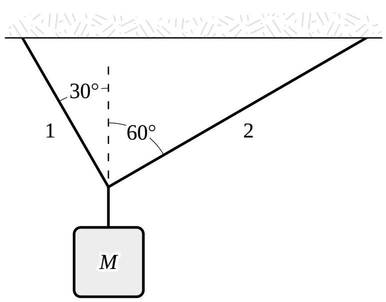
a. 7.3 kg
b. 5.5 kg
c. 1.8 kg
d. 3.7 kg
e. 4.5 kg

3. If M = 2.0 kg, what is the tension in string 1 shown?



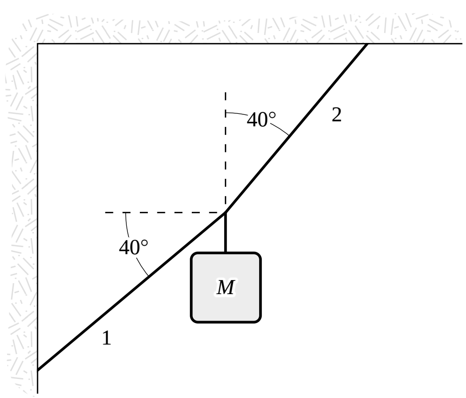
a. 1.2 N
b. 11 N
c. 34 N
d. 3.5 N
e. 40 N

4. If M = 6.0 kg, what is the tension in string 1 shown?



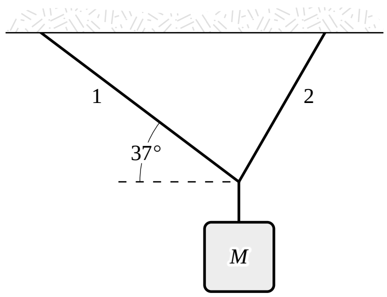
a. 39 N
b. 34 N
c. 29 N
d. 44 N
e. 51 N

5. If M = 1.1 kg, what is the tension in string 1 shown?



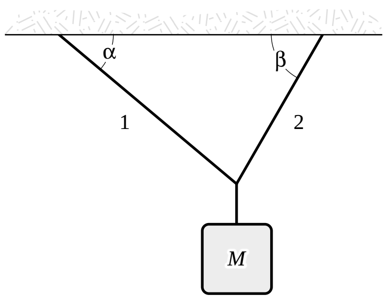
a. 54 N **b.** 47 N **c.** 40 N **d.** 62 N **e.** 57 N

6. An object of unknown weight is suspended as shown. The tension in rope 1 is 25 lb, and the tension in rope 2 is 31 lb. What is the weight of the suspended object?



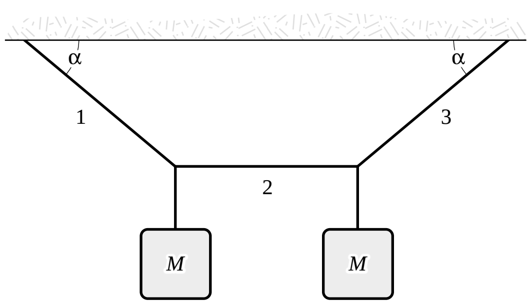
a. 36 lb **b.** 33 lb **c.** 41 lb **d.** 39 lb **e.** 56 lb

7. If $\alpha = 40°$, $\beta = 60°$, and $M = 4.0$ kg, determine the tension in string 1 shown.



a. 15 N
b. 22 N
c. 17 N
d. 20 N
e. 36 N

8. If $\alpha = 40°$ and the tension in string 2 shown is 30 N, determine M.

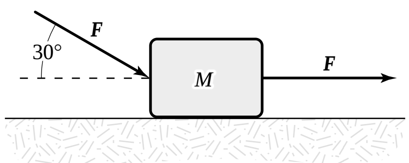


a. 3.4 kg
b. 3.6 kg
c. 2.6 kg
d. 4.9 kg
e. 7.5 kg

9. Two forces are the only forces acting on a 3.0-kg object which moves with an acceleration of 3.0 m/s in the positive y direction. If one of the forces acts in the positive x direction and has a magnitude of 8.0 N, what is the magnitude of the other force?

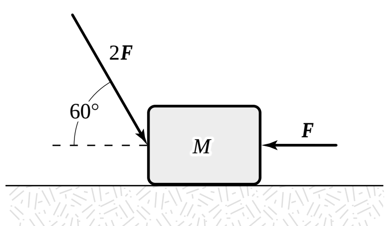
a. 12 N
b. 14 N
c. 16 N
d. 18 N
e. 22 N

10. The horizontal surface shown on which the block slides is frictionless. If F = 20 N and M = 5.0 kg, what is the magnitude of the resulting acceleration of the block?



a. 5.3 m/s^2
b. 6.2 m/s^2
c. 7.5 m/s^2
d. 4.7 m/s^2
e. 3.2 m/s^2

11. The horizontal surface shown on which the block slides is frictionless. If F = 30 N and M = 3.0 kg, what is the magnitude of the resulting acceleration of the block?



a. 6.4 m/s^2
b. 5.7 m/s^2
c. 6.1 m/s^2
d. 5.3 m/s^2
e. 2.8 m/s^2

12. The only two forces acting on a body have magnitudes of 20 N and 35 N and directions that differ by 80°. The resulting acceleration has a magnitude of 20 m/s^2. What is the mass of the body?

a. 2.4 kg
b. 2.2 kg
c. 2.7 kg
d. 3.1 kg
e. 1.5 kg

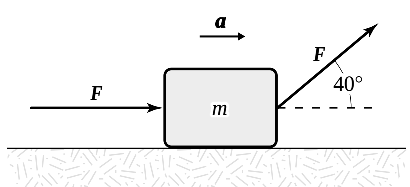
13. If the only forces acting on a 2.0-kg mass are $\mathbf{F}_1 = (3\mathbf{i} - 8\mathbf{j})$ N and $\mathbf{F}_2 = (5\mathbf{i} + 3\mathbf{j})$ N, what is the magnitude of the acceleration of the particle?

a. 1.5 m / s^2
b. 6.5 m / s^2
c. 4.7 m / s^2
d. 9.4 m / s^2
e. 7.2 m / s^2

14. At an instant when a 4.0-kg object has an acceleration equal to $(5\mathbf{i} + 3\mathbf{j})$ m / s^2, one of the two forces acting on the object is known to be $(12\mathbf{i} + 22\mathbf{j})$ N. Determine the magnitude of the other force acting on the object.

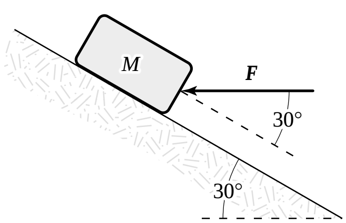
a. 2.0 N
b. 13 N
c. 18 N
d. 1.7 N
e. 20 N

15. If F = 4.0 N and m = 2.0 kg, what is the magnitude a of the acceleration for the block shown? The surface is frictionless.



a. 5.3 m / s^2
b. 4.4 m / s^2
c. 3.5 m / s^2
d. 6.2 m / s^2
e. 8.4 m / s^2

16. A block is pushed up a frictionless 30° incline by an applied force as shown. If F = 25 N and M = 3.0 kg, what is the magnitude of the resulting acceleration of the block?



a. 2.3 m / s^2
b. 4.6 m / s^2
c. 3.5 m / s^2
d. 2.9 m / s^2
e. 5.1 m / s^2

17. A 5.0-kg object is suspended by a string from the ceiling of an elevator that is accelerating downward at a rate of 2.6 m/s^2. What is the tension in the string?

a. 49 N
b. 36 N
c. 62 N
d. 13 N
e. 52 N

18. The tension in a string from which a 4.0-kg object is suspended in an elevator is equal to 44 N. What is the acceleration of the elevator?

a. 11 m/s^2 upward
b. 1.2 m/s^2 upward
c. 1.2 m/s^2 downward
d. 10 m/s^2 upward
e. 2.4 m/s^2 downward

19. What is the magnitude of the *total* force on a driver by the dragster he operates as it accelerates horizontally along a straight line from rest to 60 m/s in 8.0 s? (mass of driver = 80 kg)

a. 0.60 kN
b. 0.78 kN
c. 1.4 kN
d. 0.99 kN
e. 0.60 kN

20. A 5.0-kg mass is attached to the ceiling of an elevator by a rope whose mass is negligible. What force does the mass exert on the rope when the elevator has an acceleration of 4.0 m/s^2 upward?

a. 69 N downward
b. 29 N downward
c. 49 N downward
d. 20 N downward
e. 19 N downward

21. A 5.0-kg mass is suspended by a string from the ceiling of an elevator that is moving upward with a speed which is decreasing at a constant rate of 2.0 m/s in each second. What is the tension in the string supporting the mass?

a. 49 N
b. 39 N
c. 59 N
d. 10 N
e. 42 N

22. A person weighing 0.70 kN rides in an elevator that has an upward acceleration of 1.5 m/s^2. What is the magnitude of the force of the elevator floor on the person?

a. 0.11 kN
b. 0.81 kN
c. 0.70 kN
d. 0.59 kN
e. 0.64 kN

23. A 3.0-kg block slides on a frictionless 20° inclined plane. A force of 16 N acting parallel to the incline and up the incline is applied to the block. What is the acceleration of the block?

a. 2.0 m/s^2 down the incline
b. 5.3 m/s^2 up the incline
c. 2.0 m/s^2 up the incline
d. 3.9 m/s^2 down the incline
e. 3.9 m/s^2 up the incline

24. A 2.0-kg block slides on a frictionless 25° inclined plane. A force of 4.6 N acting parallel to the incline and up the incline is applied to the block. What is the acceleration of the block?

a. 1.8 m/s up the incline
b. 2.3 m/s up the incline
c. 6.6 m/s down the incline
d. 1.8 m/s down the incline
e. 2.3 m/s down the incline

25. A 2.0-kg block slides on a frictionless 15° inclined plane. A force acting parallel to the incline is applied to the block. The acceleration of the block is 1.5 m/s^2 down the incline. What is the applied force?

a. 8.1 N down the incline
b. 3.0 N down the incline
c. 2.1 N up the incline
d. 3.0 N up the incline
e. 8.1 N up the incline

26. A 1.5-kg object has a velocity of 5**j** m/s at $t = 0$. It is accelerated at a constant rate for five seconds after which it has a velocity of (6**i** + 12**j**) m/s. What is the magnitude of the resultant force acting on the object during this time interval?

a. 3.8 N
b. 3.2 N
c. 2.8 N
d. 4.3 N
e. 4.6 N

27. A 1.5-kg object has a velocity of 5**j** m/s at $t = 0$. It is accelerated at a constant rate for five seconds after which it has a velocity of (6**i** + 12**j**) m/s. What is the direction of the resultant force acting on the object during this time interval?

a. 65°
b. 56°
c. 61°
d. 49°
e. 27°

28. A 2.0-kg object has a velocity of 4.0**i** m/s at $t = 0$. A constant resultant force of (2.0**i** + 4.0**j**) N then acts on the object for 3.0 s. What is the magnitude of the object's velocity at the end of the 3.0-s interval?

a. 9.2 m/s
b. 6.3 m/s
c. 8.2 m/s
d. 7.2 m/s
e. 7.7 m/s

29. A 1.5-kg mass has an acceleration of (4.0**i** – 3.0**j**) m/s^2. Only two forces act on the mass. If one of the forces is (2.0**i** – 1.4**j**) N, what is the magnitude of the other force?

a. 4.1 N
b. 6.1 N
c. 5.1 N
d. 7.1 N
e. 2.4 N

30. Only two forces act on a 3.0-kg mass which has an acceleration of 4.0 m/s^2 in the positive x direction. If one of the forces acts in the negative y direction and has a magnitude of 14 N, what is the magnitude of the other force?

a. 22 N
b. 16 N
c. 18 N
d. 20 N
e. 36 N

31. Only two forces act on a 3.0-kg mass. One of the forces is 9.0 N east, and the other is 8.0 N in the direction of 62° north of west. What is the magnitude of the acceleration of the mass?

a. 2.0 m/s^2
b. 2.4 m/s^2
c. 3.3 m/s^2
d. 2.9 m/s^2
e. 5.7 m/s^2

32. A book is placed on a chair. Then a videocassette is placed on the book. The floor exerts a normal force :

a. on all three.
b. only on the book.
c. only on the chair.
d. upwards on the chair and downwards on the book.
e. only on the objects that you have defined to be part of the system.

33. The apparent weight of a fish in an elevator is greatest when the elevator:

a. moves downward at constant velocity.
b. moves upward at constant velocity.
c. accelerates downward.
d. accelerates upward.
e. when the elevator is not moving.

34. The vector sum of three co-planar forces:

a. must be zero.
b. must be perpendicular to one of the three.
c. must be parallel to one of the three.
d. must be perpendicular to the plane.
e. may have any direction in the plane.

35. When the vector sum of three co-planar forces, **A**, **B** and **C**, is parallel to **A**, we can conclude that **B** and **C**:

a. must sum to zero.
b. must be equal and opposite.
c. must have equal and opposite components perpendicular to **A**.
d. must have equal and opposite components parallel to **A**.
e. must have equal and opposite components parallel and perpendicular to **A**.

36. A constant force is applied to a body that is already moving. The force is directed at an angle of 60 degrees to the direction of the body's velocity. What is most likely to happen is that:

a. the body will stop moving.
b. the body will move in the direction of the force.
c. the body's velocity will increase in magnitude but not change direction.
d. the body will gradually change direction more and more toward that of the force while speeding up.
e. the body will first stop moving and then move in the direction of the force.

37. A juggler throws two balls up to the same height so that they pass each other halfway up when A is rising and B is descending. Ignore air resistance and buoyant forces. Which statement is true of the two balls at that point:

a. There is an residual upward force from the hand on each ball.
b. There is a greater residual force from the hand on A than there is on B.
c. Only gravity acts on B but there is an additional residual force from the hand on A.
d. There is an additional downwards force besides gravity on each ball.
e. The only force acting on each ball is the gravitational force.

38. A bumper car is moving at constant velocity when another bumper car starts to push on it with a constant force at an angle of 60 degrees with respect to the first car's initial velocity. The second bumper car continues pushing in exactly that direction for some time. What is most likely to happen is that:

a. the first car will stop moving.
b. the first car will move in the direction of the force.
c. the first car's velocity will increase in magnitude but not change direction.
d. the first car's velocity will gradually change direction more and more toward that of the force while increasing in magnitude.
e. the first car's velocity will gradually change direction more and more toward that of the force while decreasing in magnitude.

39. You have a machine which can accelerate pucks on frictionless ice. In time t the puck travels a distance x when force F is applied. If force $3F$ is applied, in time t the distance the box travels is:

a. x.
b. $(3/2)x$.
c. $3x$.
d. $(9/2)x$.
e. $9x$.

40. A constant force F is applied to a body of mass m that initially is headed east at velocity v_0 until its velocity becomes $-v_0$. The total time of travel is $2t$. The total distance the body travels in that time is

a. $\frac{1}{2}\frac{F}{m}t^2$.
b. $\frac{F}{m}t^2$.
c. $v_0t - \frac{1}{2}\frac{F}{m}t^2$.
d. $v_0t + \frac{1}{2}\frac{F}{m}t^2$.
e. $2(v_0t + \frac{1}{2}\frac{F}{m}t^2)$.

Chapter 5A

The Laws of Motion

1. Answer: c

2. Answer: d

3. Answer: c

4. Answer: e

5. Answer: c

6. Answer: d

7. Answer: d

8. Answer: c

9. Answer: a

10. Answer: c

11. Answer: d

12. Answer: b

13. Answer: c

14. Answer: b

15. Answer: c

16. Answer: a

17. Answer: b

18. Answer: b

19. Answer: d

20. Answer: a

21. Answer: b

22. Answer: b

23. Answer: c

24. Answer: d

25. Answer: c

26. Answer: c

27. Answer: d

28. Answer: a

29. Answer: c

30. Answer: c

31. Answer: d

32. Answer: c

33. Answer: d

34. Answer: e

35. Answer: c

36. Answer: d

37. Answer: e

38. Answer: d

39. Answer: c

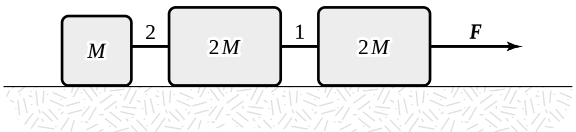
40. Answer: b

Chapter 5B

The Laws of Motion

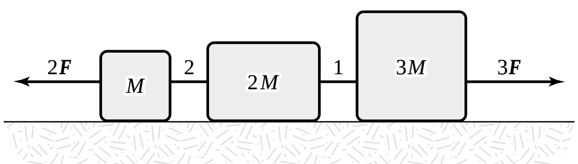
Multiple Choice

1. The horizontal surface on which the objects slide is frictionless. If M = 2.0 kg, the tension in string 1 is 12 N. Determine F.



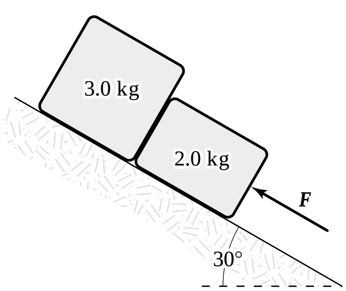
a. 25 N
b. 20 N
c. 30 N
d. 35 N
e. 40 N

2. The horizontal surface on which the objects slide is frictionless. If F = 12 N, what is the tension in string 1?



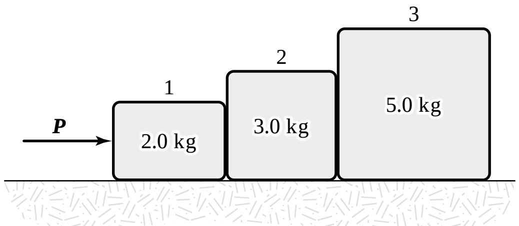
a. 35 N
b. 30 N
c. 40 N
d. 45 N
e. 25 N

3. The surface of the inclined plane shown is frictionless. If F = 30 N, what is the magnitude of the force exerted on the 3.0-kg block by the 2.0-kg block?



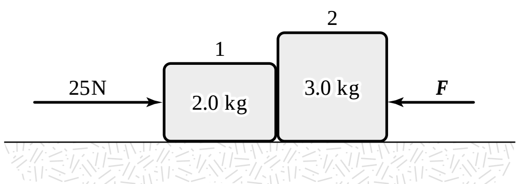
a. 18 N **b.** 27 N **c.** 24 N **d.** 21 N **e.** 15 N

4. If P = 6.0 N, what is the magnitude of the force exerted on block 1 by block 2?



a. 6.4 N
b. 5.6 N
c. 4.8 N
d. 7.2 N
e. 8.4 N

5. If F = 5.0 N, what is the magnitude of the force exerted by block 2 on block 1?

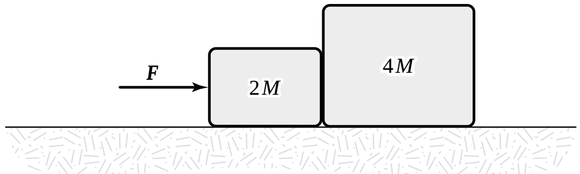


a. 17 N
b. 19 N
c. 21 N
d. 23 N
e. 5.0 N

6. An astronaut who weighs 800 N on the surface of the earth lifts off from planet Zuton in a space ship. The free-fall acceleration on Zuton is 3.0 m/s^2 (down). At the moment of liftoff the acceleration of the space ship is 0.50 m/s^2 (up). What is the magnitude of the force of the space ship on the astronaut?

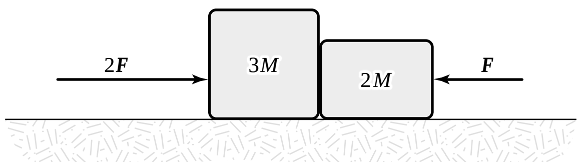
a. 41 N
b. 0.29 kN
c. 0.24 kN
d. 0.20 kN
e. 0.37 kN

7. The horizontal surface on which the objects slide is frictionless. If M = 1.0 kg and the magnitude of the force of the small block on the large block is 5.2 N, determine F.



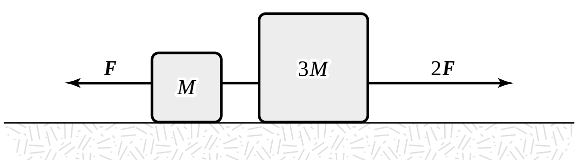
a. 6.0 N
b. 9.0 N
c. 7.8 N
d. 4.8 N
e. 4.1 N

8. The horizontal surface on which the objects slide is frictionless. If F = 6.0 N and M = 1.0 kg, what is the magnitude of the force exerted on the large block by the small block?



a. 7.7 N
b. 9.8 N
c. 9.1 N
d. 8.4 N
e. 6.5 N

9. The horizontal surface on which the objects slide is frictionless. If F = 4.0 N and M = 1.0 kg, what is the magnitude of the force of the connecting string on the smaller block?



a. 4.1 N
b. 5.9 N
c. 5.0 N
d. 6.6 N
e. 7.2 N

10. A 6.0-kg object is suspended by a vertical string from the ceiling of an elevator which is accelerating upward at a rate of 1.8 m/s^2. Determine the tension in the string.

a. 11 N
b. 70 N
c. 48 N
d. 59 N
e. 62 N

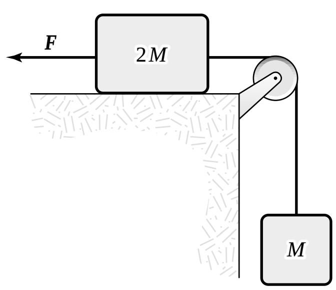
11. An 8.0-kg object rests on the floor of an elevator which is accelerating downward at a rate of 1.3 m/s^2. What is the magnitude of the force the object exerts on the floor of the elevator?

a. 59 N
b. 10 N
c. 89 N
d. 68 N
e. 78 N

12. A 70-kg stunt artist rides in a rocket sled which slides along a flat inclined surface. At an instant when the sled's acceleration has a horizontal component of 6.0 m/s^2 and a downward component of 2.8m/s^2, what is the magnitude of the force on the rider by the sled?

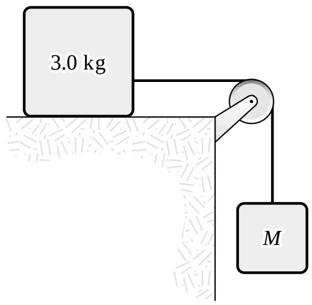
a. 0.83 kN
b. 0.98 kN
c. 0.65 kN
d. 0.68 kN
e. 0.72 kN

13. If F = 40 N and M = 1.5 kg, what is the tension in the connecting string shown? Assume that all surfaces are frictionless.



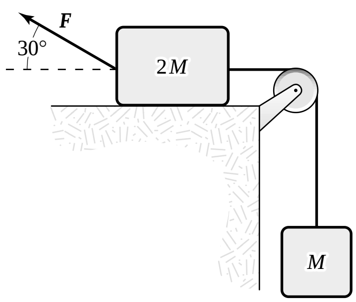
a. 13 N
b. 23 N
c. 36 N
d. 15 N
e. 28 N

14. The system shown is released from rest and moves 50 cm in 1.0 s. What is the value of *M*? All surfaces are frictionless.



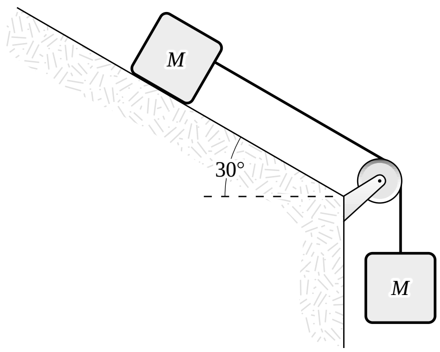
a. 0.42 kg
b. 0.34 kg
c. 0.50 kg
d. 0.59 kg
e. 0.68 kg

15. If F = 40 N and M = 2.0 kg, what is the magnitude of the acceleration of the suspended object? All surfaces are frictionless.



a. 1.2 m/s^2
b. 2.0 m/s^2
c. 1.5 m/s^2
d. 2.5 m/s^2
e. 5.6 m/s^2

16. If M = 2.2 kg, what is the tension in the connecting string? The pulley and all surfaces are frictionless.

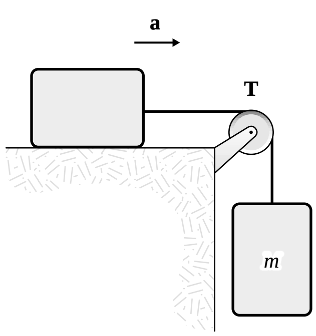


a. 6.4 N
b. 5.9 N
c. 5.4 N
d. 6.9 N
e. 8.3 N

17. A 5.0-kg mass sits on the floor of an elevator that has a downward acceleration of 1.0 m/s^2. On top of the 5.0-kg mass is an object of unknown mass. The force of the elevator on the 5.0-kg mass is 80 N up. Determine the unknown mass.

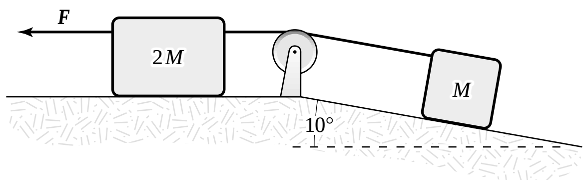
a. 3.3 kg
b. 2.4 kg
c. 1.6 kg
d. 4.1 kg
e. 5.0 kg

18. If the tension, T, is 15 N and the magnitude of the acceleration, a, is 3.0 m/s^2, what is the mass, m, of the suspended object, assuming that all surfaces and the pulley are frictionless?



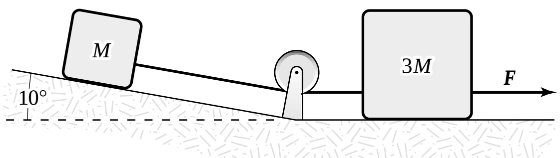
a. 3.1 kg
b. 2.5 kg
c. 2.8 kg
d. 2.2 kg
e. 3.7 kg

19. If F = 8.0 N and M = 1.0 kg, what is the tension in the connecting string? The pulley and all surfaces are frictionless.



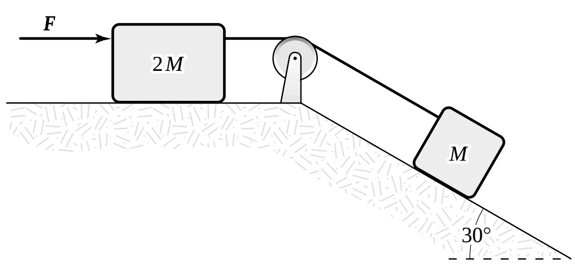
a. 4.1 N
b. 3.5 N
c. 3.8 N
d. 3.1 N
e. 4.8 N

20. If F = 8.0 N and M = 1.0 kg, what is the tension in the connecting string? The pulley and all surfaces are frictionless.



a. 0.82 N
b. 0.92 N
c. 0.72 N
d. 0.62 N
e. 0.69 N

21. In the figure, if F = 2.0 N and M = 1.0 kg, what is the tension in the connecting string? The pulley and all surfaces are frictionless.

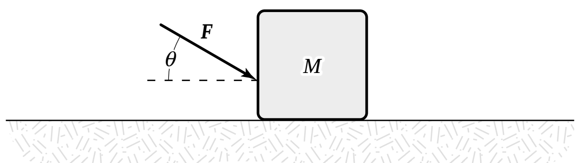


a. 2.6 N
b. 1.1 N
c. 2.1 N
d. 1.6 N
e. 3.7 N

22. A 4.0-kg block slides down a 35° incline at a constant speed when a 16-N force is applied acting up and parallel to the incline. What is the coefficient of kinetic friction between the block and the surface of the incline?

a. 0.20
b. 0.23
c. 0.26
d. 0.33
e. 0.41

23. A block is pushed across a horizontal surface by the force shown. If the coefficient of kinetic friction between the block and the surface is 0.30, F = 20 N, θ = 30°, and M = 3.0 kg, what is the magnitude of the acceleration of the block?

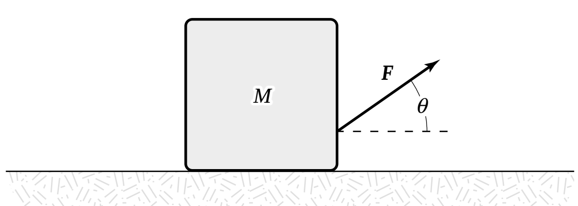


a. 2.8 m/s^2
b. 2.3 m/s^2
c. 1.8 m/s^2
d. 3.3 m/s^2
e. 5.4 m/s^2

24. A 3.0-kg block moves up a 40° incline with constant speed under the action of a 26-N force acting up and parallel to the incline. What is the magnitude of the force acting up and parallel to the incline required to allow the block to move down the incline at constant speed?

a. 14 N
b. 12 N
c. 16 N
d. 18 N
e. 25 N

25. The block shown is pulled across the horizontal surface at a constant speed by the force shown. If M = 5.0 kg, F = 14 N and θ = 35°, what is the coefficient of kinetic friction between the block and the horizontal surface?



a. 0.44 **b.** 0.33 **c.** 0.38 **d.** 0.28 **e.** 0.17

26. A block is released from rest on a 27° incline and moves 6.0 m during the next 2.0 s. What is the coefficient of kinetic friction between the block and the surface of the incline?

a. 0.28
b. 0.22
c. 0.17
d. 0.35
e. 0.12

27. A box rests on the (horizontal) back of a truck. The coefficient of static friction between the box and the surface on which it rests is 0.24. What maximum distance can the truck travel (starting from rest and moving horizontally with constant acceleration) in 3.0 s without having the box slide?

a. 14 m
b. 11 m
c. 19 m
d. 24 m
e. 29 m

28. In a game of shuffleboard (played on a horizontal surface), a puck is given an initial speed of 6.0 m/s. It slides a distance of 9.0 m before coming to rest. What is the coefficient of kinetic friction between the puck and the surface?

a. 0.20
b. 0.18
c. 0.15
d. 0.13
e. 0.27

29. A 2.0-kg block slides on a rough horizontal surface. A force (magnitude P = 4.0 N) acting parallel to the surface is applied to the block. The magnitude of the block's acceleration is 1.2 m/s^2. If P is increased to 5.0 N, determine the magnitude of the block's acceleration.

a. 2.1 m/s^2
b. 2.3 m/s^2
c. 1.9 m/s^2
d. 1.7 m/s^2
e. 3.2 m/a^2

30. A 4.0-kg block is pushed up a 36° incline by a force of magnitude P applied parallel to the incline. When P is 31 N, it is observed that the block moves up the incline with a constant speed. What value of P would be required to lower the block down the incline at a constant speed?

a. 27 N
b. 15 N
c. 13 N
d. 17 N
e. 19 N

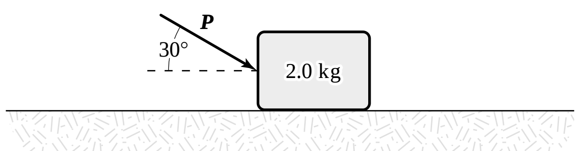
31. A 1.8-kg block is released from rest at the top of a rough 30° inclined plane. As the block slides down the incline, its acceleration is 3.0 m/s^2 down the incline. Determine the magnitude of the force of friction acting on the block.

a. 4.2 N
b. 3.0 N
c. 3.4 N
d. 3.8 N
e. 2.3 N

32. A 1.8-kg block is projected up a rough 10° inclined plane. As the block slides up the incline, its acceleration is 3.8 m/s^2 down the incline. What is the magnitude of the force of friction acting on the block?

a. 5.0 N
b. 3.8 N
c. 4.2 N
d. 4.6 N
e. 6.5 N

33. A 2.0-kg block slides on a rough horizontal surface. A force (P = 6.0 N) is applied to the block as shown. The magnitude of the block's acceleration is 1.2 m/s^2. What is the magnitude of the force of friction acting on the block?



a. 2.0 N
b. 1.4 N
c. 1.6 N
d. 2.8 N
e. 3.4 N

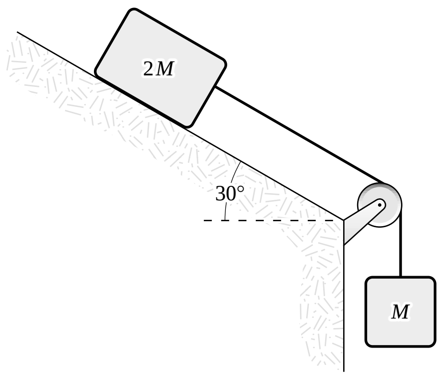
34. A 3.0-kg block slides on a rough horizontal surface. A force of 8.0 N acting parallel to the surface is applied to the block. The coefficient of kinetic friction between the block and the surface is 0.15. What is the magnitude of the block's acceleration?

a. 1.9 m/s^2
b. 1.2 m/s^2
c. 2.3 m/s^2
d. 1.5 m/s^2
e. 2.9 m/s^2

35. A 1.0-kg block is pushed up a rough 22° inclined plane by a force of 7.0 N acting parallel to the incline. The acceleration of the block is 1.4 m/s^2 up the incline. Determine the magnitude of the force of friction acting on the block.

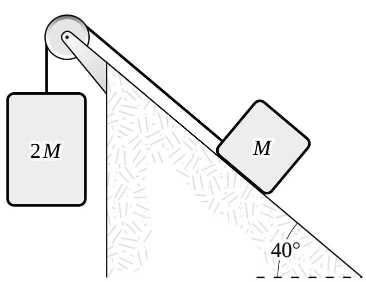
a. 1.9 N
b. 2.2 N
c. 1.3 N
d. 1.6 N
e. 3.3 N

36. In the figure shown, the coefficient of kinetic friction between the block and the incline is 0.29. What is the magnitude of the acceleration of the suspended block as it falls? Disregard any pulley mass or friction in the pulley.



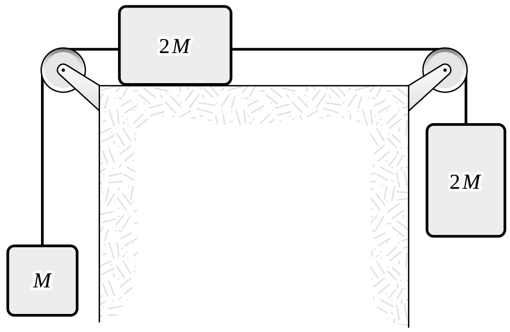
a. 5.4 m/s^2
b. 5.2 m/s^2
c. 4.9 m/s^2
d. 5.6 m/s^2
e. 7.9 m/s^2

37. In the figure shown, the coefficient of kinetic friction between the block and the incline is 0.40. What is the magnitude of the acceleration of the suspended block as it falls? Disregard any pulley mass or friction in the pulley.



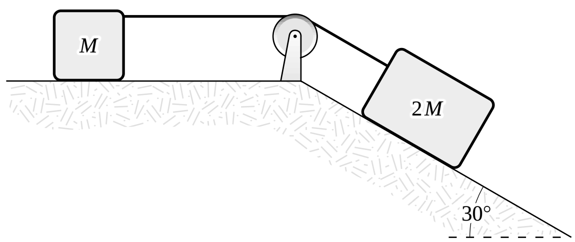
a. 3.4 m/s^2
b. 3.7 m/s^2
c. 4.2 m/s^2
d. 3.9 m/s^2
e. 5.4 m/s^2

38. The three blocks shown are released from rest and are observed to move with accelerations that have a magnitude of 1.5 m/s^2. What is the magnitude of the friction force on the block that slides horizontally? Disregard any pulley mass or friction in the pulley and let M = 2.0 kg.



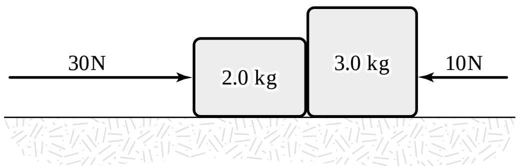
a. 6.0 N
b. 5.1 N
c. 5.5 N
d. 4.6 N
e. 3.7 N

39. The two blocks shown are released from rest. If the coefficient of kinetic friction between the blocks and the surfaces on which they slide is 0.20, what is the magnitude of the acceleration of either block? Disregard any pulley mass or friction in the pulley.



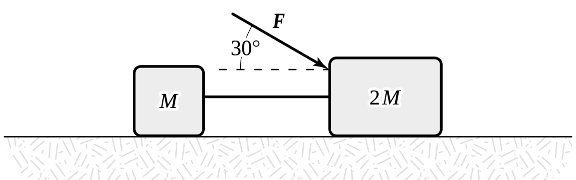
a. 1.7 m/s^2
b. 1.5 m/s^2
c. 1.9 m/s^2
d. 2.2 m/s^2
e. 3.1 m/s^2

40. Two blocks in contact with each other are pushed to the right across a rough horizontal surface by the two forces shown. If the coefficient of kinetic friction between each of the blocks and the surface is 0.30, determine the magnitude of the force exerted on the 2.0-kg block by the 3.0-kg block.



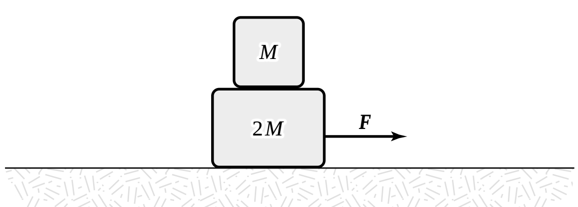
a. 15 N
b. 25 N
c. 11 N
d. 22 N
e. 33 N

41. Two blocks connected by a string are pushed across a horizontal surface by a force applied to one of the blocks as shown in the figure. The coefficient of kinetic friction between the blocks and the surface is 0.20. If F = 20 N and M = 1.5 kg, what is the tension in the connecting string?



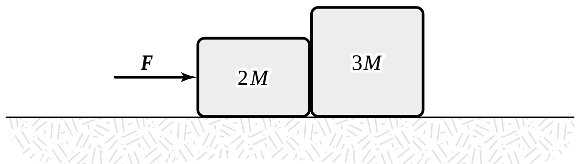
a. 5.1 N
b. 5.9 N
c. 4.6 N
d. 3.8 N
e. 6.2 N

42. Two blocks are accelerated across a horizontal frictionless surface as shown. Frictional forces keep the two blocks from sliding relative to each other, and the two move with the same acceleration. If F = 1.2 N and M = 1.0 kg, what is the horizontal component (frictional force) of the force of the large block on the small block?



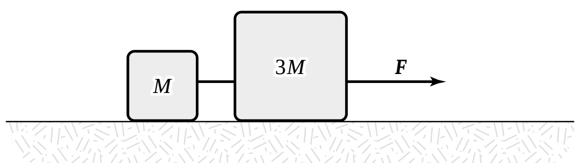
a. 0.40 N to the left
b. 0.80 N to the right
c. 0.40 N to the right
d. 0.80 N to the left
e. 1.20 N to the left

43. The coefficient of kinetic friction between the surface and the larger block is 0.25, and the coefficient of kinetic friction between the surface and the smaller block is 0.40. If F = 22N and M = 1.0 kg in the figure, what is the magnitude of the acceleration of either block?



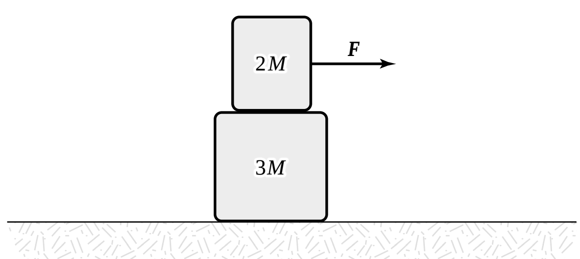
a. 1.8 m/s^2
b. 2.6 m/s^2
c. 1.4 m/s^2
d. 2.2 m/s^2
e. 3.7 m/s^2

44. In the figure, the coefficient of kinetic friction between the surface and the larger block is 0.20, and the coefficient of kinetic friction between the surface and the smaller block is 0.30. If F = 14 N and M = 1.0 kg, what is the magnitude of the acceleration of either block?



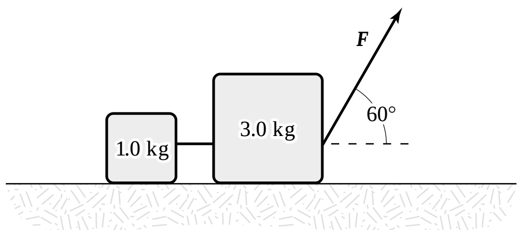
a. 2.0 m/s^2
b. 1.3 m/s^2
c. 1.5 m/s^2
d. 1.8 m/s^2
e. 3.5 m/s^2

45. Two blocks are accelerated across a horizontal frictionless surface as shown. Frictional forces keep the two blocks from sliding relative to each other, and the two move with the same acceleration. If F = 1.2 N and M = 1.0 kg, what is the horizontal component (frictional force) of the force of the small block on the large block?



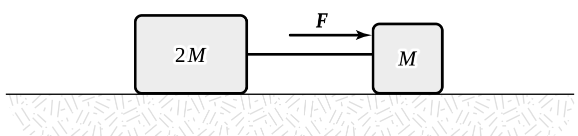
a. 0.48 N to the right
b. 0.72 N to the right
c. 0.72 N to the left
d. 0.48 N to the left
e. 0.65 N to the left

46. Two blocks connected by a string are pulled across a horizontal surface by a force applied to one of the blocks, as shown. The coefficient of kinetic friction between the blocks and the surface is 0.25. If each block has an acceleration of 2.0 m/s^2 to the right, what is the magnitude F of the applied force?



a. 25 N
b. 18 N
c. 11 N
d. 14 N
e. 7.0 N

47. In the figure, the coefficient of kinetic friction between the surface and the larger block is 0.20, and the coefficient of kinetic friction between the surface and the smaller block is 0.30. If $F = 10$ N and $M = 1.0$ kg, what is the tension in the connecting string?



a. 8.0 N
b. 6.0 N
c. 6.7 N
d. 8.7 N
e. 3.0 N

Conceptual Problems

48. A high-diver of mass 70 kg jumps off a board 10 m above the water. If, 2 s after entering the water his downward motion is stopped, what average upward force did the water exert?

49. A heavy freight train has a mass of 15,000 metric tons. If the locomotives can exert a pull of 750,000 N, how long does it take to increase the speed from zero to 80 km/h?

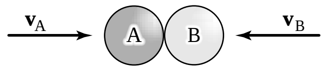
50. A 2000-kg sailboat experiences an eastward force of 3000 N by the ocean tide and a wind force against its sails of magnitude 6000 N directed toward the northwest (45° N of W). What is the magnitude and direction of the resultant acceleration?

51. A box is dropped onto a conveyor belt moving at 2 m/s. If the coefficient of friction between the box and the belt is 0.3, how long before the box moves without slipping?

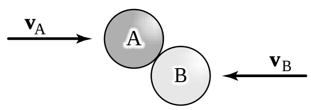
52. A book is placed on a chair. Then a videocassette is placed on the book. The floor exerts a normal force :

a. on all three.
b. only on the book.
c. only on the chair.
d. upwards on the chair and downwards on the book.
e. only on the objects that you have defined to be part of the system.

53. Two bodies, A and B, collide as shown in Figures a and b below.



a



b

Which statement is true:

a. They exert equal and opposite forces on each other in (a) but not in (b).
a. They exert equal and opposite force on each other in (b) but not in (a).
c. They exert equal and opposite force on each other in both (a) and (b).
d. The forces are equal and opposite to each other in (a), but only the components of the forces parallel to the velocities are equal in (b).
e. The forces are equal and opposite in (a), but only the components of the forces perpendicular to the velocities are equal in (b)

54. You throw a ball up in the air and hold your hand under it to catch it when it comes down. The reason why the ball stops is because

a. your hand is there: your hand exerts no force on the ball.
b. your hand exerts a force on the ball perpendicular to its velocity.
c. your hand exerts a force on the ball in the direction of its velocity.
d. your hand exerts a force on the ball in the direction opposite to its velocity.
e. your hand and the ball exerts forces in the same direction on each other.

55. You hold a tennis racket in your hand. On top of the racket you have balanced a ball. Which statement is true?

a. The force of your hand on the racket and the force of the ball on the racket are equal and opposite.
b. The force of the racket on your hand and the force of the ball on the racket are equal and opposite.
c. The force of your hand on the racket and the force of the racket on the ball are equal and opposite.
d. The force of the racket on your hand and the force of the racket on the ball are equal and opposite.
e. The force of your hand on the racket and the force of the racket on your hand are equal and opposite.

56. When you drag a toy teddy bear along the floor by a force that is parallel to the floor, the magnitude of the force of friction:

a. is independent of velocity or acceleration.
b. increases when the velocity increases.
c. is proportional to the acceleration.
d. decreases when the force parallel to the floor increases.
e. increases when the force parallel to the floor increases.

57. In order to jump off the floor, the floor must exert a force on you

a. in the direction of and equal to your weight.
b. opposite to and equal to your weight.
c. in the direction of and less than your weight.
d. opposite to and less than your weight.
e. opposite to and greater than your weight.

58. When an acrobat hangs motionless from a pair of rings

a. she has no measurable weight.
b. her weight depends on the angles the ropes make with the ceiling.
c. her weight is reduced by the upward force the rings exert on her.
d. her weight is increased by the upward force the rings exert on her.
e. she exerts a gravitational force on the earth that is equal to the sum of the forces the rings exert on her.

Chapter 5B

The Laws of Motion

1. Answer: b

2. Answer: b

3. Answer: a

4. Answer: c

5. Answer: a

6. Answer: b

7. Answer: c

8. Answer: d

9. Answer: c

10. Answer: b

11. Answer: d

12. Answer: c

13. Answer: b

14. Answer: b

15. Answer: d

16. Answer: c

17. Answer: d

18. Answer: d

19. Answer: c

20. Answer: c

21. Answer: a

22. Answer: a

23. Answer: c

24. Answer: b

25. Answer: d

26. Answer: c

27. Answer: b

28. Answer: a

29. Answer: d

30. Answer: b

31. Answer: c

32. Answer: b

33. Answer: d

34. Answer: b

35. Answer: a

36. Answer: c

37. Answer: a

38. Answer: d

39. Answer: b

40. Answer: d

41. Answer: a

42. Answer: c

43. Answer: c

44. Answer: b

45. Answer: b

46. Answer: a

47. Answer: b

48. Answer: 1180 N

49. Answer: 444 s

50. Answer: $2.2\ m/s^2$ at 74° N of W

51. Answer: 0.7 s

52. Answer: c

53. Answer: c

54. Answer: d

55. Answer: e

56. Answer: a

57. Answer: e

58. Answer: e

Chapter 6

Circular Motion and Other Applications of Newton's Law

Multiple Choice

1. A race car travels 40 m/s around a banked (45° with the horizontal) circular (radius = 0.20 km) track. What is the magnitude of the resultant force on the 80-kg driver of this car?

a. 0.68 kN
b. 0.64 kN
c. 0.72 kN
d. 0.76 kN
e. 0.52 kN

2. An airplane travels 80 m/s as it makes a horizontal circular turn which has a 0.80-km radius. What is the magnitude of the resultant force on the 75-kg pilot of this airplane?

a. 0.69 kN
b. 0.63 kN
c. 0.66 kN
d. 0.60 kN
e. 0.57 kN

3. An airplane moves 140 m/s as it travels around a vertical circular loop which has a 1.0-km radius. What is the magnitude of the resultant force on the 70-kg pilot of this plane at the bottom of this loop?

a. 2.1 kN
b. 1.4 kN
c. 0.69 kN
d. 1.5 kN
e. 1.3 kN

4. A car travels along the perimeter of a vertical circle (radius = 0.25 km) at a constant speed of 30 m/s. What is the magnitude of the resultant force on the 60-kg driver of the car at the lowest point on this circular path?

a. 0.37 kN
b. 0.80 kN
c. 0.22 kN
d. 0.59 kN
e. 0.45 kN

5. A 30-kg child rides on a circus Ferris wheel that takes her around a vertical circular path with a radius of 20 m every 22 s. What is the magnitude of the resultant force on the child at the highest point on this trajectory?

a. 49 N
b. 0.29 kN
c. 0.34 kN
d. 0.25 kN
e. 0.76 kN

6. An amusement ride consists of a car moving in a vertical circle on the end of a rigid boom. The radius of the circle is 10 m. The combined weight of the car and riders is 5.0 kN. At the top of the circle the car has a speed of 5.0 m/s which is not changing at that instant. What is the force of the boom on the car at the top of the circle?

a. 3.7 kN (Down)
b. 1.3 kN (Down)
c. 6.3 kN (Up)
d. 3.7 kN (Up)
e. 5.2 kN (Down)

7. A highway curve has a radius of 0.14 km and is unbanked. A car weighing 12 kN goes around the curve at a speed of 24 m/s without slipping. What is the magnitude of the horizontal force of the road on the car?

a. 12 kN
b. 17 kN
c. 13 kN
d. 5.0 kN
e. 49 kN

8. A 4.0-kg mass on the end of a string rotates in a circular motion on a horizontal frictionless table. The mass has a constant speed of 2.0 m/s and the radius of the circle is 0.80 m. What is the magnitude of the resultant force acting on the mass?

a. 39 N
b. 20 N
c. 44 N
d. 0 N
e. 30 N

9. A rock attached to a string swings in a vertical circle. At the highest point:

a. Two forces act on the rock, and their resultant is not zero.
b. Only one force acts on the rock.
c. Two forces act on the rock, and their resultant is zero.
d. Three forces act on the rock.
e. No forces act on the rock.

10. A stunt pilot weighing 0.70 kN performs a vertical circular dive of radius 0.80 km. At the bottom of the dive, the pilot has a speed of 0.20 km/s which at that instant is not changing. What force does the plane exert on the pilot?

a. 3.6 kN up
b. 4.3 kN up
c. 2.9 kN down
d. 2.9 kN up
e. 5.8 kN down

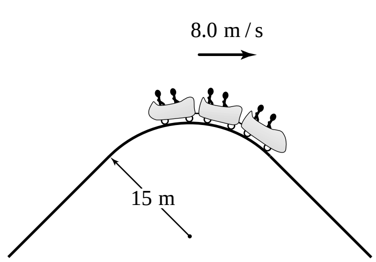
11. A car travels around an unbanked highway curve (radius 0.15 km) at a constant speed of 25 m/s. What is the magnitude of the resultant force acting on the driver, who weighs 0.80 kN?

a. 0.87 kN
b. 0.34 kN
c. 0.80 kN
d. 0.00 kN
e. 0.67 kN

12. A 0.50-kg mass attached to the end of a string swings in a vertical circle (radius = 2.0 m). When the mass is at the lowest point on the circle, the speed of the mass is 12 m/s. What is the magnitude of the force of the string on the mass at this position?

a. 31 N
b. 36 N
c. 41 N
d. 46 N
e. 23 N

13. A roller-coaster car has a mass of 500 kg when fully loaded with passengers. The car passes over a hill of radius 15 m, as shown. At the top of the hill, the car has a speed of 8.0 m/s. What is the force of the track on the car at the top of the hill?

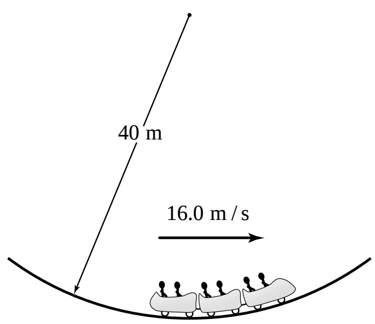


a. 7.0 kN up
b. 7.0 kN down
c. 2.8 kN down
d. 2.8 kN up
e. 5.6 kN down

14. A 0.20-kg object attached to the end of a string swings in a vertical circle (radius = 80 cm). At the top of the circle the speed of the object is 4.5 m/s. What is the magnitude of the tension in the string at this position?

a. 7.0 N
b. 2.0 N
c. 3.1 N
d. 5.1 N
e. 6.6 N

15. A roller-coaster car has a mass of 500 kg when fully loaded with passengers. At the bottom of a circular dip of radius 40 m (as shown in the figure) the car has a speed of 16 m/s. What is the magnitude of the force of the track on the car at the bottom of the dip?



a. 3.2 kN
b. 8.1 kN
c. 4.9 kN
d. 1.7 kN
e. 5.3 kN

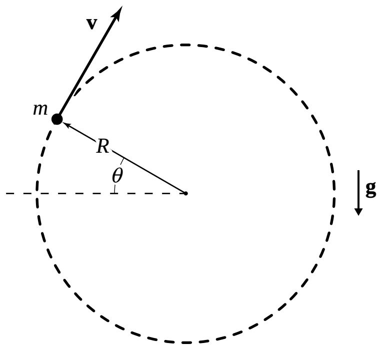
16. A 0.50 kg mass attached to the end of a string swings in a vertical circle (radius = 2.0 m). When the mass is at the highest point of the circle the speed of the mass is 8.0 m/s. What is the magnitude of the force of the string on the mass at this position?

a. 21 N
b. 11 N
c. 16 N
d. 26 N
e. 36 N

17. A 50-kg child riding a Ferris wheel (radius = 10 m) travels in a vertical circle. The wheel completes one revolution every 10 s. What is the magnitude of the force on the child by the seat at the highest point on the circular path?

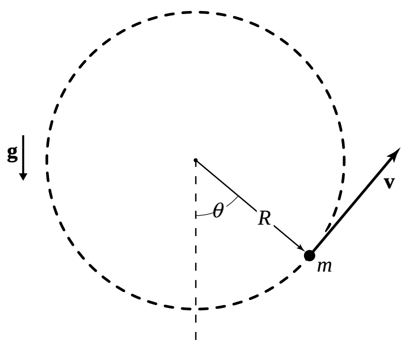
a. 0.29 kN
b. 0.49 kN
c. 0.69 kN
d. 0.20 kN
e. 0.40 kN

18. A 0.30-kg mass attached to the end of a string swings in a vertical circle (R = 1.4 m), as shown. At an instant when θ = 30°, the speed of the mass is 6.0 m/s. What is the magnitude of the resultant force on the mass at this instant?



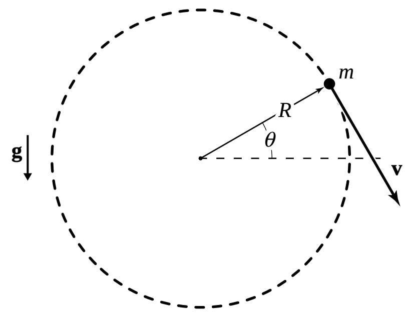
a. 5.7 N
b. 4.3 N
c. 7.1 N
d. 11 N
e. 8.2 N

19. A 0.30-kg mass attached to the end of a string swings in a vertical circle (R = 1.6 m), as shown. At an instant when θ = 50°, the tension in the string is 8.0 N. What is the magnitude of the resultant force on the mass at this instant?



a. 5.6 N
b. 6.0 N
c. 6.5 N
d. 5.1 N
e. 2.2 N

20. An object attached to the end of a string swings in a vertical circle (R = 1.2 m), as shown. At an instant when θ = 30°, the speed of the object is 5.0 m/s and the tension in the string has a magnitude of 20 N. What is the mass of the object?



a. 2.0 kg
b. 1.5 kg
c. 1.8 kg
d. 1.3 kg
e. 0.80 kg

21. A 0.40-kg mass attached to the end of a string swings in a vertical circle having a radius of 1.8 m. At an instant when the string makes an angle of 40 degrees below the horizontal, the speed of the mass is 5.0 m/s. What is the magnitude of the tension in the string at this instant?

a. 9.5 N
b. 3.0 N
c. 8.1 N
d. 5.6 N
e. 4.7 N

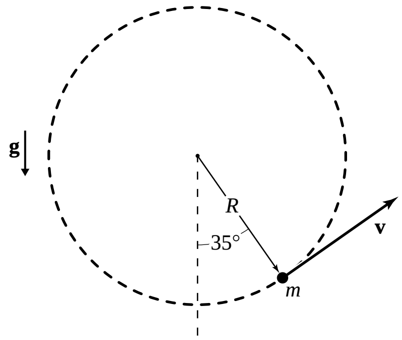
22. A 0.30-kg ball attached to the end of a string swings in a vertical circle having a radius of 1.4 m. At an instant when the string makes an angle of 40 degrees above the horizontal, the magnitude of the tension in the string is 3.0 N. What is the speed of the ball at this instant?

a. 2.7 m/s
b. 4.6 m/s
c. 3.7 m/s
d. 5.3 m/s
e. 6.4 m/s

23. A 0.50-kg mass attached to the end of a string swings in a vertical circle (radius = 2.0 m). When the string is horizontal, the speed of the mass is 8.0 m/s. What is the magnitude of the force of the string on the mass at this position?

a. 16 N
b. 17 N
c. 21 N
d. 11 N
e. 25 N

24. A 4.0-kg mass attached to the end of a string swings in a vertical circle of radius 2.0 m. When the string makes an angle of 35° with the vertical as shown, the speed of the mass is 5.0 m/s. At this instant what is the magnitude of the force on the mass by the string?



a. 50 N
b. 82 N
c. 89 N
d. 11 N
e. 61 N

Conceptual Problems

25. A sample of blood is placed into a centrifuge of radius 15.0 cm. The mass of a red corpuscle is 3.0×10^{-16} kg, and the centripetal force required to make it settle out of the plasma is 4.0×10^{-11} N. At how many revolutions per second should the centrifuge be operated?

26. A space station in the form of a large wheel, 120 m in diameter, rotates to provide an "artificial gravity" of 3.00 m/s^2 for persons located at the outer rim. Find the rotational frequency of the wheel (in revolutions per minute) that will produce this effect.

27. An aerobatic airplane pilot experiences weightlessness as she passes over the top of a loop-the-loop maneuver. If her speed is 200 m/s at the time, find the radius of the loop.

28. A race car starts from rest on a circular track of radius 400 m. Its speed increases at the constant rate of 0.5 m/s . At the point where the magnitudes of the radial and tangential accelerations are equal, determine (a) the speed of the race car, and (b) the elapsed time.

29. A student is sitting on the right side of a school bus when it makes a right turn. We know that a force of gravity acts downwards and a normal force from the seat acts upwards. If the student stays in place when the bus turns, we also know that there must be:

a. no other force on the student.
b. a force parallel to the seat directed forward on the student.
c. a force parallel to the seat directed to the left on the student.
d. a force parallel to the seat directed to the right on the student.
e. a force parallel to the seat in a direction between forward and left on the student.

30. For a plane to be able to fly clockwise in a horizontal circle as seen from above, in addition to exerting a force downwards on the air:

a. it must be increasing its speed.
b. it must exert a force on the air that is directed to the plane's left side.
c. it must exert a force on the air that is directed to the plane's right side.
d. it does not need to exert a force: it must only move the wing flaps out.
e. it only needs to deflect the air without exerting any additional force on the air.

31. When a car goes around a circular curve on a level road,

a. no frictional force is needed because the car simply follows the road.
b. the frictional force of the road on the car increases when the car's speed decreases.
c. the frictional force of the road on the car increases when the car's speed increases.
d. the frictional force of the road on the car increases when the car moves to the outside of the curve.
e. there is no net frictional force because the road and the car exert equal and opposite forces on each other.

32. A split highway has a number of lanes for traffic. For traffic going in one direction, the radius for the inside of the curve is half the radius for the outside. One car, car A, travels on the inside while another car of equal mass, car B, travels at equal speed on the outside of the curve. Which statement about resultant forces on the cars is correct?

a. The force on A is half the force on B.
b. The force on B is half the force on A.
c. The force on A is four times the force on B.
d. The force on B is four times the force on A.
e. There is no net resultant force on either as long as they stay on the road while turning.

33. An iceboat is traveling in a circle on the ice. Halfway around the circle the sail and the steering mechanism fall off the boat. Which statement is correct?

a. The boat will continue traveling in the circle because there is no friction.
b. The boat will continue to travel in the circle because its velocity exerts a force on it.
c. The boat will move off on a line tangent to the circle because there is no force on it.
d. The boat will move off tangent to the circle because there is a force on it perpendicular to the boat directed to the outside of the circle.
e. The boat will move off to the outside perpendicular to the tangent line since a force directed to the outside of the circle always acts on the boat.

34. A race car traveling at 100 m/s enters an unbanked turn of 400 m radius. The coefficient of friction between the tires and the track is 1.1. The track has both an inner and an outer wall. Which statement is correct?

a. The race car will crash into the outer wall.
b. The race car will crash into the inner wall.
c. The car will stay in the center of the track.
d. The car will stay in the center of the track if the driver speeds up.
e. The car would stay in the center of the track if the radius were reduced to 200 m.

Chapter 6

Circular Motion and Other Applications of Newton's Law

1. Answer: b

2. Answer: d

3. Answer: b

4. Answer: c

5. Answer: a

6. Answer: d

7. Answer: d

8. Answer: b

9. Answer: a

10. Answer: b

11. Answer: b

12. Answer: c

13. Answer: d

14. Answer: c

15. Answer: b

16. Answer: b

17. Answer: a

18. Answer: e

19. Answer: c

20. Answer: d

21. Answer: c

22. Answer: b

23. Answer: a

24. Answer: b

25. Answer: 150 rev / s (9000 rpm)

26. Answer: 2.14 rpm

27. Answer: 4.08

28. Answer: 14.14 m / s, 28.28 s

29. Answer: d

30. Answer: b

31. Answer: c

32. Answer: b

33. Answer: c

34. Answer: a

Chapter 7

Work and Energy

Multiple Choice

1. A constant force of 12 N in the positive *x* direction acts on a 4.0-kg object as it moves from the origin to the point (6**i** – 8**j**) m. How much work is done by the given force during this displacement?

a. +60 J
b. +84 J
c. +72 J
d. +48 J
e. +57 J

2. A 5.0-kg object is pulled along a horizontal surface at a constant speed by a 15 N force acting 20° above the horizontal. How much work is done by this force as the object moves 6.0 m?

a. 78 J
b. 82 J
c. 85 J
d. 74 J
e. 43 J

3. A 2.0-kg projectile moves from its initial position to a point that is displaced 20 m horizontally and 15 m above its initial position. How much work is done by the gravitational force on the projectile?

a. +0.29 kJ
b. –0.29 kJ
c. +30 J
d. –30 J
e. –50 J

4. How much work is done by a person lifting a 2.0-kg object from the bottom of a well at a constant speed of 2.0 m/s for 5.0 s?

a. 0.22 kJ
b. 0.20 kJ
c. 0.24 kJ
d. 0.27 kJ
e. 0.31 kJ

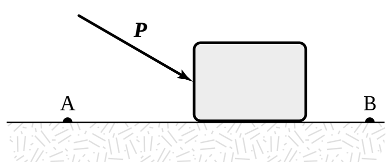
5. A 2.5-kg object falls vertically downward in a viscous medium at a constant speed of 2.5 m/s. How much work is done by the viscous force on the object as it falls 80 cm?

a. +2.0 J
b. +20 J
c. –2.0 J
d. –20 J
e. +40 J

6. A 2.0-kg particle has an initial velocity of (5**i** – 4**j**) m/s. Some time later, its velocity is (7**i** + 3**j**) m/s. What work was done by the resultant force during this time interval, assuming no energy is lost in the process?

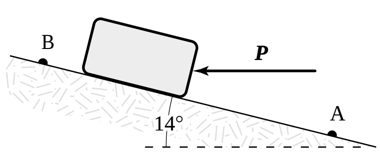
a. 17 J
b. 49 J
c. 19 J
d. 53 J
e. 27 J

7. A block is pushed across a rough horizontal surface from point A to point B by a force (magnitude P = 5.4 N) as shown in the figure. The magnitude of the force of friction acting on the block between A and B is 1.2 N and points A and B are 0.5 m apart. If the kinetic energies of the block at A and B are 4.0 J and 5.6 J, respectively, how much work is done on the block by the force P between A and B?



a. 2.7 J
b. 1.0 J
c. 2.2 J
d. 1.6 J
e. 3.2 J

8. A 1.4-kg block is pushed up a frictionless 14° incline from point A to point B by a force (magnitude P = 6.0 N) as shown in the figure. Points A and B are 1.2 m apart. If the kinetic energies of the block at A and B are 3.0 J and 4.0 J, respectively, how much work is done on the block by the force P between A and B?

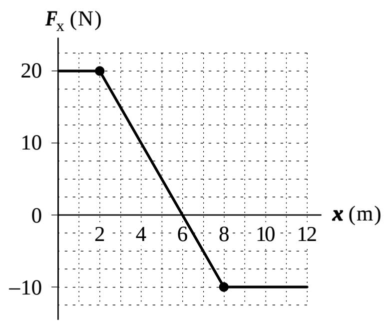


a. 7.2 J
b. 3.0 J
c. 5.0 J
d. 1.0 J
e. 4.0 J

9. A constant force of 15 N in the negative *y* direction acts on a particle as it moves from the origin to the point (3**i** + 3**j** – 1**k**) m. How much work is done by the given force during this displacement?

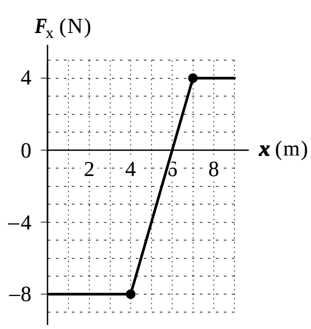
a. +45 J
b. –45 J
c. +30 J
d. –30 J
e. +75 J

10. An object moving along the *x* axis is acted upon by a force F_x that varies with position as shown. What work is done by this force as the object moves from $x = 2$ m to $x = 8$ m?



a. –10 J
b. +10 J
c. +30 J
d. –30 J
e. +40 J

11. A body moving along the *x* axis is acted upon by a force F_x that varies with *x* as shown. What work is done by this force as the object moves from $x = 1$ m to $x = 8$ m?



a. –2 J
b. –18 J
c. –10 J
d. –26 J
e. +18 J

12. A force acting on an object moving along the *x* axis is given by

$$F_x = (14x - 3.0x^2)\text{ N}$$

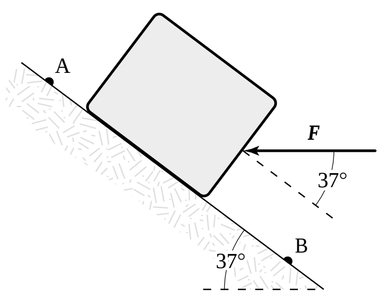
where *x* is in m. How much work is done by this force as the object moves from $x = -1$ m to $x = +2$ m?

a. +12 J
b. +28 J
c. +40 J
d. +42 J
e. –28 J

13. The force an ideal spring exerts on an object is given by $F_x = -kx$, where *x* measures the displacement of the object from its equilibrium ($x = 0$) position. If $k = 60$ N / m, how much work is done by this force as the object moves from $x = -0.20$ m to $x = 0$?

a. –1.2 J
b. +1.2 J
c. +2.4 J
d. –2.4 J
e. +3.6 J

14. A 4.0-kg block is lowered down a 37° incline a distance of 5.0 m from point A to point B. A horizontal force ($F = 10$ N) is applied to the block between A and B as shown in the figure. The kinetic energy of the block at A is 10 J and at B it is 20 J. How much work is done on the block by the force of friction between A and B?



a. –58 J **b.** –53 J **c.** –68 J **d.** –63 J **e.** –47 J

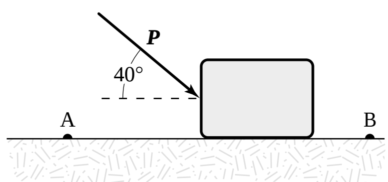
15. If the resultant force acting on a 2.0-kg object is equal to (3**i** + 4**j**) N, what is the change in kinetic energy as the object moves from (7**i** – 8**j**) m to (11**i** – 5**j**) m?

a. +36 J
b. +28 J
c. +32 J
d. +24 J
e. +60 J

16. As a 2.0-kg object moves from (2**i** + 5**j**) m to (6**i** – 2**j**) m, the constant resultant force acting on it is equal to (4**i** – 3**j**) N. If the speed of the object at the initial position is 4.0 m/s, what is its kinetic energy at its final position?

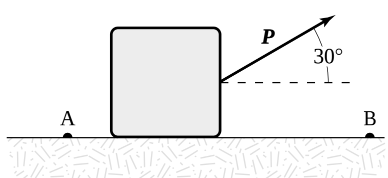
a. 62 J
b. 53 J
c. 73 J
d. 86 J
e. 24 J

17. A block slides on a rough horizontal surface from point A to point B. A force (magnitude *P* = 2.0 N) acts on the block between A and B, as shown. Points A and B are 1.5 m apart. If the kinetic energies of the block at A and B are 5.0 J and 4.0 J, respectively, how much work is done on the block by the force of friction as the block moves from A to B?



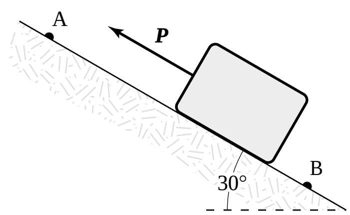
a. –3.3 J
b. +1.3 J
c. +3.3 J
d. –1.3 J
e. +4.6 J

18. A block slides on a rough horizontal surface from point A to point B. A force (magnitude *P* = 1.5 N) acts on the block between A and B, as shown. Points A and B are 1.4 m apart. If the kinetic energies of the block at A and B are 5.0 J and 2.0 J, respectively, how much work is done on the block by the force of friction as the block moves from A to B?



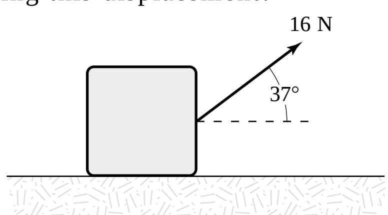
a. +1.2 J
b. –1.2 J
c. –4.8 J
d. +4.8 J
e. +6.0 J

19. A 2.0-kg block slides down a frictionless incline from point A to point B. A force (magnitude P = 3.0 N) acts on the block between A and B, as shown. Points A and B are 2.0 m apart. If the kinetic energy of the block at A is 10 J, what is the kinetic energy of the block at B?



a. 27 J
b. 20 J
c. 24 J
d. 17 J
e. 37 J

20. A 3.0-kg block is dragged over a rough horizontal surface by a constant force of 16 N acting at an angle of 37° below the horizontal as shown. The speed of the block increases from 4.0 m/s to 6.0 m/s in a displacement of 5.0 m. What work was done by the friction force during this displacement?



a. –34 J
b. –64 J
c. –30 J
d. –94 J
e. +64 J

21. A 6.0-kg block slides along a horizontal surface. If μ_k = 0.20 for the block and surface, at what rate is the friction force doing work on the block at an instant when its speed is 4.0 m/s?

a. –59 W
b. –47 W
c. –71 W
d. –82 W
e. +71 W

22. At what rate is the gravitational force on a 2.0-kg projectile doing work at an instant when the velocity of the projectile is 4.0 m/s directed 30° above the horizontal?

a. +39 W
b. –78 W
c. –39 W
d. +78 W
e. +25 W

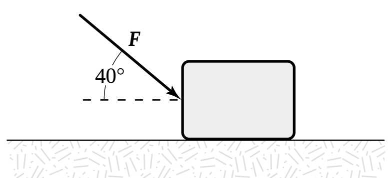
23. A 2.0-kg block slides down a plane (inclined at 40° with the horizontal) at a constant speed of 5.0 m/s. At what rate is the gravitational force on the block doing work?

a. +98 W
b. +63 W
c. zero
d. +75 W
e. –75 W

24. The speed of a 4.0-kg object is given by $v = (2t)$ m/s, where t is in s. At what rate is the resultant force on this object doing work at $t = 1$ s?

a. 48 W
b. 40 W
c. 32 W
d. 56 W
e. 16 W

25. Starting from rest at $t = 0$, a 2.0-kg block is pushed across a horizontal surface by a force directed as shown ($F = 8.0$ N). The magnitude of the resulting acceleration of the block is 2.0 m/s^2. At what rate is the force of friction doing work on the block at $t = 3.0$ s?



a. +13 W
b. +24 W
c. –24 W
d. –13 W
e. –2.1 W

26. A 3.0-kg block is on a frictionless horizontal surface. The block is at rest when at $t = 0$, a force (magnitude $P = 2.0$ N) acting at an angle of 22° above the horizontal is applied to the block. At what rate is the force P doing work at $t = 2.0$ s?

a. 2.3 W
b. 2.0 W
c. 1.4 W
d. 1.7 W
e. 1.2 W

27. A 1.6-kg block slides down a plane (inclined at 25° with the horizontal) at a constant speed of 2.0 m/s. At what rate is the frictional force doing work on the block?

a. +28 W
b. +13 W
c. –13 W
d. –28 W
e. +6.5 W

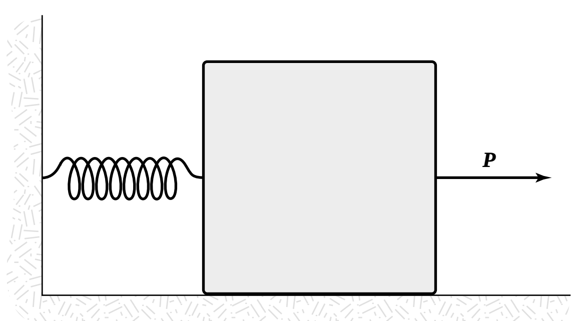
28. A 3.0-kg block is on a horizontal surface. The block is at rest when at $t = 0$, a force (magnitude $P = 12$ N) acting parallel to the surface is applied to the block causing it to accelerate. The coefficient of kinetic friction between the block and the surface is 0.20. At what rate is the force P doing work on the block at $t = 2.0$ s?

a. 54 W
b. 49 W
c. 44 W
d. 59 W
e. 24 W

29. Starting from rest at $t = 0$, a 5.0-kg block is pulled across a horizontal surface by a constant horizontal force having a magnitude of 12 N. If the coefficient of friction between the block and the surface is 0.20, at what rate is the 12-N force doing work at $t = 5.0$ s?

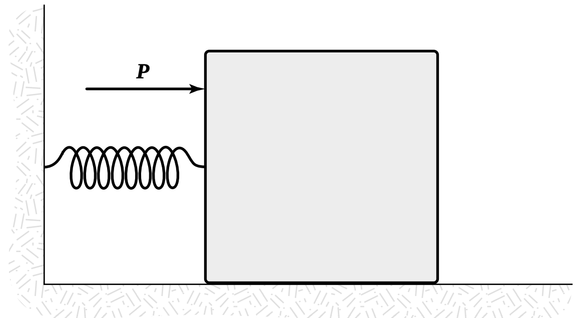
a. 0.13 kW
b. 0.14 kW
c. 0.12 kW
d. 26 W
e. 12 W

30. A 10-kg block on a horizontal frictionless surface is attached to a light spring (force constant = 0.80 kN/m). The block is initially at rest at its equilibrium position when a force (magnitude $P = 80$ N) acting parallel to the surface is applied to the block, as shown. What is the speed of the block when it is 13 cm from its equilibrium position?



a. 0.85 m/s
b. 0.89 m/s
c. 0.77 m/s
d. 0.64 m/s
e. 0.52 m/s

31. A 10-kg block on a horizontal frictionless surface is attached to a light spring (force constant = 1.2 kN / m). The block is initially at rest at its equilibrium position when a force (magnitude *P*) acting parallel to the surface is applied to the block, as shown. When the block is 8.0 cm from the equilibrium position, it has a speed of 0.80 m / s. How much work is done on the block by the force *P* as the block moves the 8.0 cm?

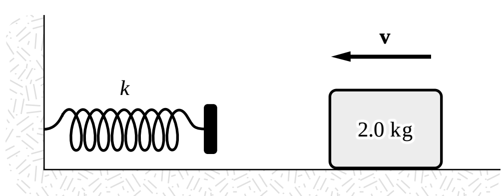


a. 8.3 J
b. 6.4 J
c. 7.0 J
d. 7.7 J
e. 3.8 J

32. A 20-kg block on a horizontal surface is attached to a light spring (force constant = 8.0 kN / m). The block is pulled 10 cm to the right from its equilibrium position and released from rest. When the block has moved 2.0 cm toward its equilibrium position, its kinetic energy is 13 J. How much work is done by the frictional force on the block as it moves the 2.0 cm?

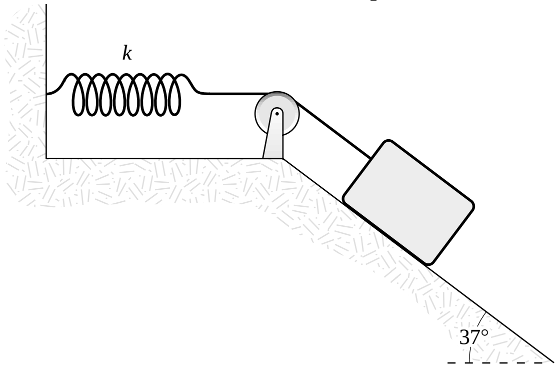
a. –2.5 J
b. –1.4 J
c. –3.0 J
d. –1.9 J
e. –14 J

33. The horizontal surface on which the block slides is frictionless. The speed of the block before it touches the spring is 6.0 m / s. How fast is the block moving at the instant the spring has been compressed 15 cm? k = 2.0 kN / m



a. 3.7 m / s
b. 4.4 m / s
c. 4.9 m / s
d. 5.4 m / s
e. 14 m / s

34. A 2.0-kg block situated on a frictionless incline is connected to a light spring (k = 100 N / m), as shown. The block is released from rest when the spring is unstretched. The pulley is frictionless and has negligible mass. What is the speed of the block when it has moved 0.20 m down the plane?



a. 76 cm / s **b.** 68 cm / s **c.** 60 cm / s **d.** 82 cm / s **e.** 57 cm / s

35. A 2.0-kg block sliding on a frictionless horizontal surface is attached to one end of a horizontal spring (k = 600 N / m) which has its other end fixed. The speed of the block when the spring is extended 20 cm is equal to 3.0 m / s. What is the maximum speed of this block as it oscillates?

a. 4.6 m / s
b. 5.3 m / s
c. 5.7 m / s
d. 4.9 m / s
e. 3.5 m / s

36. A 10-kg block on a rough horizontal surface is attached to a light spring (force constant = 1.4 kN / m). The block is pulled 8.0 cm to the right from its equilibrium position and released from rest. The frictional force between the block and surface has a magnitude of 30 N. What is the kinetic energy of the block as it passes through its equilibrium position?

a. 4.5 J
b. 2.1 J
c. 6.9 J
d. 6.6 J
e. 4.9 J

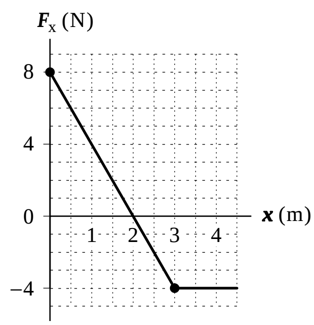
37. A 5.0-kg block on a rough horizontal surface is attached to a light spring (force constant = 1.6 kN / m). The block passes through its equilibrium position with a kinetic energy of 5.0 J and is brought momentarily to rest after stretching the spring 0.060 m. How much work is done by the frictional force on the block as it moves from its equilibrium position to the point of momentary rest?

a. –7.9 J
b. +2.1 J
c. –2.1 J
d. +7.9 J
e. +2.9 J

38. A 2.0-kg body moving along the x axis has a velocity $V_x = 5.0$ m/s at $x = 0$. The only force acting on the object is given by $F_x = (-4.0x)$ N, where x is in m. For what value of x will this object first come (momentarily) to rest?

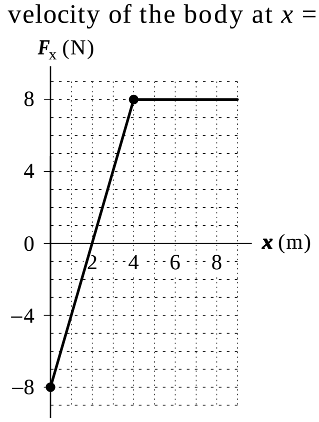
a. 4.2 m
b. 3.5 m
c. 5.3 m
d. 6.4 m
e. 5.0 m

39. A 1.5-kg object moving along the x axis has a velocity of +4.0 m/s at $x = 0$. If the only force acting on this object is shown in the figure, what is the kinetic energy of the object at $x = +3.0$ m?



a. 18 J
b. 21 J
c. 23 J
d. 26 J
e. 8 J

40. The only force acting on a 1.6-kg body as it moves along the x axis is given in the figure. If the velocity of the body at $x = 2.0$ m is 5.0 m/s, what is its kinetic energy at $x = 5.0$ m?



a. 52 J
b. 44 J
c. 36 J
d. 60 J
e. 25 J

41. The only force acting on a 2.0-kg body moving along the x axis is given by $F_x = (2.0x)$ N, where x is in m. If the velocity of the object at $x = 0$ is +3.0 m/s, how fast is it moving at $x = 2.0$ m?

a. 4.2 m/s
b. 3.6 m/s
c. 5.0 m/s
d. 5.8 m/s
e. 2.8 m/s

42. The only force acting on a 0.50-kg object as it moves along the x axis is given by

$$F_x(x) = (4.0x^3) \text{ N}$$

where x is measured in m. If the speed of the object at $x = 0$ is equal to 3.5 m/s, what is its speed at $x = 2.0$ m?

a. 8.7 m/s
b. 9.2 m/s
c. 9.4 m/s
d. 9.7 m/s
e. 4.0 m/s

43. The only force acting on a 2.0-kg body as it moves along the x axis is given by $F_x = (12 - 2.0x)$ N, where x is in m. The velocity of the body at $x = 2.0$ m is 5.5**i** m/s. What is the maximum kinetic energy attained by the body?

a. 36 J
b. 39 J
c. 43 J
d. 46 J
e. 30 J

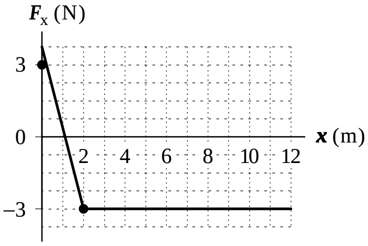
44. The only force acting on a 1.8-kg body as it moves along the x axis is given by $F_x = -(3.0x)$ N, where x is in m. If the velocity of the body at $x = 0$ is $V_x = +8.0$ m/s, at what value of x will the body have a velocity of +4.0 m/s?

a. 5.7 m
b. 5.4 m
c. 4.8 m
d. 4.1 m
e. 6.6 m

45. The only force acting on a 2.0-kg body as it moves out on the positive x axis is given by $F_x = (4.0x)$ N, where x is in m. If the kinetic energy of the body at $x = 2.0$ m is 20 J, what is its kinetic energy at $x = 3.0$ m?

a. 40 J
b. 10 J
c. 38 J
d. 30 J
e. 20 J

46. The only force acting on a 2.0-kg body as it moves along the *x* axis is given in the figure. At $x = 0$, the body is moving 3.0 m/s in the positive *x* direction. At what value of *x* will the body be momentarily at rest?



a. 9.0 m **b.** 3.0 m **c.** 5.0 m **d.** 12 m **e.** 7.0 m

47. Two vectors **A** and **B** are given by **A** = 5**i** + 6**j** + 7**k** and **B** = 3**i** – 8**j** + 2**k**. If these two vectors are drawn starting at the same point, what is the angle between them?

a. 106°
b. 102°
c. 110°
d. 113°
e. 97°

48. If **A** = 7**i** – 6**j** + 5**k**, **B** = 7, and the angle between **A** and **B** (when the two are drawn starting from the same point) is 60°, what is the scalar product of these two vectors?

a. –13
b. +13
c. +37
d. –37
e. 73

49. If vectors **A** and **B** have magnitudes 12 and 15, respectively, and the angle between the two when they are drawn starting from the same point is 110°, what is the scalar product of these two vectors?

a. –76
b. –62
c. –90
d. –47
e. –170

50. If the vectors **A** and **B** have magnitudes of 10 and 11, respectively, and the scalar product of these two vectors is –100, what is the magnitude of the sum of these two vectors?

a. 6.6
b. 4.6
c. 8.3
d. 9.8
e. 7.6

51. If the scalar product of two vectors, **A** and **C**, is equal to –3.5, if **A** = 2.0, and the angle between the two vectors when they are drawn starting from the same point is equal to 130°, what is the magnitude of **C**?

a. 2.1
b. 2.5
c. 2.3
d. 2.7
e. 3.1

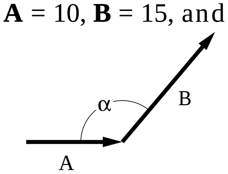
52. If **A** · **C** = –7.5, **A** = 3**i** – 4**j**, and $|\mathbf{C}|$ = 6.5, what is the angle between the two vectors when they are drawn starting from the same point?

a. 118°
b. 107°
c. 112°
d. 103°
e. 77°

53. Two vectors **A** and **B** are given by **A** = 4**i** + 8**j** and **B** = 6**i** – 2**j**. The scalar product of **A** and a third vector **C** is –16. The scalar product of **B** and **C** is +18. The *z* component of **C** is 0. What is the magnitude of **C**?

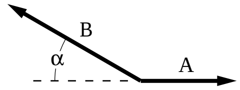
a. 7.8
b. 6.4
c. 3.6
d. 5.0
e. 4.8

54. If **A** = 10, **B** = 15, and α = 130°, determine the scalar product of the two vectors shown.



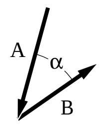
a. +96
b. –96
c. +51
d. –51
e. –35

55. If **A** = 5.0, **B** = 8.0, and α = 30°, determine the scalar product of the two vectors shown.



a. –35
b. +35
c. –20
d. +20
e. +40

56. If **A** = 6.0, **B** = 5.0, and α = 40°, determine the scalar product of the two vectors shown.



a. +19
b. +23
c. –19
d. –23
e. +30

Conceptual Problems

57. While running, a person dissipates about 0.6 J of mechanical energy per step per kilogram of body mass. If a 60-kg person runs with a power of 70 Watts during a race, how fast is the person running? Assume a running step is 1.5 m long.

58. A baseball outfielder throws a baseball of mass 0.15 kg at a speed of 40 m/s and initial angle of 30°. What is the kinetic energy of the baseball at the highest point of the trajectory?

59. When an automobile moves with constant velocity the power developed is used to overcome the frictional forces exerted by the air and the road. If the power developed in an engine is 50.0 hp, what total frictional force acts on the car at 55 mph (24.6 m/s)? One horsepower equals 746 W.

60. In a contest, two tractors pull two identical blocks of stone the same distance over identical surfaces. However, block A is moving twice as fast as block B when it crosses the finish line. Which statement is correct?

a. Block A has twice as much kinetic energy as block B.
b. Block B has lost twice as much kinetic energy to friction as block A.
c. Block B has lost twice as much kinetic energy as block A.
d. Both blocks have had equal losses of energy to friction.
e. No energy is lost to friction because the ground has no displacement.

61. The same constant force is used to accelerate two carts of the same mass on frictionless tracks. The force is applied to cart A twice as long as it is applied to cart B. The work the force does on A is W_A; that on B is W_B. Which statement is correct?

a. $W_A = W_B$.
b. $W_A = \sqrt{2}\ W_B$.
c. $W_A = 2\ W_B$.
d. $W_A = 4\ W_B$.
e. $W_B = 2W_A$.

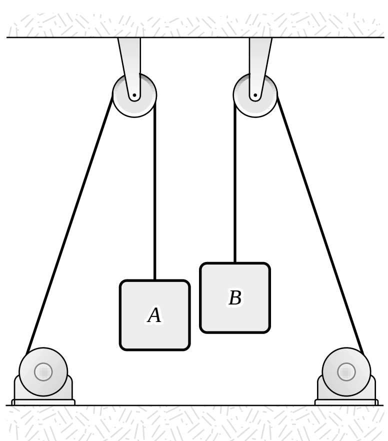
62. Carts A and B have equal masses and travel equal distances on straight frictionless tracks while a constant force F is applied to A, and a constant force 2F is applied to B. The relative amounts of work done by the two forces are related by:

a. $W_A = 4\ W_B$.
b. $W_A = 2\ W_B$.
c. $W_A = W_B$.
d. $W_B = 2\ W_A$.
e. $W_B = 4\ W_A$.

63. Carts A and B have equal masses and travel equal distances D on side-by-side straight frictionless tracks while a constant force F acts on A and a constant force 2F acts on B. Both carts start from rest. The velocities $\mathbf{v}_A$ and $\mathbf{v}_B$ of the bodies at the end of distance D are related by:

a. $\mathbf{v}_B = \mathbf{v}_A$.
b. $\mathbf{v}_B = \sqrt{2}\ \mathbf{v}_A$.
c. $\mathbf{v}_B = 2\ \mathbf{v}_A$.
d. $\mathbf{v}_B = 4\ \mathbf{v}_A$.
e. $\mathbf{v}_A = 2\mathbf{v}_B$.

64. Two equal masses are raised at constant velocity by ropes that run over pulleys, as shown below. Mass B is raised twice as fast as mass A. The magnitudes of the forces are F_A and F_B, while the power supplied is respectively P_A and P_B. Which statement is correct ?



a. $F_B = F_A$; $P_B = P_A$.
b. $F_B = F_A$; $P_B = 2\ P_A$.
c. $F_B = 2\ F_A$; $P_B = P_A$.
d. $F_B = 2\ F_A$; $P_B = 2\ P_A$.
e. $P_A = F_A$; $P_B = F_B$.

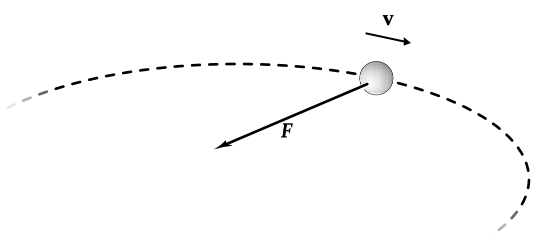
65. If the scalar (dot) product of two vectors is negative, it means that:

a. there was a calculator error.
b. the angle between the vectors is less than 90 degrees.
c. the angle between the vectors is 90 degrees.
d. the angle between the vectors is greater than 270 degrees.
e. the angle between the vectors is between 90 and 180 degrees.

66. Two eggs of equal mass are thrown at a blanket with equal velocity. Egg A hits the wall instead but egg B hits the blanket. Compare the work done on the eggs in stopping them:

a. More work was done on A than on B.
b. More work was done on B than on A.
c. The amount of work is the same for both.
d. It is meaningless to compare the amount of work because the forces were so different.
e. Work was done on B, but no work was done on A because the wall did not move.

67. Planets go around the sun in elliptical orbits. The highly exaggerated diagram below shows a portion of such an orbit and the force on the planet at one position along that orbit. The planet is moving to the right. $F_{||}$ and $F_{\perp}$ are the components of the force parallel and perpendicular to the orbit. The work they do is $W_{||}$ and $W_{\perp}$.



a. $W_{||}$ slows the planet down; $W_{\perp}$ speeds it up.
b. $W_{||}$ slows the planet down; $W_{\perp}$ does no work on it.
c. $W_{||}$ speeds the planet up; $W_{\perp}$ does no work on it.
d. $W_{||}$ speeds the planet up; $W_{\perp}$ slows it down.
e. $W_{||}$ does no work on it; $W_{\perp}$ speeds the planet up.

68. Movers want to set the ramp of their truck so that the work they do against the combination of gravity and friction is a minimum for crates moving up the ramp with constant velocity. μ is the coefficient of kinetic friction and θ is the angle between the ramp and the ground. For the work to be a minimum, they must choose:

a. $\tan\theta = \mu$
b. $\tan\theta = -\mu$.
c. $\tan\theta = -\dfrac{1}{\mu}$
d. $\tan\theta = \dfrac{1}{\mu}$
e. $\tan\theta = 1 - \mu$

Chapter 7

Work and Energy

1. Answer: c

2. Answer: c

3. Answer: b

4. Answer: b

5. Answer: d

6. Answer: a

7. Answer: c

8. Answer: c

9. Answer: b

10. Answer: c

11. Answer: d

12. Answer: a

13. Answer: b

14. Answer: c

15. Answer: d

16. Answer: b

17. Answer: a

18. Answer: c

19. Answer: c

20. Answer: a

21. Answer: b

22. Answer: c

23. Answer: b

24. Answer: e

25. Answer: d

26. Answer: a

27. Answer: c

28. Answer: b

29. Answer: d

30. Answer: a

31. Answer: c

32. Answer: b

33. Answer: a

34. Answer: c

35. Answer: a

36. Answer: b

37. Answer: c

38. Answer: b

39. Answer: a

40. Answer: c

41. Answer: b

42. Answer: a

43. Answer: d

44. Answer: b

45. Answer: d

46. Answer: c

47. Answer: b

48. Answer: c

49. Answer: b

50. Answer: b

51. Answer: d

52. Answer: d

53. Answer: c

54. Answer: a

55. Answer: a

56. Answer: d

57. Answer: 2.92 m / s

58. Answer: 90 J

59. Answer: 1520 N

60. Answer: d

61. Answer: d

62. Answer: d

63. Answer: b

64. Answer: b

65. Answer: e

66. Answer: c

67. Answer: b

68. Answer: d

Chapter 8

Potential Energy and Conservation of Energy

Multiple Choice

1. A single conservative force $F_x = (6.0x - 12)$ N (x is in m) acts on a particle moving along the x axis. The potential energy associated with this force is assigned a value of +20 J at $x = 0$. What is the potential energy at $x = 3.0$ m?

a. +11 J
b. +29 J
c. +9.0 J
d. –9.0 J
e. +20 J

2. As a particle moves along the x axis it is acted upon by a single conservative force given by $F_x = (20 - 4.0x)$ N where x is in m. The potential energy associated with this force has the value +30 J at the origin ($x = 0$). What is the value of the potential energy at $x = 4.0$ m?

a. –48 J
b. +78 J
c. –18 J
d. +48 J
e. +80 J

3. A 0.40-kg particle moves under the influence of a single conservative force. At point A where the particle has a speed of 10 m/s, the potential energy associated with the conservative force is +40 J. As the particle moves from A to B, the force does +25 J of work on the particle. What is the value of the potential energy at point B?

a. +65 J
b. +15 J
c. +35 J
d. +45 J
e. –40 J

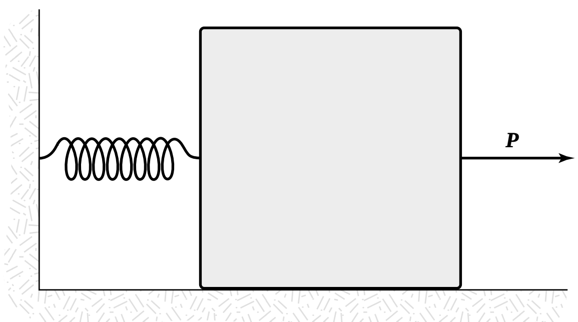
4. As a 1.0-kg object moves from point A to point B, it is acted upon by a single conservative force which does –40 J of work during this motion. At point A the speed of the particle is 6.0 m/s and the potential energy associated with the force is +50 J. What is the potential energy at point B?

a. +72 J
b. +10 J
c. +90 J
d. +28 J
e. +68 J

5. As a 1.5-kg mass moves along the *x* axis, it is acted upon by a single conservative force given by $F_x = (6.0x^2)$ N, where x is in m. At $x = 0$ (where its speed is 4.0 m/s), the potential energy associated with the force is +30 J. What is the potential energy at $x = 2.0$ m?

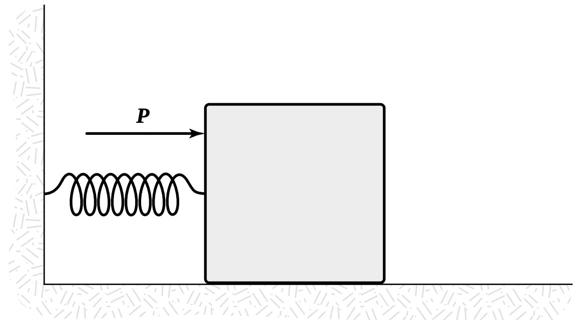
a. 16 J
b. +46 J
c. +36 J
d. +14 J
e. 28 J

6. A 12-kg block on a horizontal frictionless surface is attached to a light spring (force constant = 0.80 kN/m). The block is initially at rest at its equilibrium position when a force (magnitude $P = 80$ N) acting parallel to the surface is applied to the block, as shown. What is the speed of the block when it is 13 cm from its equilibrium position?



a. 0.78 m/s
b. 0.81 m/s
c. 0.71 m/s
d. 0.58 m/s
e. 0.64 m/s

7. A 7.0-kg block on a horizontal frictionless surface is attached to a light spring (force constant = 1.2 kN / m). The block is initially at rest at its equilibrium position when a force (magnitude *P* acting parallel to the surface is applied to the block, as shown. When the block is 8.0 cm from the equilibrium position, it has a speed of 0.80 m / s. How much work is done on the block by the force *P* as the block moves the 8.0 cm?



a. 7.4 J
b. 5.4 J
c. 6.1 J
d. 6.7 J
e. 4.9 J

8. A 0.60-kg object is suspended from the ceiling at the end of a 2.0-m string. As this suspended object swings, it has a speed of 4.0 m / s at the lowest point of its path. What maximum angle does the string make with the vertical as the object swings?

a. 61°
b. 54°
c. 69°
d. 77°
e. 47°

9. A pendulum is made by letting a 2.0-kg object swing at the end of a string that has a length of 1.5 m. The maximum angle the string makes with the vertical as the pendulum swings is 30°. What is the speed of the object as it goes through the lowest point in its trajectory?

a. 2.0 m / s
b. 2.2 m / s
c. 2.5 m / s
d. 2.7 m / s
e. 3.1 m / s

10. A 2.0-kg mass swings at the end of a light string (length = 3.0 m.) Its speed at the lowest point on its circular path is 6.0 m/s. What is its kinetic energy at an instant when the string makes an angle of 50° with the vertical?

a. 21 J
b. 15 J
c. 28 J
d. 36 J
e. 23 J

11. A 2.5-kg object suspended from the ceiling by a string that has a length of 2.5 m is released from rest with the string 40° below the horizontal position. What is the tension in the string at the instant the object passes through its lowest position?

a. 11 N
b. 25 N
c. 42 N
d. 18 N
e. 32 N

12. A certain pendulum consists of a 1.5-kg mass swinging at the end of a string (length = 2.0 m). At the lowest point in the swing the tension in the string is equal to 20 N. To what maximum height above this lowest point will the mass rise during its oscillation?

a. 77 cm
b. 50 cm
c. 63 cm
d. 36 cm
e. 95 cm

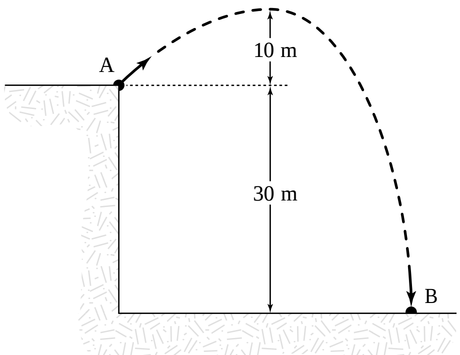
13. A 0.80-kg object tied to the end of a 2.0-m string swings as a pendulum. At the lowest point of its swing, the object has a kinetic energy of 10 J. Determine the speed of the object at the instant when the string makes an angle of 50° with the vertical.

a. 5.6 m/s
b. 4.4 m/s
c. 3.3 m/s
d. 5.0 m/s
e. 6.1 m/s

14. A 2.0-kg mass tied to the end of a 1.5-m string swings as a pendulum. At the lowest point in its swing, the speed of the mass is 4.6 m/s. What is the kinetic energy of the mass at the instant when the string makes an angle of 35° with the vertical?

a. 18 J
b. 16 J
c. 20 J
d. 22 J
e. 27 J

15. A 0.04-kg ball is thrown from the top of a 30-m tall building (point A) at an unknown angle above the horizontal. As shown in the figure, the ball attains a maximum height of 10 m above the top of the building before striking the ground at point B. If air resistance is negligible, what is the value of the kinetic energy of the ball at B minus the kinetic energy of the ball at A?



a. 12 J
b. –12 J
c. 20 J
d. –20 J
e. 32 J

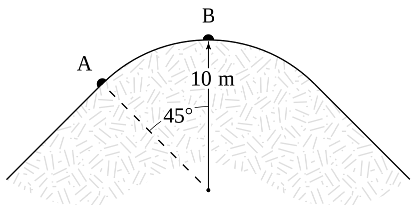
16. A 1.2-kg mass is projected from ground level with a velocity of 30 m/s at some unknown angle above the horizontal. A short time after being projected, the mass barely clears a 16-m tall fence. Disregard air resistance and assume the ground is level. What is the kinetic energy of the mass as it clears the fence?

a. 0.35 kJ
b. 0.73 kJ
c. 0.40 kJ
d. 0.68 kJ
e. 0.19 kJ

17. A 2.0-kg mass is projected from the edge of the top of a 20-m tall building with a velocity of 24 m/s at some unknown angle above the horizontal. Disregard air resistance and assume the ground is level. What is the kinetic energy of the mass just before it strikes the ground?

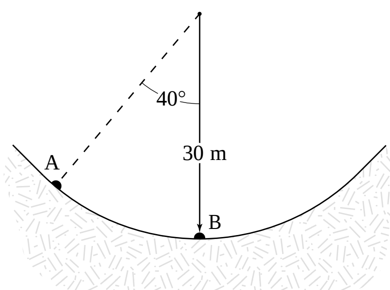
a. 0.18 kJ
b. 0.97 kJ
c. 0.89 kJ
d. 0.26 kJ
e. 0.40 kJ

18. A skier weighing 0.70 kN goes over a frictionless circular hill as shown. If the skier's speed at point A is 9.2 m / s, what is his speed at the top of the hill (point B)?



a. 3.1 m / s
b. 6.2 m / s
c. 5.2 m / s
d. 4.1 m / s
e. 6.5 m / s

19. A skier weighing 0.80 kN comes down a frictionless ski run that is circular (R = 30 m) at the bottom, as shown. If her speed is 12 m / s at point A, what is her speed at the bottom of the hill (point B)?



a. 17 m / s
b. 19 m / s
c. 18 m / s
d. 20 m / s
e. 12 m / s

20. A spring (k = 600 N / m) is placed in a vertical position with its lower end supported by a horizontal surface. The upper end is depressed 20 cm, and a 4.0-kg block is placed on the depressed spring. The system is then released from rest. How far above the point of release will the block rise?

a. 46 cm
b. 36 cm
c. 41 cm
d. 31 cm
e. 20 cm

21. A spring (k = 200 N / m) is suspended with its upper end supported from a ceiling. With the spring hanging in its equilibrium configuration, an object (mass = 2.0 kg) is attached to the lower end and released from rest. What is the speed of the object after it has fallen 4.0 cm?

a. 90 cm / s
b. 79 cm / s
c. 96 cm / s
d. 83 cm / s
e. 57 cm / s

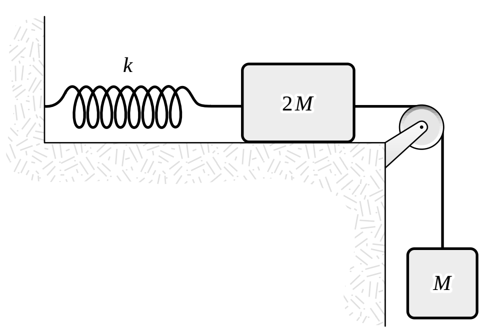
22. A 2.0-kg block sliding on a horizontal frictionless surface is attached to one end of a horizontal spring (k = 200 N / m) which has its other end fixed. If the block has a speed of 4.0 m / s as it passes through the equilibrium position, what is its speed when it is 20 cm from the equilibrium position?

a. 2.6 m / s
b. 3.1 m / s
c. 3.5 m / s
d. 1.9 m / s
e. 2.3 m / s

23. A block (mass = 4.0 kg) sliding on a horizontal frictionless surface is attached to one end of a horizontal spring (k = 100 N / m) which has its other end fixed. If the maximum distance the block slides from the equilibrium position is equal to 20 cm, what is the speed of the block at an instant when it is a distance of 16 cm from the equilibrium position?

a. 71 cm / s
b. 60 cm / s
c. 80 cm / s
d. 87 cm / s
e. 57 cm / s

24. The blocks shown are released from rest with the spring unstretched. The pulley and the horizontal surface are frictionless. If k = 400 N / m and M = 4.5 kg, what is the maximum extension of the spring?

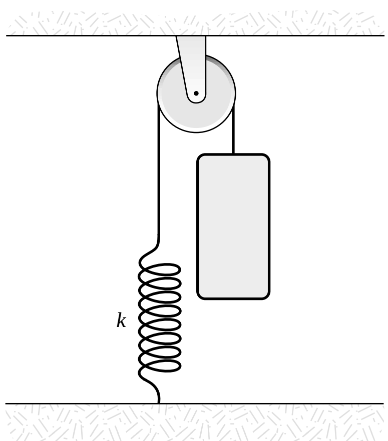


a. 11 cm
b. 66 cm
c. 22 cm
d. 33 cm
e. 55 cm

25. A 1.0-kg block is released from rest at the top of a frictionless incline that makes an angle of 37° with the horizontal. An unknown distance down the incline from the point of release, there is a spring with $k = 200$ N / m. It is observed that the mass is brought momentarily to rest after compressing the spring 0.20 m. What distance does the mass slide from the point of release until it is brought momentarily to rest?

a. 0.98 m
b. 0.68 m
c. 0.82 m
d. 0.55 m
e. 0.20 m

26. A 20-kg mass is fastened to a light spring ($k = 380$ N / m) that passes over a pulley as shown. The pulley is frictionless, and the mass is released from rest when the spring is unstretched. After the mass has dropped 0.40 m, what is its speed?



a. 2.2 m / s
b. 2.5 m / s
c. 1.9 m / s
d. 1.5 m / s
e. 3.6 m / s

27. A 1.6-kg block sliding on a horizontal frictionless surface is attached to one end of a horizontal spring ($k = 300$ N / m) which has its other end fixed. If the block has a speed of 4.0 m / s as it passes through the equilibrium position, what is its speed when it is 0.20 m from the equilibrium position?

a. 2.0 m / s
b. 3.3 m / s
c. 2.9 m / s
d. 2.4 m / s
e. 1.7 m / s

28. A spring (k = 600 N / m) is at the bottom of a frictionless plane that makes an angle of 30° with the horizontal. The upper end of the spring is depressed 0.10 m, and a 2.0-kg block is placed against the depressed spring. The system is then released from rest. What is the kinetic energy of the block at the instant it has traveled 0.10 m and the spring has returned to its uncompressed length?

a. 2.0 J
b. 1.8 J
c. 2.2 J
d. 1.6 J
e. 1.0 J

29. A spring (k = 600 N / m) is placed in a vertical position with its lower end supported by a horizontal surface. A 2.0-kg block that is initially 0.40 m above the upper end of the spring is dropped from rest onto the spring. What is the kinetic energy of the block at the instant it has fallen 0.50 m (compressing the spring 0.10 m)?

a. 5.3 J
b. 6.8 J
c. 6.3 J
d. 5.8 J
e. 6.5 J

30. A 2.0-kg block slides down a fixed, rough curved track. The block has a speed of 5.0 m / s after its height above a horizontal surface has decreased by 1.8 m. If the block started from rest, how much work was done by the friction force on the block by the surface during this descent?

a. –14 J
b. –12 J
c. –10 J
d. –16 J
e. –25 J

31. A 1.5-kg block sliding on a rough horizontal surface is attached to one end of a horizontal spring (k = 200 N / m) which has its other end fixed. If this system is displaced 20 cm horizontally from the equilibrium position and released from rest, the block first reaches the equilibrium position with a speed of 2.0 m / s. What is the coefficient of kinetic friction between the block and the horizontal surface on which it slides?

a. 0.34
b. 0.24
c. 0.13
d. 0.44
e. 0.17

32. A 0.75-kg sphere is released from rest and is moving 5.0 m/s after falling 2.0 m in a viscous medium. How much work is done by the viscous force on the block during this descent?

a. –6.1 J
b. –4.6 J
c. –5.3 J
d. –6.8 J
e. –2.7 J

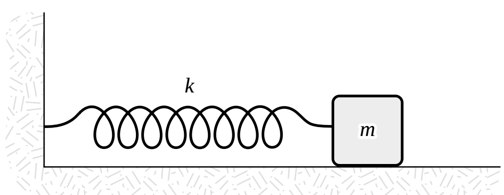
33. A 12-kg projectile is launched with an initial vertical speed of 20 m/s. It rises to a maximum height of 18 m above the launch point. How much work is done by the dissipative (air) resistive force on the projectile during this ascent?

a. –0.64 kJ
b. –0.40 kJ
c. –0.52 kJ
d. –0.28 kJ
e. –0.76 kJ

34. A 10-kg object is dropped from rest. After falling a distance of 50 m, it has a speed of 26 m/s. How much work is done by the dissipative (air) resistive force on the object during this descent?

a. –1.3 kJ
b. –1.5 kJ
c. –1.8 kJ
d. –2.0 kJ
e. –2.3 kJ

35. The block shown is released from rest when the spring is stretched a distance *d*. If k = 50 N/m, m = 0.50 kg, d = 10 cm, and the coefficient of kinetic friction between the block and the horizontal surface is equal to 0.25, determine the speed of the block when it first passes through the position for which the spring is unstretched.



a. 92 cm/s
b. 61 cm/s
c. 71 cm/s
d. 82 cm/s
e. 53 cm/s

36. A 2.0-kg block sliding on a rough horizontal surface is attached to one end of a horizontal spring (k = 250 N / m) which has its other end fixed. The block passes through the equilibrium position with a speed of 2.6 m / s and first comes to rest at a displacement of 0.20 m from equilibrium. What is the coefficient of kinetic friction between the block and the horizontal surface?

a. 0.32
b. 0.45
c. 0.58
d. 0.19
e. 0.26

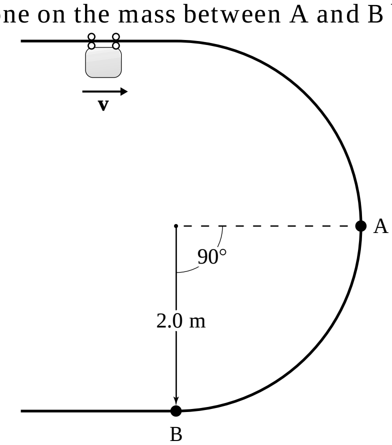
37. In a given displacement of a particle, its kinetic energy increases by 25 J while its potential energy decreases by 10 J. Determine the work of the nonconservative forces acting on the particle during this displacement.

a. –15 J
b. +35 J
c. +15 J
d. –35 J
e. +55 J

38. A particle is acted upon by only two forces, one conservative and one nonconservative, as it moves from point A to point B. The kinetic energies of the particle at points A and B are equal if:

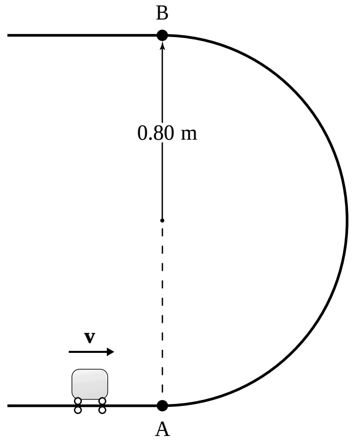
a. the sum of the works of the two forces is zero.
b. the work of the conservative force is equal to the work of the nonconservative force.
c. the work of the conservative force is zero.
d. the work of the nonconservative force is zero.
e. None of the above.

39. A 1.2-kg mass is projected down a rough circular track (radius = 2.0 m) as shown. The speed of the mass at point A is 3.2 m / s, and at point B, it is 6.0 m / s. How much work is done on the mass between A and B by the force of friction?



a. –8.9 J
b. –7.3 J
c. –8.1 J
d. –6.6 J
e. –24 J

40. A 1.2-kg mass is projected up a rough circular track (radius = 0.80 m) as shown. The speed of the mass at point A is 8.4 m/s, and at point B, it is 5.6 m/s. How much work is done on the mass between A and B by the force of friction?



a. –2.7 J **b.** –8.8 J **c.** –4.7 J **d.** –6.7 J **e.** –19 J

41. A 3.0-kg mass is dropped from the edge of a 50-m tall building with an initial speed of zero. The mass strikes the ground with a downward velocity of 25 m/s. How much work is done on the mass by air resistance between the point where it is dropped and the point where it strikes the ground?

a. –0.46 kJ
b. –0.53 kJ
c. –0.61 kJ
d. –0.38 kJ
e. –0.81 kJ

42. A 2.0-kg mass is projected vertically upward from ground level with an initial speed of 30 m/s. The mass rises to a maximum height of 35 m above ground level. How much work is done on the mass by air resistance between the point of projection and the point of maximum height?

a. –0.21 kJ
b. –0.47 kJ
c. –0.40 kJ
d. –0.34 kJ
e. –0.69 kJ

43. A 25-kg block on a horizontal surface is attached to a light spring (force constant = 8.0 kN / m). The block is pulled 10 cm to the right from its equilibrium position and released from rest. When the block has moved 2.0 cm toward its equilibrium position, its kinetic energy is 12 J. How much work is done by the frictional force on the block as it moves the 2.0 cm?

a. –4.0 J
b. –3.5 J
c. –2.4 J
d. –2.9 J
e. –15 J

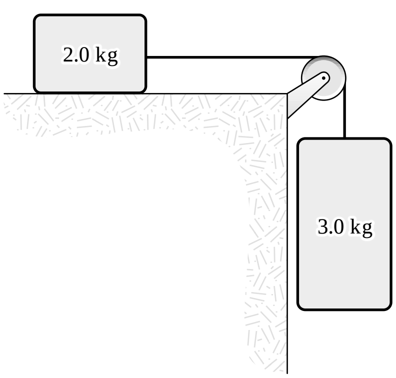
44. As an object moves from point A to point B only two forces act on it: one force is nonconservative and does –30 J of work, the other force is conservative and does +50 J of work. Between A and B,

a. kinetic energy of object increases, mechanical energy decreases.
b. kinetic energy of object decreases, mechanical energy decreases.
c. kinetic energy of object decreases, mechanical energy increases.
d. kinetic energy of object increases, mechanical energy increases.
e. None of the above.

45. As an object moves from point A to point B only two forces act on it: one force is conservative and does –70 J of work, the other force is nonconservative and does +50 J of work. Between A and B,

a. kinetic energy of object increases, mechanical energy increases.
b. kinetic energy of object decreases, mechanical energy increases.
c. kinetic energy of object decreases, mechanical energy decreases.
d. kinetic energy of object increases, mechanical energy decreases.
e. None of the above.

46. The two masses in the figure are released from rest. After the 3.0-kg mass has fallen 1.5 m, it is moving with a speed of 3.8 m / s. How much work is done during this time interval by the frictional force on the 2.0 kg mass?



a. –12 J
b. –17 J
c. –20 J
d. –8.0 J
e. –28 J

47. A 2.0-kg block is projected down a plane that makes an angle of 20 with the horizontal with an initial kinetic energy of 2.0 J. If the coefficient of kinetic friction between the block and plane is 0.40, how far will the block slide down the plane before coming to rest?

a. 3.0 m
b. 1.8 m
c. 0.30 m
d. 1.0 m
e. 1.3 m

Conceptual Problems

48. A rain cloud contains 2.66×10^7 kg of water vapor. How long would it take for a 2.0 kW pump to lift the same amount of water to an altitude of 2000 m ?

49. A surprising demonstration involves dropping an egg from a third-floor window to land on a foam-rubber pad 2 in (5 cm) thick without breaking. If a 56-gram egg falls 12 m, and the foam pad stops the egg in 6.25 ms, by how much is the pad compressed?

50. A 70-kg high jumper leaves the ground with a vertical velocity of 6 m/s. How high can he jump?

51. A simple pendulum, 2.0 m in length, is released from rest when the support string is at an angle of 25° from the vertical. What is the speed of the suspended mass at the bottom of the swing?

52. An astronaut tosses a ball out in space where gravitational fields may be neglected. What will happen to the ball?

a. It will stop as soon as the force the astronaut gave it is used up.
b. It will stop when the energy the astronaut gave it runs out.
c. It will stop after a short time because there is no gravity to keep it moving.
d. It will move in a circle like a boomerang.
e. It will be slowed down very gradually by collisions with molecules in space.

53. Which of the following is a conservative force? (All refer to a car on a slope.)

a. The force you exert on a car pushing it uphill.
b. The normal force of the road on the car.
c. The frictional force of the road on the car.
d. The component of the gravitational force parallel to the road.
e. The vertical component of the normal force of the road on the car.

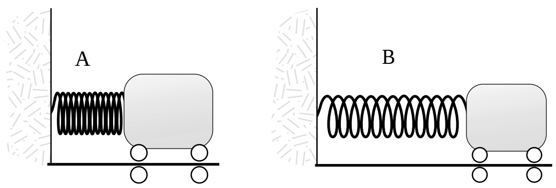
54. For a force to be a conservative force, when applied to a single test body:

a. It must have the same value at all points in space.
b. It must have the same direction at all points in space.
c. It must be parallel to a displacement in any direction.
d. Equal work must be done in equal displacements.
e. No work must be done for motion in closed paths.

55. The force a spring exerts on a body is a conservative force because:

a. a spring always exerts a force opposite to the displacement of the body.
b. a spring always exerts a force parallel to the displacement of the body.
c. the work a spring does on a body is equal for compressions and extensions of equal magnitude.
d. the work a spring does on a body is equal and opposite for compressions and extensions of equal magnitude.
e. the net work a spring does on a body is zero when the body returns to its initial position.

56. A large spring is used to stop the cars after they come down the last hill of a roller coaster. The cars start at rest at the top of the hill and are caught by a mechanism at the instant their velocities at the bottom are zero. Compare the compression of the spring, x_A, for a fully loaded car with that, x_B, for a lightly loaded car. $m_A = 2m_B$.



a. $x_A = \frac{1}{2} x_B$.
b. $x_A = x_B$.
c. $x_A = \sqrt{2}\ x_B$.
d. $x_A = 2\ x_B$.
e. $x_A = 4\ x_B$.

57. A small lead sphere of mass *m* is hung from a spring of spring constant *k*. The gravitational potential energy of the system equals zero at the equilibrium position of the spring before the weight is attached. The total mechanical energy of the system when the mass is hanging at rest is:

a. $-kx^2$.
b. $-\frac{1}{2}kx^2$.
c. 0.
d. $+\frac{1}{2}kx^2$.
e. $+kx^2$.

58. A block of mass *m* is hung from a vertical spring of spring constant *k*, which is hung in turn from another identical spring. The amount by which each spring stretches is *x*. The total elastic potential energy of the system when at rest is:

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

b. mgx.

c. 2mgx.

d. $\frac{1}{2}\frac{m^2g^2}{k}$.

e. $\frac{2m^2g^2}{k}$

59. Cubical blocks of mass m and side l are piled up in a vertical column. The total gravitational potential energy of a column of three blocks is:

a. $\frac{5}{2}$ mgl

b. 3mgl.

c. $\frac{9}{2}$ mgl.

d. 6mgl.

e. 9mgl.

60. An all-terrain vehicle of 2000 kg mass moves up a 15° slope at a constant velocity of 6 m/s. The rate of change of gravitational potential energy with time is:

a. 5.25 kW.

b. 24.8 kW.

c. 30.4 kW.

d. 118 kW.

e. 439 kW.

61. Concrete blocks are balanced on two identical vertical springs. $m_A = 2\ m_B$. The gravitational potential energy of each system is zero at the equilibrium position of the springs. Which statement is true for the *total mechanical energy* of the systems when the blocks are balanced on the springs?

a. $E_A = E_B$.

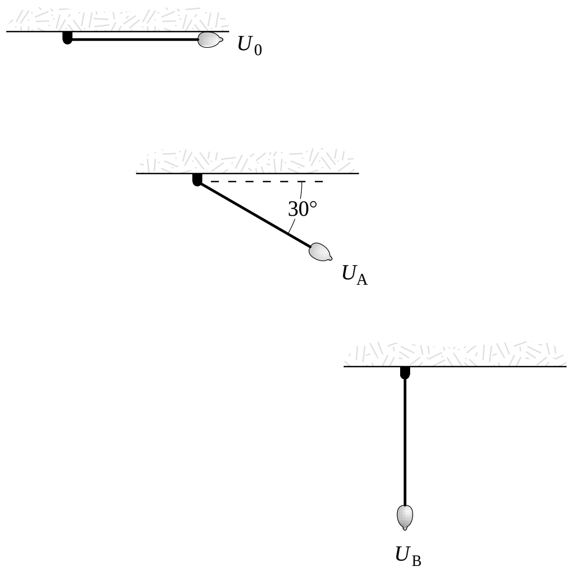
b. $E_A = 2\ E_B$.

c. $E_A = 4\ E_B$.

d. $E_A = -2\ E_B$.

e. $E_A = -4\ E_B$.

62. A pendulum bob has potential energy U_o when held taut in a horizontal position. The bob falls until it is 30° away from the horizontal position, when it has potential energy U_A. It continues to fall until the string is vertical, when it has potential energy U_B. Compare its potential energies at O, A, and B:



a. $U_o = U_A = U_B$.
b. $U_A = 2\ U_B$; $U_o = 2\ U_A$.
c. $U_A - U_B = U_o - U_A$.
d. $U_o - U_B = 2U_A$.
e. $U_o - U_A = 2(U_A - U_B)$.

Chapter 8

The Laws of Motion

1. Answer: b

2. Answer: c

3. Answer: b

4. Answer: c

5. Answer: d

6. Answer: a

7. Answer: c

8. Answer: b

9. Answer: a

10. Answer: b

11. Answer: c

12. Answer: d

13. Answer: c

14. Answer: b

15. Answer: a

16. Answer: a

17. Answer: b

18. Answer: c

19. Answer: a

20. Answer: d

21. Answer: b

22. Answer: c

23. Answer: b

24. Answer: c

25. Answer: b

26. Answer: a

27. Answer: c

28. Answer: a

29. Answer: b

30. Answer: c

31. Answer: a

32. Answer: c

33. Answer: d

34. Answer: b

35. Answer: c

36. Answer: b

37. Answer: a

38. Answer: a

39. Answer: c

40. Answer: c

41. Answer: b

42. Answer: a

43. Answer: c

44. Answer: a

45. Answer: b

46. Answer: d

47. Answer: a

48. Answer: 8.26 years

49. Answer: 4.8 cm

50. Answer: 1.84 m

51. Answer: 1.9 m / s

52. Answer: e

53. Answer: d

54. Answer: e

55. Answer: e

56. Answer: c

57. Answer: b

58. Answer: b

59. Answer: c

60. Answer: c

61. Answer: c

62. Answer: c

Chapter 9

Linear Momentum and Collisions

Multiple Choice

1. A 2000-kg truck traveling at a speed of 6.0 m/s makes a 90° turn in a time of 4.0 s and emerges from this turn with a speed of 4.0 m/s. What is the magnitude of the average resultant force on the truck during this turn?

a. 4.0 kN
b. 5.0 kN
c. 3.6 kN
d. 6.4 kN
e. 0.67 kN

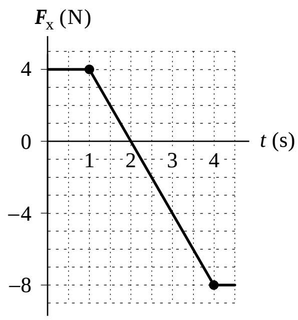
2. A 1.2-kg object moving with a speed of 8.0 m/s collides perpendicularly with a wall and emerges with a speed of 6.0 m/s in the opposite direction. If the object is in contact with the wall for 2.0 ms, what is the magnitude of the average force on the object by the wall?

a. 9.8 kN
b. 8.4 kN
c. 7.7 kN
d. 9.1 kN
e. 1.2 kN

3. A 1.5-kg playground ball is moving with a velocity of 3.0 m/s directed 30° below the horizontal just before it strikes a horizontal surface. The ball leaves this surface 0.50 s later with a velocity of 2.0 m/s directed 60° above the horizontal. What is the magnitude of the average resultant force on the ball?

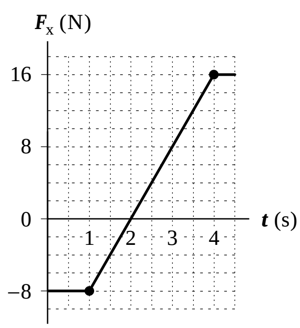
a. 14 N
b. 11 N
c. 18 N
d. 22 N
e. 3.0 N

4. The only force acting on a 2.0-kg object moving along the x axis is shown. If the velocity v_x is –2.0 m/s at t = 0, what is the velocity at t = 4.0 s?



a. –2.0 m/s
b. –4.0 m/s
c. –3.0 m/s
d. +1.0 m/s
e. +5.0 m/s

5. The only force acting on a 2.0-kg object moving along the x axis is shown. If the velocity v_x is +2.0 m/s at t = 0, what is the velocity at t = 4.0 s?



a. +4.0 m/s
b. +5.0 m/s
c. +6.0 m/s
d. +7.0 m/s
e. +2.0 m/s

6. The speed of a 2.0-kg object changes from 30 m/s to 40 m/s during a 5.0-s time interval. During this same time interval, the velocity of the object changes its direction by 90°. What is the magnitude of the average total force acting on the object during this time interval?

a. 30 N
b. 20 N
c. 40 N
d. 50 N
e. 6.0 N

7. A 3.0-kg ball with an initial velocity of (4**i** + 3**j**) m/s collides with a wall and rebounds with a velocity of (–4**i** + 3**j**) m/s. What is the impulse exerted on the ball by the wall?

a. +24**i** N s
b. –24**i** N s
c. +18**j** N s
d. –18**j** N s
e. +8.0**i** N s

8. A 2.4-kg ball falling vertically hits the floor with a speed of 2.5 m/s and rebounds with a speed of 1.5 m/s. What is the magnitude of the impulse exerted on the ball by the floor?

a. 9.6 N s
b. 2.4 N s
c. 6.4 N s
d. 1.6 N s
e. 1.0 N s

9. A 0.16-kg baseball is thrown with a speed of 40 m/s. It is hit straight back at the pitcher with a speed of 80 m/s. What is the magnitude of the impulse exerted on the ball by the bat?

a. 16 N · s
b. 6.4 N · s
c. 19 N · s
d. 3.2 N · s
e. 64 N · s

10. An 8.0-kg object moving 4.0 m/s in the positive x direction has a one-dimensional collision with a 2.0-kg object moving 3.0 m/s in the opposite direction. The final velocity of the 8.0-kg object is 2.0 m/s in the positive x direction. What is the total kinetic energy of the two-mass system after the collision?

a. 32 J
b. 52 J
c. 41 J
d. 25 J
e. 29 J

11. A 1.6-kg ball is attached to the end of a 0.40-m string to form a pendulum. This pendulum is released from rest with the string horizontal. At the lowest point of its swing, when it is moving horizontally, the ball collides with a 0.80-kg block initially at rest on a horizontal frictionless surface. The speed of the block just after the collision is 3.0 m/s. What is the speed of the ball just after the collision?

a. 1.7 m/s
b. 1.1 m/s
c. 1.5 m/s
d. 1.3 m/s
e. 2.1 m/s

12. A 4.0-kg particle is moving horizontally with a speed of 5.0 m/s when it strikes a vertical wall. The particle rebounds with a speed of 3.0 m/s. What is the magnitude of the impulse delivered to the particle?

a. 24 N · s
b. 32 N · s
c. 40 N · s
d. 30 N · s
e. 8.0 N · s

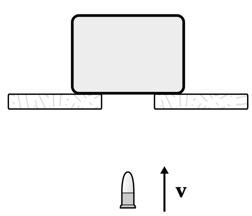
13. A 2.0-kg object moving with a velocity of 5.0 m/s in the positive *x* direction strikes and sticks to a 3.0-kg object moving with a speed of 2.0 m/s in the same direction. How much kinetic energy is lost in this collision?

a. 2.4 J
b. 9.6 J
c. 5.4 J
d. 0.6 J
e. 6.0 J

14. A 12-g bullet is fired into a 3.0-kg ballistic pendulum initially at rest and becomes embedded in it. The pendulum subsequently rises a vertical distance of 12 cm. What was the initial speed of the bullet?

a. 0.38 km/s
b. 0.44 km/s
c. 0.50 km/s
d. 0.54 km/s
e. 0.024 km/s

15. A 10-g bullet moving 1000 m/s strikes and passes through a 2.0-kg block initially at rest, as shown. The bullet emerges from the block with a speed of 400 m/s. To what maximum height will the block rise above its initial position?



a. 78 cm
b. 66 cm
c. 56 cm
d. 46 cm
e. 37 cm

16. A 12-g bullet moving horizontally strikes and remains in a 3.0-kg block initially at rest on the edge of a table. The block, which is initially 80 cm above the floor, strikes the floor a horizontal distance of 120 cm from its initial position. What was the initial speed of the bullet?

a. 0.68 km/s
b. 0.75 km/s
c. 0.81 km/s
d. 0.87 km/s
e. 0.41 km/s

17. A 6.0-kg object moving 5.0 m/s collides with and sticks to a 2.0-kg object. After the collision the composite object is moving 2.0 m/s in a direction opposite to the initial direction of motion of the 6.0-kg object. Determine the speed of the 2.0-kg object before the collision.

a. 15 m/s
b. 7.0 m/s
c. 8.0 m/s
d. 23 m/s
e. 11 m/s

18. A 2.0-kg object moving 5.0 m/s collides with and sticks to an 8.0-kg object initially at rest. Determine the kinetic energy lost by the system as a result of this collision.

a. 20 J
b. 15 J
c. 30 J
d. 25 J
e. 5.0 J

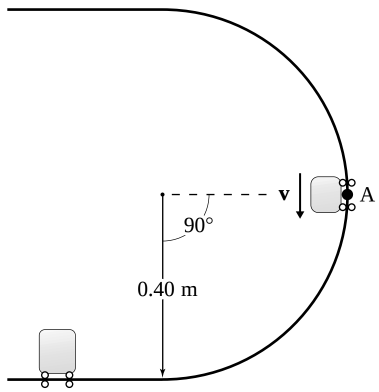
19. A 1.6-kg block is attached to the end of a 2.0-m string to form a pendulum. The pendulum is released from rest when the string is horizontal. At the lowest point of its swing when it is moving horizontally, the block is hit by a 10-g bullet moving horizontally in the opposite direction. The bullet remains in the block and causes the block to come to rest at the low point of its swing. What was the magnitude of the bullet's velocity just before hitting the block?

a. 1.0 km/s
b. 1.6 km/s
c. 1.2 km/s
d. 1.4 km/s
e. 1.8 km/s

20. A 3.0-kg mass sliding on a frictionless surface has a velocity of 5.0 m/s east when it undergoes a one-dimensional inelastic collision with a 2.0-kg mass that has an initial velocity of 2.0 m/s west. After the collision the 3.0-kg mass has a velocity of 1.0 m/s east. How much kinetic energy does the two-mass system lose during the collision?

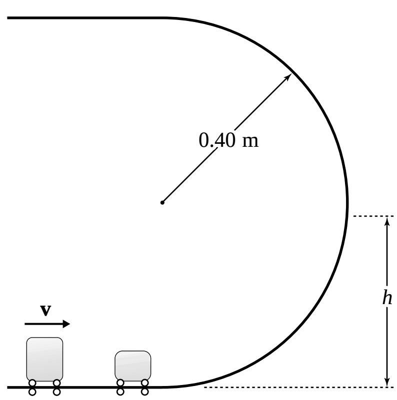
a. 22 J
b. 24 J
c. 26 J
d. 20 J
e. 28 J

21. A 3.0-kg mass is released from rest at point A of a circular frictionless track of radius 0.40 m as shown in the figure. The mass slides down the track and collides with a 1.4-kg mass that is initially at rest on a horizontal frictionless surface. If the masses stick together, what is their speed after the collision?



a. 2.1 m/s
b. 1.7 m/s
c. 1.9 m/s
d. 1.5 m/s
e. 2.3 m/s

22. A 3.0-kg mass is sliding on a horizontal frictionless surface with a speed of 3.0 m/s when it collides with a 1.0-kg mass initially at rest as shown in the figure. The masses stick together and slide up a frictionless circular track of radius 0.40 m. To what maximum height, *h*, above the horizontal surface will the masses slide?



a. 0.18 m
b. 0.15 m
c. 0.21 m
d. 0.26 m
e. 0.40 m

23. A 10-g bullet moving horizontally with a speed of 2.0 km/s strikes and passes through a 4.0-kg block moving with a speed of 4.2 m/s in the opposite direction on a horizontal frictionless surface. If the block is brought to rest by the collision, what is the kinetic energy of the bullet as it emerges from the block?

a. 0.51 kJ
b. 0.29 kJ
c. 0.80 kJ
d. 0.13 kJ
e. 20 kJ

24. A 10-g bullet moving horizontally with a speed of 1.8 km/s strikes and passes through a 5.0-kg block initially at rest on a horizontal frictionless surface. The bullet emerges from the block with a speed of 1.0 km/s. What is the kinetic energy of the block immediately after the bullet emerges?

a. 8.0 J
b. 6.4 J
c. 5.3 J
d. 9.4 J
e. 10 J

25. A pendulum consists of a 2.0-kg block hanging on a 1.5-m length string. If a 10-g bullet moving with a horizontal velocity of 900 m/s strikes, passes through the block (initially at rest), and emerges with a horizontal velocity of 300 m/s, to what maximum height will the block swing above its initial position?

a. 32 cm
b. 38 cm
c. 46 cm
d. 27 cm
e. 9 cm

26. A 1.0-kg ball is attached to the end of a 2.5-m string to form a pendulum. This pendulum is released from rest with the string horizontal. At the lowest point in its swing when it is moving horizontally, the ball collides elastically with a 2.0-kg block initially at rest on a horizontal frictionless surface. What is the speed of the block just after the collision?

a. 2.3 m/s
b. 4.7 m/s
c. 3.5 m/s
d. 3.0 m/s
e. 7.0 m/s

27. A 4.0-kg mass moving 6.0 m/s undergoes a one-dimensional elastic collision with a 1.0-kg mass moving 4.0 m/s in a direction opposite to that of the greater mass. What is the magnitude of the change in momentum of the 1.0-kg mass as a result of this collision?

a. 12 kg · m/s
b. 16 kg · m/s
c. 8.0 kg · m/s
d. 4.0 kg · m/s
e. 2.0 kg · m/s

28. A 3.0-kg object moving in the positive *x* direction has a one-dimensional elastic collision with a 5.0-kg object initially at rest. After the collision the 5.0-kg object has a velocity of 6.0 m/s in the positive *x* direction. What was the initial speed of the 3.0 kg object?

a. 6.0 m/s
b. 7.0 m/s
c. 4.5 m/s
d. 8.0 m/s
e. 5.5 m/s

29. A 3.0-kg object moving 8.0 m/s in the positive *x* direction has a one-dimensional elastic collision with an object (mass = M) initially at rest. After the collision the object of unknown mass has a velocity of 6.0 m/s in the positive *x* direction. What is M?

a. 7.5 kg
b. 5.0 kg
c. 6.0 kg
d. 4.2 kg
e. 8.0 kg

30. A 6.0-kg object moving 2.0 m/s in the positive *x* direction has a one-dimensional elastic collision with a 4.0-kg object moving 3.0 m/s in the opposite direction. What is the total kinetic energy of the two-mass system after the collision?

a. 30 J
b. 62 J
c. 20 J
d. 44 J
e. 24 J

31. Two blocks with masses 2.0 kg and 3.0 kg are placed on a horizontal frictionless surface. A light spring is placed in a horizontal position between the blocks. The blocks are pushed together, compressing the spring, and then released from rest. After contact with the spring ends, the 3.0-kg mass has a speed of 2.0 m/s. How much potential energy was stored in the spring when the blocks were released?

a. 15 J
b. 3.0 J
c. 6.0 J
d. 12 J
e. 9.0 J

32. An 80-g particle moving with an initial speed of 50 m/s in the positive *x* direction strikes and sticks to a 60-g particle moving 50 m/s in the positive *y* direction. How much kinetic energy is lost in this collision?

a. 96 J
b. 89 J
c. 175 J
d. 86 J
e. 110 J

33. A 2.0-kg object moving 3.0 m/s strikes a 1.0-kg object initially at rest. Immediately after the collision, the 2.0-kg object has a velocity of 1.5 m/s directed 30° from its initial direction of motion. What is the speed of the 1.0-kg object just after the collision?

a. 3.7 m/s
b. 3.4 m/s
c. 1.5 m/s
d. 2.4 m/s
e. 4.1 m/s

34. A 6.0-kg object, initially at rest in free space, "explodes" into three segments of equal mass. Two of these segments are observed to be moving with equal speeds of 20 m/s with an angle of 60° between their directions of motion. How much kinetic energy is released in this explosion?

a. 2.4 kJ
b. 2.9 kJ
c. 2.0 kJ
d. 3.4 kJ
e. 1.2 kJ

35. A 5.0-g particle moving 60 m/s collides with a 2.0-g particle initially at rest. After the collision each of the particles has a velocity that is directed 30° from the original direction of motion of the 5.0-g particle. What is the speed of the 2.0-g particle after the collision?

a. 72 m/s
b. 87 m/s
c. 79 m/s
d. 94 m/s
e. 67 m/s

36. A 1.0-kg object moving 9.0 m/s collides with a 2.0-kg object moving 6.0 m/s in a direction that is perpendicular to the initial direction of motion of the 1.0-kg object. The two masses remain together after the collision, and this composite object then collides with and sticks to a 3.0-kg object. After these collisions, the final composite (6.0-kg) object remains at rest. What was the speed of the 3.0-kg object before the collisions?

a. 15 m/s
b. 10 m/s
c. 5.0 m/s
d. 20 m/s
e. 25 m/s

37. A 3.0-kg mass sliding on a frictionless surface explodes into three 1.0-kg masses. After the explosion the velocities of the three masses are: (1) 9.0 m/s, north; (2) 4.0 m/s, 30° south of west; and (3) 4.0 m/s, 30° south of east. What was the magnitude of the original velocity of the 3.0-kg mass?

a. 1.7 m/s
b. 1.0 m/s
c. 1.3 m/s
d. 2.0 m/s
e. 2.8 m/s

38. A 3.0-kg mass moving in the positive x direction with a speed of 10 m/s collides with a 6.0-kg mass initially at rest. After the collision, the speed of the 3.0-kg mass is 8.0 m/s, and its velocity vector makes an angle of 35° with the positive x axis. What is the magnitude of the velocity of the 6.0-kg mass after the collision?

a. 2.2 m/s
b. 2.9 m/s
c. 4.2 m/s
d. 3.5 m/s
e. 4.7 m/s

39. A 70-kg man who is ice skating north collides with a 30-kg boy who is ice skating west. Immediately after the collision, the man and boy are observed to be moving together with a velocity of 2.0 m/s, in a direction 37° north of west. What was the magnitude of the boy's velocity before the collision?

a. 8.5 m/s
b. 5.3 m/s
c. 3.7 m/s
d. 6.7 m/s
e. 1.0 m/s

40. A 5.0-kg mass with an initial velocity of 4.0 m/s, east collides with a 4.0-kg mass with an initial velocity of 3.0 m/s, west. After the collision the 5.0-kg mass has a velocity of 1.2 m/s, south. What is the magnitude of the velocity of the 4.0-kg mass after the collision?

a. 2.0 m/s
b. 1.5 m/s
c. 1.0 m/s
d. 2.5 m/s
e. 3.0 m/s

41. A 4.0-kg mass has a velocity of 4.0 m/s, east when it explodes into two 2.0-kg masses. After the explosion one of the masses has a velocity of 3.0 m/s at an angle of 60° north of east. What is the magnitude of the velocity of the other mass after the explosion?

a. 7.9 m/s
b. 8.9 m/s
c. 7.0 m/s
d. 6.1 m/s
e. 6.7 m/s

42. A 4.2-kg object, initially at rest, "explodes" into three objects of equal mass. Two of these are determined to have velocities of equal magnitudes (5.0 m/s) with directions that differ by 90°. How much kinetic energy was released in the explosion?

a. 70 J
b. 53 J
c. 60 J
d. 64 J
e. 35 J

43. A 4.0-kg mass, initially at rest on a horizontal frictionless surface, is struck by a 2.0-kg mass moving along the *x* axis with a speed of 8.0 m/s. After the collision, the 2.0-kg mass has a speed of 4.0 m/s at an angle of 37° from the positive *x* axis. What is the speed of the 4.0-kg mass after the collision?

a. 2.0 m/s
b. 2.7 m/s
c. 4.9 m/s
d. 2.4 m/s
e. 3.6 m/s

44. A 3.0-kg mass, initially at rest on a frictionless surface, explodes into three 1.0-kg masses. After the explosion the velocities of two of the 1.0-kg masses are: (1) 5.0 m/s, north and (2) 4.0 m/s, 30° south of east. What is the magnitude of the velocity of the third 1.0-kg mass after the explosion?

a. 5.3 m/s
b. 4.6 m/s
c. 4.9 m/s
d. 5.7 m/s
e. 2.6 m/s

45. At an instant when a particle of mass 50 g has an acceleration of 80 m/s^2 in the positive *x* direction, a 75-g particle has an acceleration of 40 m/s^2 in the positive *y* direction. What is the magnitude of the acceleration of the center of mass of this two-particle system at this instant?

a. 60 m/s
b. 56 m/s
c. 40 m/s
d. 50 m/s
e. 46 m/s

46. At an instant when a particle of mass 80 g has a velocity of 25 m/s in the positive *y* direction, a 75-g particle has a velocity of 20 m/s in the positive *x* direction. What is the speed of the center of mass of this two-particle system at this instant?

a. 16 m/s
b. 45 m/s
c. 23 m/s
d. 20 m/s
e. 36 m/s

47. Three particles are placed in the *xy* plane. A 40-g particle is located at (3, 4) m, and a 50-g particle is positioned at (–2, –6) m. Where must a 20-g particle be placed so that the center of mass of this three-particle system is located at the origin?

a. (–1, –3) m
b. (–1, 2) m
c. (–1, 12) m
d. (–1, 7) m
e. (–1, 3) m

48. A rocket engine consumes 450 kg of fuel per minute. If the exhaust speed of the ejected fuel is 5.2 km/s, what is the thrust of the rocket?

a. 42 kN
b. 39 kN
c. 45 kN
d. 48 kN
e. 35 kN

49. A rocket with an initial mass of 1000 kg adjusts its thrust by varying the rate at which mass is ejected. The ejection speed relative to the rocket is 40 km/s. If the acceleration of the rocket is to have a magnitude of 20 m/s^2 at an instant when its mass is 80% of the original mass, at what rate is mass being ejected at this instant? Ignore any external forces on the rocket.

a. 0.40 kg/s
b. 0.50 kg/s
c. 0.60 kg/s
d. 0.70 kg/s
e. 0.80 kg/s

50. A rocket moving in outer space maintains a constant acceleration (magnitude = 20 m/s^2) while ejecting fuel at a speed of 15 km/s relative to the rocket. If the initial mass of the rocket is 3000 kg, what is the magnitude of the thrust after 800 kg of fuel have been consumed?

a. 56 kN
b. 48 kN
c. 52 kN
d. 44 kN
e. 36 kN

51. Three particles are placed in the *xy* plane. A 30-g particle is located at (3, 4) m, and a 40-g particle is located at (–2, –2) m. Where must a 20-g particle be placed so that the center of mass of the three-particle system is at the origin?

a. (–3, –1) m
b. (+1, +3) m
c. (+3, –1) m
d. (–1, –3) m
e. (–.5, –2) m

52. At the instant a 2.0-kg particle has a velocity of 4.0 m/s in the positive *x* direction, a 3.0-kg particle has a velocity of 5.0 m/s in the positive *y* direction. What is the speed of the center of mass of the two-particle system?

a. 3.8 m/s
b. 3.4 m/s
c. 5.0 m/s
d. 4.4 m/s
e. 4.6 m/s

Conceptual Problems

53. A child bounces a 50-gram superball on the sidewalk. The velocity change of the superball is from 21 m/s downward to 19 m/s upward. If the contact time with the sidewalk is 1/800 s, what is the magnitude of the force exerted on the superball by the sidewalk?

54. High-speed stroboscopic photographs show that the head of a golf club of mass 200 grams is traveling at 55 m/s just before it strikes a 46-gram golf ball at rest on a tee. After the collision, the clubhead travels (in the same direction) at 40 m/s. Find the speed of the golf ball just after impact.

55. A pitcher claims he can throw a baseball with as much momentum as a 3.00-g bullet moving with a speed of 1500 m/s. A baseball has a mass of 0.145 kg. What must be its speed if the pitcher's claim is valid?

56. A U-238 nucleus (mass = 238 units) decays, transforming into an alpha particle (mass = 4 units) and a residual thorium nucleus (mass = 234 units). If the uranium nucleus was at rest, and the alpha particle has a speed of 1.5×10^7 m/s, determine the recoil speed of the thorium nucleus.

57. Two 0.20 kg balls moving at 4 m/s, East strike a wall. Ball A bounces backwards at the same speed. Ball B stops. Which statement correctly describes the change in momentum of the two balls?

a. $|\Delta\mathbf{p}_B| < |\Delta\mathbf{p}_A|$.
b. $|\Delta\mathbf{p}_B| = |\Delta\mathbf{p}_A|$.
c. $|\Delta\mathbf{p}_B| > |\Delta\mathbf{p}_A|$.
d. $\Delta\mathbf{p}_B = \Delta\mathbf{p}_A$.
e. $\Delta\mathbf{p}_B > \Delta\mathbf{p}_A$.

58. A ball falls to the ground from height *h* and bounces to height *h*'. Momentum is conserved in the ball-earth system:

a. no matter what height *h*' it reaches.
b. only if $h' < h$.
c. only if $h' = h$.
d. only if $h' > h$.
e. only if $h' \geq h$.

59. The law of conservation of momentum applies to a collision between two bodies if:

a. they exert equal and opposite forces on each other.
b. they exert forces on each other respectively proportional to their masses.
c. they exert forces on each other respectively proportional to their velocities.
d. they exert forces on each other respectively inversely proportional to their masses.
e. their accelerations are proportional to their masses.

60. When two bodies of different masses collide, the impulses they exert on each other are:

a. equal for all collisions.
b. equal but opposite for all collisions.
c. equal but opposite only for elastic collisions.
d. equal but opposite only for inelastic collisions.
e. equal but opposite only when the bodies have equal but opposite accelerations.

61. The magnitude of the velocity of the center of mass of a system of two bodies, m_1 and m_2, moving east with velocities of magnitudes v_1 and v_2, where v_1 is less than v_2, is:

a. less than v_1.
b. equal to v_1.
c. equal to the average of v_1 and v_2.
d. greater than v_1 and less than v_2.
e. greater than v_2.

62. A car of mass m_1 traveling at velocity v passes a car of mass m_2 parked at the side of the road. The momentum of the system of two cars is:

a. 0.
b. $m_1 v$.
c. $(m_1 - m_2)v$.
d. $\frac{m_1 v}{m_1 + m_2}$
e. $(m_1 + m_2)v$.

63. If you know the impulse that has acted on a body of mass m you can calculate:

a. its initial velocity.
b. its final velocity.
c. its final momentum.
d. the change in its velocity.
e. its acceleration during the impulse.

64. Two boys in a canoe toss a baseball back and forth. What effect will this have on the canoe?

a. None, because the ball remains in the canoe.
b. The canoe will drift in the direction of the boy who throws the ball harder each time.
c. The canoe will drift in the direction of the boy who throws the ball with less force each time.
d. The canoe will oscillate back and forth always moving opposite to the ball.
e. The canoe will oscillate in the direction of the ball because the canoe and ball exert forces in opposite directions upon the person throwing the ball.

65. An astronaut outside a spaceship hammers a loose rivet back in place. What happens to the astronaut as he swings the hammer?

a. Nothing. The space ship takes up the momentum of the hammer.
b. He moves away from the space ship.
c. He moves towards the space ship.
d. He moves towards the space ship as he pulls the hammer back and moves away from it as he swings the hammer forward.
e. He moves away from the space ship as he pulls the hammer back and moves toward it as he swings the hammer forward.

66. Car A rear ends Car B, which has twice the mass of A, on an icy road at a speed low enough so that the collision is essentially elastic. Car B is stopped at a light when it is struck. Car A has mass m and speed v before the collision. After the collision:

a. each car has half the momentum.
b. car A stops and car B has momentum mv.
c. car A stops and car B has momentum $2mv$.
d. the momentum of car B is four times as great in magnitude as that of car A.
e. each car has half of the kinetic energy.

Chapter 9

Linear Momentum and Collisions

1. Answer: c

2. Answer: b

3. Answer: b

4. Answer: c

5. Answer: a

6. Answer: b

7. Answer: b

8. Answer: a

9. Answer: c

10. Answer: c

11. Answer: d

12. Answer: b

13. Answer: c

14. Answer: a

15. Answer: d

16. Answer: b

17. Answer: d

18. Answer: a

19. Answer: a

20. Answer: b

21. Answer: c

22. Answer: d

23. Answer: a

24. Answer: b

25. Answer: c

26. Answer: b

27. Answer: b

28. Answer: d

29. Answer: b

30. Answer: a

31. Answer: a

32. Answer: d

33. Answer: a

34. Answer: c

35. Answer: b

36. Answer: c

37. Answer: a

38. Answer: b

39. Answer: b

40. Answer: d

41. Answer: c

42. Answer: a

43. Answer: b

44. Answer: b

45. Answer: c

46. Answer: a

47. Answer: d

48. Answer: b

49. Answer: a

50. Answer: d

51. Answer: e

52. Answer: b

53. Answer: 1600 N

54. Answer: 65.2 m / s

55. Answer: 31.0 m / s

56. Answer: 2.56×10^5 m / s

57. Answer: a

58. Answer: a

59. Answer: a

60. Answer: b

61. Answer: d

62. Answer: b

63. Answer: d

64. Answer: d

65. Answer: d

66. Answer: d

Chapter 10

Rotation of a Rigid Object About a Fixed Axis

Multiple Choice

1. At $t = 0$, a wheel rotating about a fixed axis at a constant angular acceleration has an angular velocity of 2.0 rad / s. Two seconds later it has turned through 5.0 complete revolutions. What is the angular acceleration of this wheel?

a. 17 rad / s^2
b. 14 rad / s^2
c. 20 rad / s^2
d. 23 rad / s^2
e. 13 rad / s^2

2. At $t = 0$, a wheel rotating about a fixed axis at a constant angular acceleration of –0.40 rad / s^2 has an angular velocity of 1.5 rad / s and an angular position of 2.3 rad. What is the angular position of the wheel at $t = 2.0$ s?

a. 4.9 rad
b. 4.7 rad
c. 4.5 rad
d. 4.3 rad
e. 4.1 rad

3. A wheel rotating about a fixed axis has an angular position given by $\theta = 3.0 - 2.0t^3$, where θ is measured in radians and t in seconds. What is the angular acceleration of the wheel at $t = 2.0$ s?

a. –1.0 rad / s^2
b. –24 rad / s^2
c. –2.0 rad / s^2
d. –4.0 rad / s^2
e. –3.5 rad / s^2

4. A wheel rotating about a fixed axis with a constant angular acceleration of 2.0 rad / s^2 turns through 2.4 revolutions during a 2.0-s time interval. What was the angular velocity at the end of this time interval?

a. 9.5 rad / s
b. 9.7 rad / s
c. 9.3 rad / s
d. 9.1 rad / s
e. 8.8 rad / s

5. The turntable of a record player has an angular velocity of 8.0 rad/s when it is turned off. The turntable comes to rest 2.5 s after being turned off. Through how many radians does the turntable rotate after being turned off? Assume constant angular acceleration.

a. 12 rad
b. 8.0 rad
c. 10 rad
d. 16 rad
e. 6.8 rad

6. A wheel rotates about a fixed axis with an initial angular velocity of 20 rad/s. During a 5.0-s interval the angular velocity increases to 40 rad/s. Assume that the angular acceleration was constant during the 5.0-s interval. How many revolutions does the wheel turn through during the 5.0-s interval?

a. 20 rev
b. 24 rev
c. 32 rev
d. 28 rev
e. 39 rev

7. A wheel rotates about a fixed axis with an initial angular velocity of 20 rad/s. During a 5.0-s interval the angular velocity decreases to 10 rad/s. Assume that the angular acceleration is constant during the 5.0-s interval. How many radians does the wheel turn through during the 5.0-s interval?

a. 95 rad
b. 85 rad
c. 65 rad
d. 75 rad
e. 125 rad

8. A wheel starts from rest and rotates with a constant angular acceleration about a fixed axis. It completes the first revolution 6.0 s after it started. How long after it started will the wheel complete the second revolution?

a. 9.9 s
b. 7.8 s
c. 8.5 s
d. 9.2 s
e. 6.4 s

9. A thin uniform rod (length = 1.2 m, mass = 2.0 kg) is pivoted about a horizontal, frictionless pin through one end of the rod. (The moment of inertia of the rod about this axis is $ML^2/3$.) The rod is released when it makes an angle of 37° with the horizontal. What is the angular acceleration of the rod at the instant it is released?

a. 9.8 rad/s^2
b. 7.4 rad/s^2
c. 8.4 rad/s^2
d. 5.9 rad/s^2
e. 6.5 rad/s^2

10. A wheel rotating about a fixed axis has a constant angular acceleration of 4.0 rad / s^2. In a 4.0-s interval the wheel turns through an angle of 80 radians. Assuming the wheel started from rest, how long had it been in motion at the start of the 4.0-s interval?

a. 2.5 s
b. 4.0 s
c. 3.5 s
d. 3.0 s
e. 4.5 s

11. A wheel rotating about a fixed axis with a constant angular acceleration of 2.0 rad / s^2 starts from rest at $t = 0$. The wheel has a diameter of 20 cm. What is the magnitude of the total linear acceleration of a point on the outer edge of the wheel at $t = 0.60$ s?

a. 0.25 m / s^2
b. 0.50 m / s^2
c. 0.14 m / s^2
d. 0.34 m / s^2
e. 0.20 m / s^2

12. A wheel rotating about a fixed axis with a constant angular acceleration of 2.0 rad / s^2 starts from rest at $t = 0$. The wheel has a diameter of 30 cm. At what time will a point on the outer edge of the wheel have a linear acceleration with a magnitude of 0.50 m / s^2?

a. 0.88 s
b. 0.93 s
c. 0.82 s
d. 0.98 s
e. 1.7 s

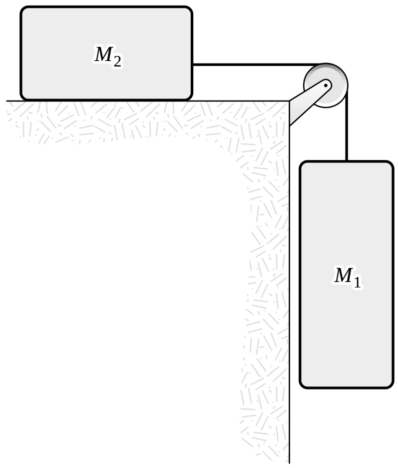
13. A wheel rotates about a fixed axis with a constant angular acceleration of 4.0 rad / s^2. The diameter of the wheel is 40 cm. What is the linear speed of a point on the rim of this wheel at an instant when that point has a total linear acceleration with a magnitude of 1.2 m / s^2?

a. 39 cm / s
b. 42 cm / s
c. 45 cm / s
d. 35 cm / s
e. 53 cm / s

14. A disk (radius = 8.0 cm) that rotates about a fixed axis starts from rest and accelerates at a constant rate to an angular velocity of 4.0 rad / s in 2.0 s. What is the magnitude of the total linear acceleration of a point on the rim of the disk at the instant when the angular velocity of the disk is 1.5 rad / s?

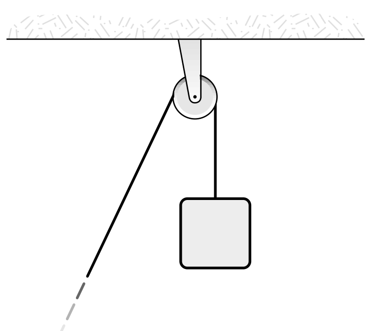
a. 24 cm / s^2
b. 16 cm / s^2
c. 18 cm / s^2
d. 34 cm / s^2
e. 44 cm / s^2

15. A mass (m_1 = 5.0 kg) is connected by a light cord to a mass (m_2 = 4.0 kg) which slides on a smooth surface, as shown in the figure. The pulley (radius = 0.20 m) rotates about a frictionless axle. The acceleration of m_2 is 3.5 m/s^2. What is the moment of inertia of the pulley?



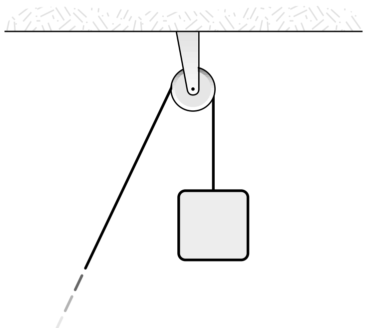
a. 0.29 kg · m^2
b. 0.42 kg · m^2
c. 0.20 kg · m^2
d. 0.62 kg · m^2
e. 0.60 kg · m^2

16. A wheel (radius = 0.20 m) is mounted on a frictionless, horizontal axis. A light cord wrapped around the wheel supports a 0.50-kg object, as shown in the figure. When released from rest the object falls with a downward acceleration of 5.0 m/s^2. What is the moment of inertia of the wheel?



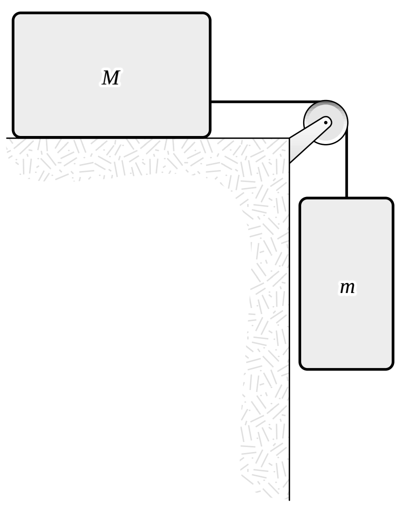
a. 0.023 kg · m^2
b. 0.027 kg · m^2
c. 0.016 kg · m^2
d. 0.019 kg · m^2
e. 0.032 kg · m^2

17. A wheel (radius = 0.25 m) is mounted on a frictionless, horizontal axis. The moment of inertia of the wheel about the axis is 0.040 kg · m². A light cord wrapped around the wheel supports a 0.50-kg object as shown in the figure. The object is released from rest. What is the magnitude of the acceleration of the 0.50-kg object?



a. 3.0 m / s²
b. 3.4 m / s²
c. 4.3 m / s²
d. 3.8 m / s²
e. 2.7 m / s²

18. A mass m = 4.0 kg is connected, as shown, by a light cord to a mass M = 6.0 kg, which slides on a smooth horizontal surface. The pulley rotates about a frictionless axle and has a radius R = 0.12 m and a moment of inertia I = 0.090 kg · m². The cord does not slip on the pulley. What is the magnitude of the acceleration of m?



a. 2.4 m / s²
b. 2.8 m / s²
c. 3.2 m / s²
d. 4.2 m / s²
e. 1.7 m / s²

19. A cylinder rotating about its axis with a constant angular acceleration of 1.6 rad / s^2 starts from rest at $t = 0$. At the instant when it has turned through 0.40 radian, what is the magnitude of the total linear acceleration of a point on the rim (radius = 13 cm)?

a. 0.31 m / s^2
b. 0.27 m / s^2
c. 0.35 m / s^2
d. 0.39 m / s^2
e. 0.45 m / s^2

20. A wheel (radius = 0.20 m) starts from rest and rotates with a constant angular acceleration of 2.0 rad / s^2. At the instant when the angular velocity is equal to 1.2 rad / s, what is the magnitude of the total linear acceleration of a point on the rim of the wheel?

a. 0.40 m / s^2
b. 0.29 m / s^2
c. 0.69 m / s^2
d. 0.49 m / s^2
e. 0.35 m / s^2

21. A horizontal disk with a radius of 10 cm rotates about a vertical axis through its center. The disk starts from rest at $t = 0$ and has a constant angular acceleration of 2.1 rad / s^2. At what value of t will the radial and tangential components of the linear acceleration of a point on the rim of the disk be equal in magnitude?

a. 0.55 s
b. 0.63 s
c. 0.69 s
d. 0.59 s
e. 0.47 s

22. Five particles, each of which has a mass of 0.24 kg, are fixed at positions that are equally spaced along a meter stick with one of these particles at each end. What is the moment of inertia about an axis that is perpendicular to the meter stick (which has negligible mass) and through the center of mass of this rigid body?

a. 0.30 kg · m^2
b. 0.15 kg · m^2
c. 0.25 kg · m^2
d. 0.20 kg · m^2
e. 0.35 kg · m^2

23. Two particles (m_1 = 0.20 kg, m_2 = 0.30 kg) are positioned at the ends of a 2.0-m long rod of negligible mass. What is the moment of inertia of this rigid body about an axis perpendicular to the rod and through the center of mass?

a. 0.48 kg · m^2
b. 0.50 kg · m^2
c. 1.2 kg · m^2
d. 0.80 kg · m^2
e. 0.70 kg · m^2

24. Four identical particles (mass of each = 0.24 kg) are placed at the vertices of a rectangle (2.0 m × 3.0 m) and held in those positions by four light rods which form the sides of the rectangle. What is the moment of inertia of this rigid body about an axis that passes through the center of mass of the body and is parallel to the shorter sides of the rectangle?

a. 2.4 kg · m^2
b. 2.2 kg · m^2
c. 1.9 kg · m^2
d. 2.7 kg · m^2
e. 8.6 kg · m^2

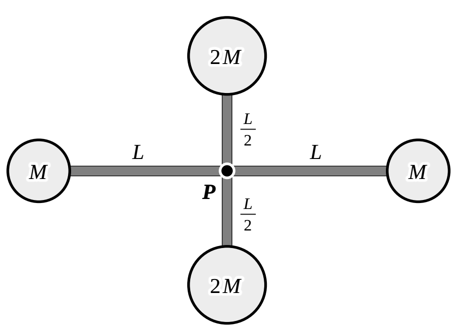
25. Four identical particles (mass of each = 0.40 kg) are placed at the vertices of a rectangle (2.5 m × 4.0 m) and held in those positions by four light rods which form the sides of the rectangle. What is the moment of inertia of this rigid body about an axis that passes through the mid-points of the shorter sides and is parallel to the longer sides?

a. 2.2 kg · m^2
b. 2.8 kg · m^2
c. 2.5 kg · m^2
d. 3.1 kg · m^2
e. 1.6 kg · m^2

26. Four identical particles (mass of each = 0.40 kg) are placed at the vertices of a rectangle (2.0 m × 3.0 m) and held in those positions by four light rods which form the sides of the rectangle. What is the moment of inertia of this rigid body about an axis that passes through the mid-points of the longer sides and is parallel to the shorter sides?

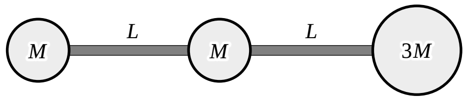
a. 2.7 kg · m^2
b. 3.6 kg · m^2
c. 3.1 kg · m^2
d. 4.1 kg · m^2
e. 1.6 kg · m^2

27. The rigid object shown is rotated about an axis perpendicular to the paper and through point P. The total kinetic energy of the object as it rotates is equal to 1.4 J. If M = 1.3 kg and L = 0.50 m, what is the angular velocity of the object? Neglect the mass of the connecting rods and treat the masses as particles.



a. 1.3 rad / s
b. 1.5 rad / s
c. 1.7 rad / s
d. 1.2 rad / s
e. 2.1 rad / s

28. If M = 0.50 kg, L = 1.2 m, and the mass of each connecting rod shown is negligible, what is the moment of inertia about an axis perpendicular to the paper through the center of mass? Treat the mass as particles.



a. 3.7 kg · m^2
b. 2.8 kg · m^2
c. 3.2 kg · m^2
d. 2.3 kg · m^2
e. 3.9 kg · m^2

29. Three particles, each of which has a mass of 80 g, are positioned at the vertices of an equilateral triangle with sides of length 60 cm. The particles are connected by rods of negligible mass. What is the moment of inertia of this rigid body about an axis that is parallel to one side of the triangle and passes through the respective midpoints of the other two sides?

a. 0.018 kg · m^2
b. 0.020 kg · m^2
c. 0.016 kg · m^2
d. 0.022 kg · m^2
e. 0.032 kg · m^2

30. A uniform rod (mass = 2.0 kg, length = 0.60 m) is free to rotate about a frictionless pivot at one end. The rod is released from rest in the horizontal position. What is the magnitude of the angular acceleration of the rod at the instant it is 60° below the horizontal?

a. 15 rad / s^2
b. 12 rad / s^2
c. 18 rad / s^2
d. 29 rad / s^2
e. 23 rad / s^2

31. Particles (mass of each = 0.20 kg) are placed at the 40-cm and 100-cm marks of a meter stick of negligible mass. This rigid body is free to rotate about a frictionless pivot at the 0-cm end. The body is released from rest in the horizontal position. What is the initial angular acceleration of the body?

a. 12 rad / s^2
b. 5.9 rad / s^2
c. 8.4 rad / s^2
d. 5.4 rad / s^2
e. 17 rad / s^2

32. Particles (mass of each = 0.40 kg) are placed at the 60-cm and 100-cm marks of a meter stick of negligible mass. This rigid body is free to rotate about a frictionless pivot at the 0-cm end. The body is released from rest in the horizontal position. What is the magnitude of the initial linear acceleration of the end of the body opposite the pivot?

a. 15 m/s^2
b. 9.8 m/s^2
c. 5.8 m/s^2
d. 12 m/s^2
e. 4.7 m/s^2

33. A wheel (radius = 12 cm) is mounted on a frictionless, horizontal axle that is perpendicular to the wheel and passes through the center of mass of the wheel. A light cord wrapped around the wheel supports a 0.40-kg object. If released from rest with the string taut, the object is observed to fall with a downward acceleration of 3.0 m/s^2. What is the moment of inertia (of the wheel) about the given axle?

a. 0.023 $kg \cdot m^2$
b. 0.013 $kg \cdot m^2$
c. 0.020 $kg \cdot m^2$
d. 0.016 $kg \cdot m^2$
e. 0.035 $kg \cdot m^2$

34. A uniform rod (mass = 1.5 kg) is 3.0 m long. The rod is pivoted about a horizontal, frictionless pin through one end. The rod is released from rest at an angle of 30° above the horizontal. What is the angular acceleration of the rod at the instant it is released? (The moment of inertia of the rod about the pin is 4.5 $kg \cdot m^2$).

a. 2.0 rad/s^2
b. 4.2 rad/s^2
c. 3.9 rad/s^2
d. 3.0 rad/s^2
e. 2.7 rad/s^2

35. A uniform rod is 2.0 m long. The rod is pivoted about a horizontal, frictionless pin through one end. The rod is released from rest at an angle of 30° above the horizontal. What is the angular acceleration of the rod at the instant it is released?

a. 4.7 rad/s^2
b. 6.9 rad/s^2
c. 6.4 rad/s^2
d. 5.6 rad/s^2
e. 4.2 rad/s^2

36. A uniform rod is 2.0 m long. The rod is pivoted about a horizontal, frictionless pin through one end. The rod is released from rest at the horizontal position. What is the angular acceleration of the rod at the instant the rod makes an angle of 70° with the horizontal?

a. 3.7 rad/s^2
b. 1.3 rad/s^2
c. 2.5 rad/s^2
d. 4.9 rad/s^2
e. 1.9 rad/s^2

37. A uniform rod of mass M = 1.2 kg and length = 0.80 m is free to pivot about one end as shown. The moment of inertia of the rod about an axis perpendicular to the rod and through the center of mass is given by $ML^2/12$. If a force (F = 5.0 N, θ = 40°) acts as shown, what is the resulting angular acceleration about the pivot point?

a. 16 rad/s^2
b. 12 rad/s^2
c. 14 rad/s^2
d. 10 rad/s^2
e. 33 rad/s^2

38. A uniform meter stick is pivoted to rotate about a horizontal axis through the 25-cm mark on the stick. The stick is released from rest in a horizontal position. The moment of inertia of a uniform rod about an axis perpendicular to the rod and through the center of mass of the rod is given by $(1/12)ML^2$. Determine the magnitude of the initial angular acceleration of the stick.

a. 17 rad/s^2
b. 13 rad/s^2
c. 15 rad/s^2
d. 19 rad/s^2
e. 23 rad/s^2

39. A uniform rod (length = 2.0 m) is mounted to rotate freely about a horizontal axis that is perpendicular to the rod and that passes through the rod at a point 0.50 m from one end of the rod. If the rod is released from rest in a horizontal position, what is the angular speed of the rod as it rotates through its lowest position?

a. 3.5 rad/s
b. 3.8 rad/s
c. 4.1 rad/s
d. 2.0 rad/s
e. 5.6 rad/s

40. A uniform meter stick is free to rotate about a horizontal axis that is perpendicular to the rod and that passes through the rod at a point 20 cm from one end of the rod. If the rod is released from rest in a horizontal position, what is the angular speed of the rod at the instant it is 30° below the horizontal?

a. 6.0 rad/s
b. 5.8 rad/s
c. 4.6 rad/s
d. 4.1 rad/s
e. 4.9 rad/s

41. Identical particles are placed at the 50-cm and 80-cm marks on a meter stick of negligible mass. This rigid body is then mounted so as to rotate freely about a pivot at the 0-cm mark on the meter stick. If this body is released from rest in a horizontal position, what is the angular speed of the meter stick as it swings through its lowest position?

a. 4.2 rad / s
b. 5.4 rad / s
c. 4.6 rad / s
d. 5.0 rad / s
e. 1.7 rad / s

42. A uniform sphere (radius = 20 cm) is mounted so as to rotate freely about a horizontal axis that is tangential to the sphere. If the sphere is released from rest with its center at the same height as the axis, what is the angular speed of the sphere about this axis as the sphere moves through its lowest position?

a. 6.8 rad / s
b. 8.4 rad / s
c. 5.9 rad / s
d. 5.3 rad / s
e. 7.2 rad / s

43. A uniform cylinder (radius = 10 cm) is mounted so as to rotate freely about a horizontal axis that is parallel to and 5.0 cm from the axis of the cylinder. If the cylinder is released from rest with its axis at the same height as the axis about which the cylinder rotates, what is the angular speed of the cylinder as it passes through its lowest position?

a. 17 rad / s
b. 13 rad / s
c. 15 rad / s
d. 11 rad / s
e. 7.0 rad / s

44. A uniform rod (mass = 1.5 kg) is 2.0 m long. The rod is pivoted about a horizontal, frictionless pin through one end. The rod is released from rest in a horizontal position. What is the angular speed of the rod when the rod makes an angle of 30° with the horizontal? (The moment of inertia of the rod about the pin is 2.0 kg · m^2).

a. 2.2 rad / s
b. 3.6 rad / s
c. 2.7 rad / s
d. 3.1 rad / s
e. 1.8 rad / s

45. A uniform rod is 3.0 m long. The rod is pivoted about a horizontal, frictionless pin through one end. The rod is released from rest at an angle of 27° above the horizontal. What is the angular speed of the rod as it passes through the horizontal position?

a. 3.0 rad / s
b. 2.8 rad / s
c. 2.1 rad / s
d. 2.5 rad / s
e. 3.4 rad / s

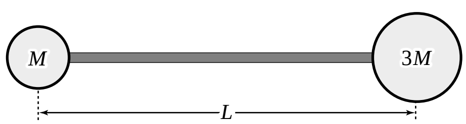
46. A uniform rod of length (L = 2.0 m) and mass (M = 1.5 kg) is pivoted about a horizontal frictionless pin through one end. The rod is released from rest at an angle of 30 below the horizontal. What is the angular speed of the rod when it passes through the vertical position? (The moment of inertia of the rod about the pin is 2.0 kg-m^2.)

a. 3.5 rad / s
b. 2.7 rad / s
c. 3.1 rad / s
d. 2.3 rad / s
e. 1.6 rad / s

47. A nonuniform 2.0-kg rod is 2.0 m long. The rod is mounted to rotate freely about a horizontal axis perpendicular to the rod that passes through one end of the rod. The moment of inertia of the rod about this axis is 4.0 kg · m^2. The center of mass of the rod is 1.2 m from the axis. If the rod is released from rest in the horizontal position, what is its angular speed as it swings through the vertical position?

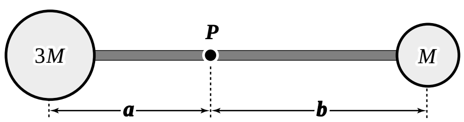
a. 3.4 rad / s
b. 4.4 rad / s
c. 4.3 rad / s
d. 5.8 rad / s
e. 6.8 rad / s

48. The rigid body shown rotates about an axis through its center of mass and perpendicular to the paper. If M = 2.0 kg and L = 80 cm, what is the kinetic energy of this object when its angular speed about this axis is equal to 5.0 rad / s? Neglect the mass of the connecting rod and treat the masses as particles.



a. 18 J
b. 15 J
c. 12 J
d. 23 J
e. 26 J

49. The rigid body shown is rotated about an axis perpendicular to the paper and through the point P. If M = 0.40 kg, a = 30 cm, and b = 50 cm, how much work is required to take the body from rest to an angular speed of 5.0 rad / s? Neglect the mass of the connecting rods and treat the masses as particles.



a. 2.9 J
b. 2.6 J
c. 3.1 J
d. 3.4 J
e. 1.6 J

50. A uniform rod (length = 2.4 m) of negligible mass has a 1.0-kg point mass attached to one end and a 2.0-kg point mass attached to the other end. The rod is mounted to rotate freely about a horizontal axis that is perpendicular to the rod and that passes through a point 1.0 m from the 2.0-kg mass. The rod is released from rest when it is horizontal. What is the angular velocity of the rod at the instant the 2.0-kg mass passes through its low point?

a. 1.7 rad/s
b. 2.2 rad/s
c. 2.0 rad/s
d. 1.5 rad/s
e. 3.1 rad/s

Conceptual Problems

51. The net work done in accelerating a propeller from rest to an angular velocity of 200 rad/s is 3000 J. What is the moment of inertia of the propeller?

52. A horizontal force of magnitude 6.5 N is exerted tangentially on a frisbee of mass 32 grams and radius 14.3 cm. Assuming the frisbee is originally at rest and the force is exerted for 0.08 s, determine the angular velocity of rotation about the central axis when the frisbee is released.

53. A celestial object called a pulsar emits its light in short bursts that are synchronized with its rotation. A pulsar in the Crab Nebula is rotating at a rate of 30 revolutions/second. What is the maximum radius of the pulsar, if no part of its surface can move faster than the speed of light (3×10^8 m/s)?

54. A uniform solid sphere rolls without slipping along a horizontal surface. What fraction of its total kinetic energy is in the form of rotational kinetic energy about the CM?

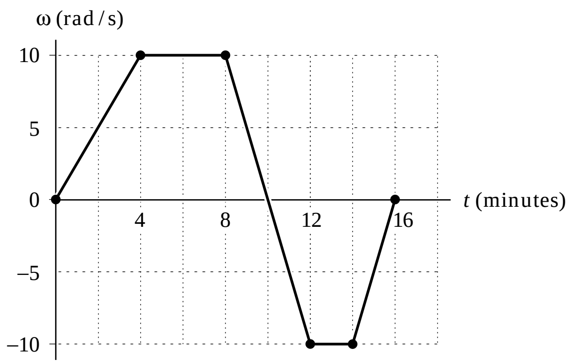
55. A campus bird spots a member of an opposing football team in an amusement park. The football player is on a ride where he goes around at angular velocity ω at distance R from the center. The bird flies in a horizontal circle above him. Will a dropping the bird releases while flying directly above the person's head hit him?

a. Yes, because it falls straight down.
b. Yes, because it maintains the acceleration of the bird as it falls.
c. No, because it falls straight down and will land behind the person.
d. Yes, because it mainatins the angular velocity of the bird as it falls.
e. No, because it maintains the tangential velocity the bird had at the instant it started falling.

56. Two people are on a ride where the inside cars rotate at constant angular velocity three times the constant angular velocity of the outer cars. If the two cars are in line at $t = 0$, and moving at 3ω and ω respectively, at what time will they next pass each other?

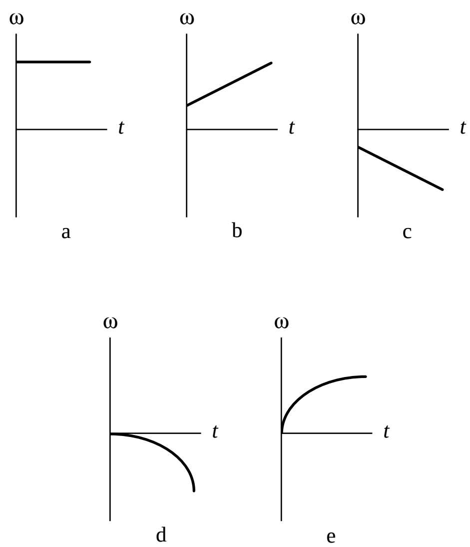
a. $t = 0$.
b. $t = \dfrac{\pi}{2\omega}$.
c. $t = \dfrac{\pi}{\omega}$.
d. $t = \dfrac{2\pi}{\omega}$.
e. $t = \dfrac{3\pi}{\omega}$.

57. The figure below shows a graph of angular velocity as a function of time for a car driving around a circular track. Through how many radians does the car travel in the first 10 minutes?



a. 30.
b. 50.
c. 70.
d. 90.
e. 100

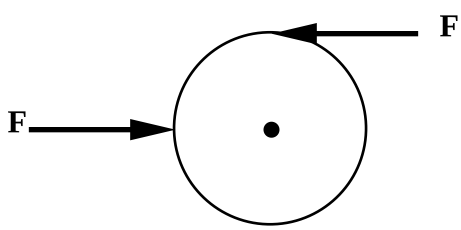
58. The graphs below show angular velocity as a function of time. In which one is the magnitude of the angular acceleration constantly decreasing?



59. You throw a frisbee of mass m and radius *r* so that it is spinning about a horizontal axis perpendicular to the plane of the frisbee. Ignoring air resistance, the torque exerted on it by gravity is:

a. 0.
b. *mgr*.
c. 2*mgr*.
d. a function of the angular velocity.
e. small at first, then increasing as the frisbee loses the torque given it by your hand.

60. Two forces of magnitude 50 N, as shown in the figure below, act on a cylinder of radius 4 m and mass 6.25 kg. The cylinder sits on a frictionless surface. After 1 second, the velocity and angular velocity of the cylinder in m/s and rad/s are respectively:



a. $v = 0$; $\omega = 0$.
b. $v = 0$; $\omega = 4$.
c. $v = 0$; $\omega = 8$.
d. $v = 8$; $\omega = 8$.
e. $v = 16$; $\omega = 8$.

61. Two cylinders made of the same material roll down a plane inclined at an angle θ with the horizontal. Each travels the same distance. The radius of cylinder B is twice the radius of cylinder A. In what order do they reach the bottom?

a. A reaches the bottom first because it has the greater acceleration.
b. A reaches the bottom first because it has a smaller moment of inertia.
c. B reaches the bottom first because is experiences a larger torque.
d. B reaches the bottom first because it travels a larger distance in one rotation.
e. They both reach the bottom at the same time, because each has the same linear velocity.

Chapter 10

The Laws of Motion

1. Answer: b

2. Answer: c

3. Answer: b

4. Answer: a

5. Answer: c

6. Answer: b

7. Answer: d

8. Answer: c

9. Answer: a

10. Answer: d

11. Answer: a

12. Answer: c

13. Answer: b

14. Answer: a

15. Answer: c

16. Answer: d

17. Answer: c

18. Answer: a

19. Answer: b

20. Answer: d

21. Answer: c

22. Answer: b

23. Answer: a

24. Answer: b

25. Answer: c

26. Answer: b

27. Answer: c

28. Answer: d

29. Answer: c

30. Answer: b

31. Answer: a

32. Answer: d

33. Answer: b

34. Answer: b

35. Answer: c

36. Answer: c

37. Answer: d

38. Answer: a

39. Answer: c

40. Answer: d

41. Answer: b

42. Answer: b

43. Answer: d

44. Answer: c

45. Answer: c

46. Answer: b

47. Answer: a

48. Answer: c

49. Answer: b

50. Answer: a

51. Answer: 0.15 kg-m^2

52. Answer: 227 rad/s

53. Answer: 1590 km

54. Answer: 2/7

55. Answer: e

56. Answer: c

57. Answer: c

58. Answer: e

59. Answer: a

60. Answer: b

61. Answer: e

Chapter 11

Rolling Motion, Angular Momentum, and Torque

Multiple Choice

1. Two vectors lying in the *xy* plane are given by the equations **A** = 5**i** + 2**j** and **B** = 2**i** – 3**j**. **A** × **B** is

a. 19**k**
b. –11**k**
c. –19**k**
d. 11**k**
e. 10**i** – **j**

2. Two vectors lying in the *xz* plane are given by the equations **A** = 2**i** + 3**k** and **B** = –**i** + 2**k**. The value of **A** × **B** is

a. **j**
b. –**j**
c. 7**k**
d. –7**j**
e. **i** + 5**k**

3. A particle located at the position vector **r** = (**i** + **j**) m has a force **F** = (2**i** + 3**j**) N acting on it. The torque about the origin is:

a. (1**k**)N m
b. (5**k**)N m
c. (–1**k**)N m
d. (–5**k**)N m
e. (2**i** + 3**j**)N m

4. A car of mass 1000 kg moves with a speed of 50 m/s on a circular track of radius 100 m. What is the magnitude of its angular momentum (in $kg \cdot m^2/s$) relative to the center of the race track?

a. 5.0×10^2
b. 5.0×10^6
c. 2.5×10^4
d. 2.5×10^6
e. 5.0×10^3

5. A thin spherical shell of radius R = 0.50 m and mass 15 kg rotates about the z-axis through its center and parallel to its axis. When the angular velocity is 5.0 rad/s, its angular momentum (in kg · m^2/s) is approximately:

a. 15
b. 9.0
c. 12
d. 19
e. 25

6. A solid cylinder of radius R = 1.0 m and mass 10 kg rotates about its axis. When its angular velocity is 10 rad/s, its angular momentum (in kg m^2/s) is

a. 50
b. 20
c. 40
d. 25
e. 70

7. A particle whose mass is 2 kg moves in the xy plane with a constant speed of 3 m/s in the x-direction along the line $y = 5$. What is its angular momentum (in kg m^2/s) relative to the origin?

a. –30 **k**
b. 30 **k**
c. –15 **k**
d. 15 **k**
e. 45 **k**

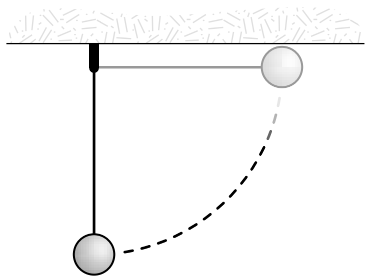
8. A particle whose mass is 2 kg moves in the xy plane with a constant speed of 3 m/s along the direction **r** = **i** + **j**. What is its angular momentum (in kg m^2/s) relative to the origin?

a. 0 **k**
b. $6\sqrt{2}$ **k**
c. $-6\sqrt{2}$ **k**
d. 6 **k**
e. –6 **k**

9. A particle whose mass is 2.0 kg moves in the xy plane with a constant speed of 3.0 m/s along the direction **r** = **i** + **j**. What is its angular momentum (in kg m^2/s) relative to the point (0, 5.0) meters?

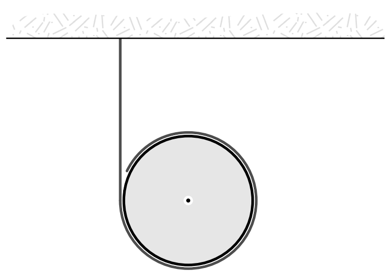
a. 12 **k**
b. 11 **k**
c. 13 **k**
d. 14 **k**
e. 21 **k**

10. In the figure, a 1.5-kg weight swings in a vertical circle at the end of a string having negligible weight. The string is 2 m long. If the weight is released with zero initial velocity from a horizontal position, its angular momentum (in kg · m^2/s) at the lowest point of its path relative to the center of the circle is approximately



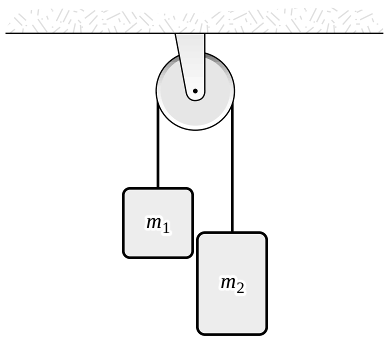
a. 40
b. 10
c. 30
d. 20
e. 50

11. A massless rope is wrapped around a uniform cylinder that has radius *R* and mass *M*, as shown in the figure. Initially, the unwrapped portion of the rope is vertical and the cylinder is horizontal. The linear acceleration of the cylinder is



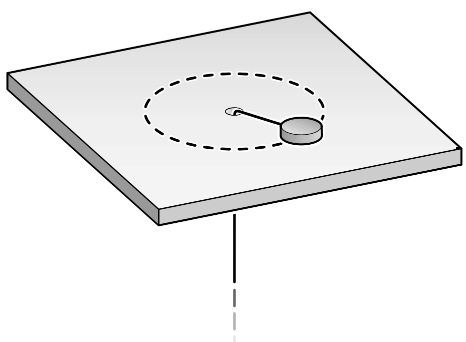
a. $(2/3)g$
b. $(1/2)g$
c. $(1/3)g$
d. $(1/6)g$
e. $(5/6)g$

12. Two blocks, $m_1 = 1$ kg and $m_2 = 2$ kg, are connected by a light string as shown in the figure. If the radius of the pulley is 1 m and its moment of inertia is 5 kg · m^2, the acceleration of the system is



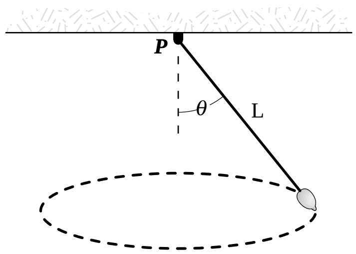
a. (1/6)g
b. (3/8)g
c. (1/8)g
d. (1/2)g
e. (5/8)g

13. A puck on a frictionless air hockey table has a mass of 5 kg and is attached to a cord passing through a hole in the surface as in the figure. The puck is revolving at a distance 2 m from the hole with an angular velocity of 3 rad/s. The angular momentum of the puck (in kg · m^2/s) is



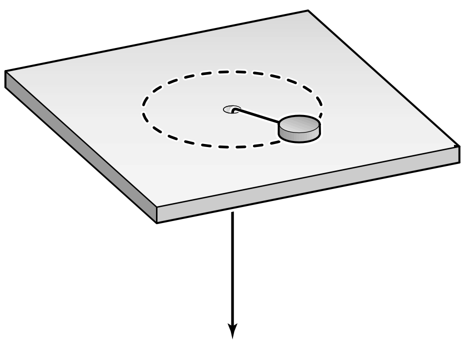
a. 80
b. 20
c. 30
d. 60
e. 50

14. A pendulum bob of mass m , is set into motion in a circular path in a horizontal plane as shown in the figure. The square of the angular momentum of the bob about the vertical axis through the point **P** is



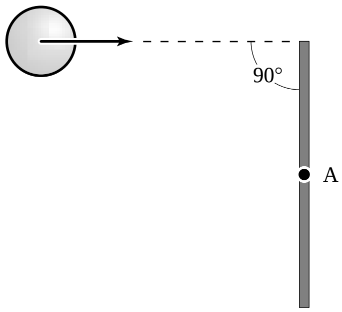
a. $m^2 g l^3 \sin^4 \theta / \cos \theta$
b. $m^2 g l^3 \sin^3 \theta / \cos \theta$
c. $m^2 g l^3 \sin^2 \theta / \cos \theta$
d. $m^2 g l^3 \sin \theta / \cos \theta$
e. $m^2 g l^3 \sin^2 \theta$

15. A puck on a frictionless air hockey table has a mass of 5.0 g and is attached to a cord passing through a hole in the surface as in the figure. The puck is revolving at a distance 2.0 m from the hole with an angular velocity of 3.0 rad/s. The cord is then pulled from below, shortening the radius to 1.0 m. The new angular velocity (in rad/s) is



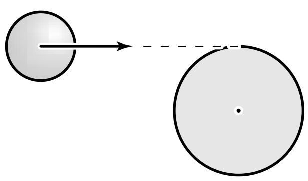
a. 4.0
b. 6.0
c. 12
d. 2.0
e. 8.0

16. A thin rod of mass M and length L is struck at one end by a ball of clay of mass m, moving with speed v as shown in the figure. The ball sticks to the rod. After the collision, the angular momentum of the clay-rod system about A, the midpoint of the rod, is



a. $(m + M/3)(vL/2)$
b. $(m + M/12)(vL/2)$
c. $(m + M/3)(vL/2)$
d. $mvL/2$
e. mvL

17. A particle of mass $m = 0.10$ kg and speed $v_0 = 5.0$ m/s collides and sticks to the end of a uniform solid cylinder of mass $M = 1.0$ kg and radius $R = 20$ cm. If the cylinder is initially at rest and is pivoted about a frictionless axle through its center, what is the final angular velocity (in rad/s) of the system after the collision?



a. 8.1
b. 2.0
c. 6.1
d. 4.2
e. 10

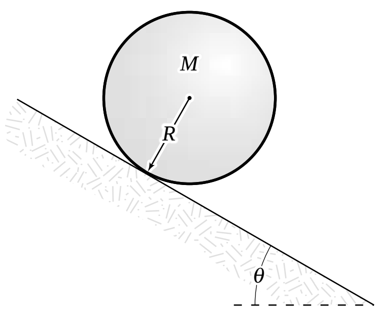
18. A skater extends her arms horizontally, holding a 5-kg mass in each hand. She is rotating about a vertical axis with an angular velocity of one revolution per second. If she drops her hands to her sides, what will the final angular velocity (in rev/s) be if her moment of inertia remains approximately constant at 5 kg · m^2, and the distance of the masses from the axis changes from 1 m to .1 m?

a. 6
b. 3
c. 9
d. 4
e. 7

19. A merry-go-round of radius $R = 2.0$ m has a moment of inertia $I = 250\ \text{kg}\cdot\text{m}^2$, and is rotating at 10 rpm. A child whose mass is 25 kg jumps onto the edge of the merry-go-round, heading directly toward the center at 6.0 m/s. The new angular speed (in rpm) of the merry-go-round is approximately

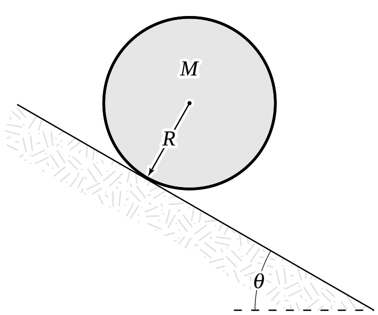
a. 10
b. 9.2
c. 8.5
d. 7.1
e. 6.4

20. A solid sphere (radius R, mass M) rolls down an incline as shown in the figure. Its linear acceleration of the center of mass is



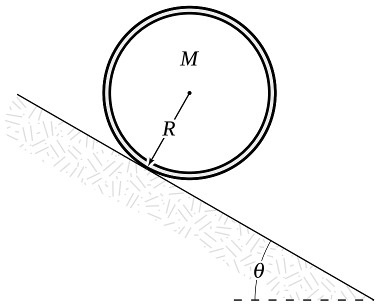
a. $(5/7)g \sin \theta$
b. $(3/5)g \sin \theta$
c. $(2/3)g \sin \theta$
d. $(1/2)g \sin \theta$
e. $(4/5)g \sin \theta$

21. A solid cylinder rolls down an incline as shown in the figure. The linear acceleration of its center of mass is



a. $(5/7)g \sin \theta$
b. $(1/2)g \sin \theta$
c. $(2/3)g \sin \theta$
d. $(3/5)g \sin \theta$
e. $(4/5)g \sin \theta$

22. A cylindrical shell rolls down an incline as shown in the figure. The linear acceleration of its center of mass is



a. $(5/7)g \sin \theta$
b. $(1/2)g \sin \theta$
c. $(3/5)g \sin \theta$
d. $(2/3)g \sin \theta$
e. $(4/5)g \sin \theta$

23. A solid sphere, spherical shell, solid cylinder and a cylindrical shell all have the same mass, m and radius R. If they are all released from rest at the same elevation and roll without stopping, which reaches the bottom of an inclined plane first?

a. solid sphere
b. spherical shell
c. solid cylinder
d. cylindrical shell
e. all take the same time

24. Stars originate as large bodies of slowly rotating gas. Because of gravity, these clumps of gas slowly decrease in size. The angular velocity of a star increases as it shrinks because of

a. conservation of angular momentum
b. conservation of linear momentum
c. conservation of energy
d. the law of universal gravitation
e. conservation of mass

Conceptual Problems

25. Halley's comet moves about the sun in an elliptical orbit with its closest approach to the sun being 0.59 A.U. and its furthest distance being 35 A.U. [1 Astronomical Unit (A.U.) is the Earth-sun distance]. If the comet's speed at closest approach is 54 km/s, what is its speed when it is farthest from the sun?

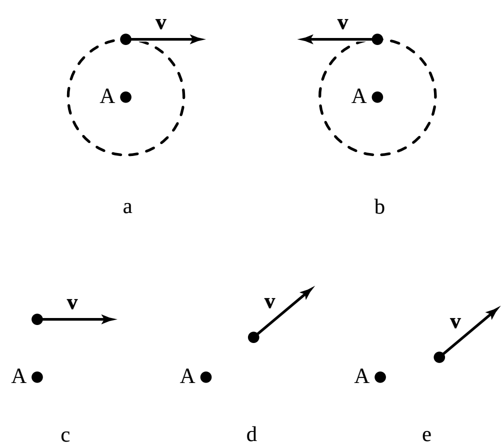
26. What is the angular momentum of the moon about the Earth? The mass of the moon is 7.35×10^{22} kg, the center-to-center separation of the Earth and the moon is 3.84×10^{5} km, and the orbital period of the moon is 27.3 days.

27. A regulation basketball has a 25-cm diameter and a mass of 0.56 kg. It may be approximated as a thin spherical shell with a moment of inertia $\frac{2}{3}MR^2$. Starting from rest, how long will it take a basketball to roll without slipping 4.0 m down an incline at 30° to the horizontal?

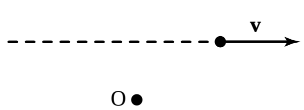
28. A coin with a diameter 3.0 cm rolls up a 30° inclined plane. The coin starts out with an initial angular speed of 60.0 rad/s and rolls in a straight line without slipping. If the moment of inertia of the coin is $\frac{1}{2}MR^2$, how far will the coin roll up the inclined plane?

Multiple Choice Conceptual Problems

29. Five objects of mass m move at velocity **v** at a distance r from an axis of rotation perpendicular to the page through point A, as shown below. The one that has zero angular momentum about that axis is:

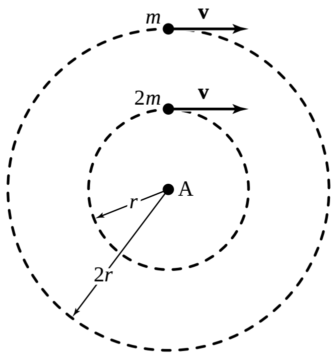


30. The object shown below has mass m and velocity **v**. The direction of its angular momentum vector with respect to an axis perpendicular to the page through point O is:



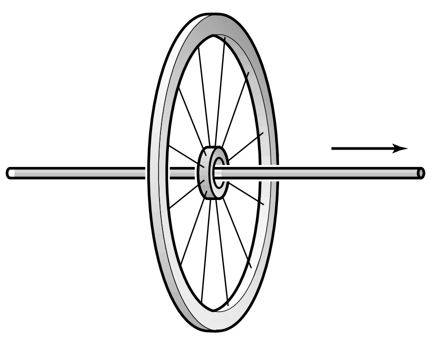
a. downwards.
b. to the right.
c. into the page.
d. up out of the page.
e. counterclockwise.

31. Two objects move in parallel circles around a rotation axis O with equal tangential speeds. $r_1 = r$; $r_2 = 2r$. $m_1 = 2m$; $m_2 = m$. Forces of equal magnitude are applied opposite to their velocities to stop them. Which statement is correct?



a. m_2 will stop first because it has the smaller mass.
b. m_1 will stop first because it has the smaller radius.
c. m_2 will stop first because the torque on it is greater.
d. m_1 will stop first because it has the smaller moment of inertia.
e. both objects will stop at the same time because the angular accelerations are equal.

32. A spinning bicycle wheel is mounted on an axle you can hold in your hands. You hold it in front of you with the axle horizontal. The direction of the angular momentum vector is to your right. You then rotate the axle clockwise in a vertical plane as seen by you. Because of the torque you exert on it the axle will additionally tend to turn (as seen by you):



a. in no other direction other than the one you gave it.
b. so the right side moves up and the left side moves down.
c. so the right side moves into the page and the left side moves out.
d. so the left side moves into the page and the right side moves out.
e. back to the position it had before you started to turn it.

Chapter 11

Rolling Motion, Angular Momentum, and Torque

1. Answer: c

2. Answer: d

3. Answer: a

4. Answer: b

5. Answer: d

6. Answer: a

7. Answer: a

8. Answer: a

9. Answer: e

10. Answer: d

11. Answer: a

12. Answer: c

13. Answer: d

14. Answer: a

15. Answer: c

16. Answer: d

17. Answer: d

18. Answer: b

19. Answer: d

20. Answer: a

21. Answer: c

22. Answer: b

23. Answer: a

24. Answer: a

25. Answer: 910 m/s

26. Answer: $2.88 \times 10^{34} \text{ kg-m}^2/\text{s}$

27. Answer: 1.65 s

28. Answer: 12.4 cm

29. Answer: d

30. Answer: c

31. Answer: c

32. Answer: d

Chapter 12

Static Equilibrium and Elasticity

Multiple Choice

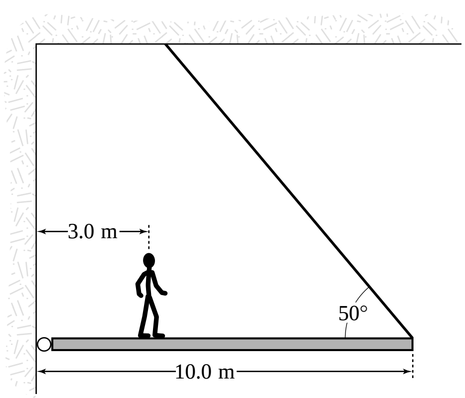
1. A uniform ladder 15 ft long is leaning against a frictionless wall at an angle of 53° above the horizontal. The weight of the ladder is 30 pounds. A 75-lb boy climbs 6.0-ft up the ladder. What is the magnitude of the friction force exerted on the ladder by the floor?

a. 43 lb
b. 34 lb
c. 38 lb
d. 47 lb
e. 24 lb

2. A horizontal meter stick supported at the 50-cm mark has a mass of 0.50 kg hanging from it at the 20-cm mark and a 0.30 kg mass hanging from it at the 60-cm mark. Determine the position on the meter stick at which one would hang a third mass of 0.60 kg to keep the meter stick balanced.

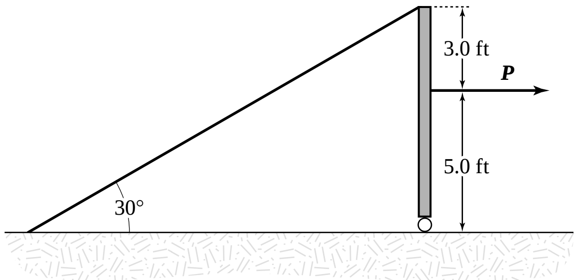
a. 74 cm
b. 70 cm
c. 65 cm
d. 86 cm
e. 62 cm

3. The figure shows a uniform, horizontal beam (length = 10 m, mass = 25 kg) that is pivoted at the wall, with its far end supported by a cable that makes an angle of 50° with the horizontal. If a person (mass = 60 kg) stands 3.0 m from the pivot, what is the tension in the cable?



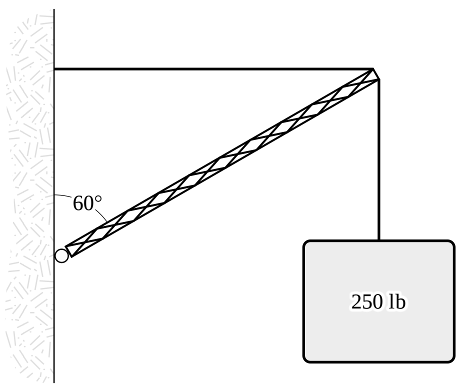
a. 0.83 kN
b. 0.30 kN
c. 0.39 kN
d. 0.42 kN
e. 3.0 kN

4. A uniform 100-lb beam is held in a vertical position by a pin at its lower end and a cable at its upper end. A horizontal force (magnitude *P*) acts as shown in the figure. If *P* = 75 lb, what is the tension in the cable?



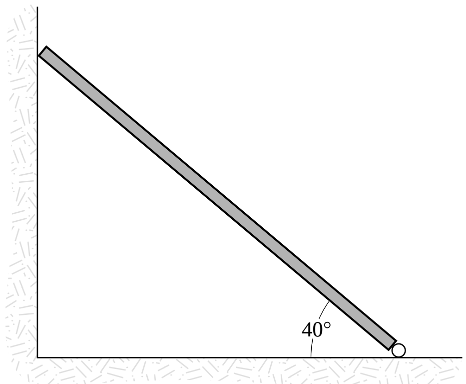
a. 54 lb
b. 69 lb
c. 47 lb
d. 61 lb
e. 75 lb

5. A 25-ft crane supported at its lower end by a pin is elevated by a horizontal cable as shown in the figure. A 250-lb load is suspended from the outer end of the crane. The center of gravity of the crane is 10 ft from the pin, and the crane weighs 200 lb. What is the tension in the horizontal cable?



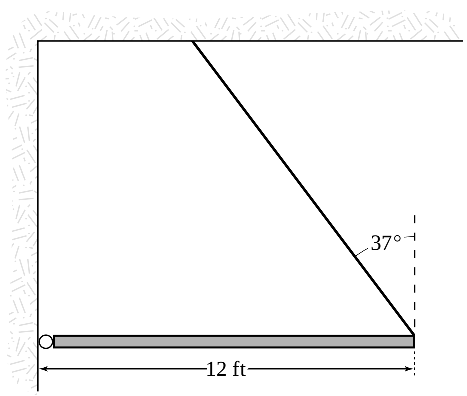
a. 610 lb
b. 540 lb
c. 640 lb
d. 570 lb
e. 2000 lb

6. A uniform beam having a mass of 60 kg and a length of 2.8 m is held in place at its lower end by a pin. Its upper end leans against a vertical frictionless wall as shown in the figure. What is the magnitude of the force by the pin on the beam?



a. 0.68 kN
b. 0.57 kN
c. 0.74 kN
d. 0.63 kN
e. 0.35 kN

7. A uniform 120-lb beam is supported in a horizontal position by a pin and cable as shown in the figure. What is the magnitude of the force by the pin on the beam?



a. 94 lb
b. 88 lb
c. 63 lb
d. 75 lb
e. 150 lb

8. A 20-m long steel wire (cross-section 1 cm^2, Young's modulus 2×10^{11} N / m^2), is subjected to a load of 25,000 N. How much will the wire stretch under the load?

a. .25 cm
b. 2.5 cm
c. 12.5 cm
d. 25 cm
e. 1.25 cm

9. How large a force is necessary to stretch a 2-mm diameter copper wire ($Y = 11 \times 10^{10}$ N / m^2) by 1%?

a. 2163 N
b. 3454 N
c. 6911 N
d. 11,146 N
e. 5,420 N

10. How large a pressure increase (in ATM) must be applied to water if it is to be compressed in volume by 1%? The bulk modulus of water is 2×10^9 N / m^2 and 1 ATM = 10^5 N / m^2.

a. 50 ATM
b. 100 ATM
c. 1080 ATM
d. 400 ATM
e. 200 ATM

Conceptual Problems

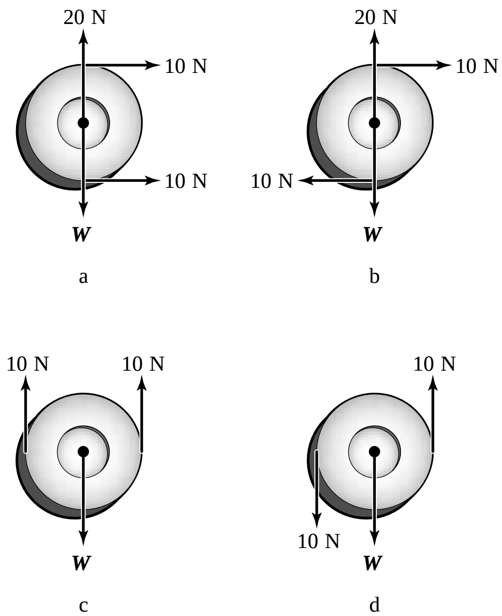
11. For safety in climbing, a mountaineer uses a 50-m long nylon rope that is 1.0 cm in diameter. When supporting a 90-kg climber, the rope elongates 1.6 m. Find the Young's modulus for the rope material.

12. The four tires of an automobile are inflated to a gauge pressure of 2.0×10^5 N / m (29 PSI). Each of the four tires has an area of 0.024 m^2 that is in contact with the ground. Determine the weight of the auto.

13. Find the minimum diameter of a steel wire 18 m long that will stretch no more than 9 mm when a load of 380 kg is hung on the lower end. ($Y_{steel} = 2.0 \times 10^{11}$ N / m^2).

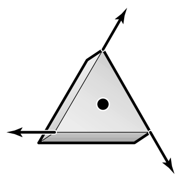
14. If 1.0 m^3 of concrete weighs 5×10^4 N, what is the height of the tallest cylindrical concrete pillar that will not collapse under its own weight? (The compression strength of concrete is 1.7×10^7 N / m^2)

15. The diagrams below show forces applied to a wheel that weighs 20 N. The symbol **W** stands for the weight. In which diagram(s) is the wheel in equilibrium?

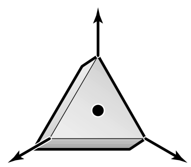


a. A
b. B
c. C
d. D
e. A and C

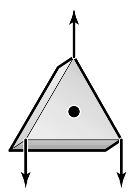
16. The diagrams below show forces of magnitude F applied to an equilateral triangular block of uniform thickness. In which diagram(s) is the block in equilibrium?



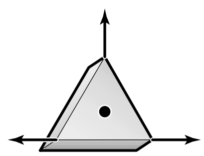
a



b



c



d

a. A
b. B
c. C
d. D
e. A and B

Chapter 12

Static Equilibrium and Elasticity

1. Answer: b

2. Answer: b

3. Answer: c

4. Answer: a

5. Answer: d

6. Answer: a

7. Answer: d

8. Answer: b

9. Answer: b

10. Answer: e

11. Answer: 3.46×10^9 N / m^2

12. Answer: 19,000 N

13. Answer: 6.89 mm

14. Answer: 340 m

15. Answer: c

16. Answer: b