Physics for Scientists and Engineers, 4e **(Giancoli)**

Chapter 7 Work and Energy

7.1 Conceptual Questions

1) Explain how a satellite can remain in orbit around the Earth without the expenditure of fuel.
Answer: The gravitational force on the satellite acts toward the Earth inward along the radius of the satellite's orbit. The satellite's displacement at any moment is tangent to the circular orbit, in the direction of its velocity, perpendicular to the radius and perpendicular to the force of gravity. Therefore, the work done by gravity is zero. Hence, no work needs to be done against the force of gravity.
Diff: 2 Page Ref: Sec. 7-1

2) List the three useful ways in physics to multiply vectors.
Answer: 1. Multiplication of a vector by a scalar
2. Multiplication of one vector by a second vector to produce a scalar
3. Multiplication of one vector by a second vector to produce another vector
Diff: 1 Page Ref: Sec. 7-2

3) State the work-energy principle.
Answer: The net work done on an object is equal to the change in the object's kinetic energy.
Diff: 1 Page Ref: Sec. 7-4

4) If the net work done on a certain object is zero, make a statement concerning its speed?
Answer: If the net work done on an object is zero, it follows that its change in kinetic energy is also zero. Therefore, its speed remains constant.
Diff: 1 Page Ref: Sec. 7-4

5) A force can be exerted on an object and yet do no work.
Answer: TRUE
Diff: 1 Page Ref: Sec. 7-1

6) If a force is directed perpendicular to the displacement, no work is done by that force.
Answer: TRUE
Diff: 1 Page Ref: Sec. 7-1

7) The scalar product is commutative.
Answer: TRUE
Diff: 1 Page Ref: Sec. 7-2

8) The scalar product is not distributive.
Answer: FALSE
Diff: 1 Page Ref: Sec. 7-2

9) The work done by a variable force in moving an object between two points is equal to the area under the force versus displacement curve between those two points.
Answer: TRUE
Diff: 1 Page Ref: Sec. 7-3

10) If the net work W is done on an object is positive, the object's kinetic energy increases by an amount W.
Answer: TRUE
Diff: 1 Page Ref: Sec. 7-4

11) If the net work *W* is done on an object is negative, the object's kinetic energy increases by an amount *W*.
Answer: FALSE
Diff: 1 Page Ref: Sec. 7-4

12) A net force exerted on an object opposite to the object's direction of motion decreases it speed and its kinetic energy.
Answer: TRUE
Diff: 1 Page Ref: Sec. 7-4

13) If you push twice as hard against a stationary brick wall, the amount of work you do
A) quadruples.
B) doubles.
C) is cut in half.
D) remains constant but non-zero.
E) remains constant at zero.
Answer: E
Diff: 1 Page Ref: Sec. 7-1

14) A person applies a constant force of 20 N to a rock of mass 1000 kg, for a total of 20 seconds. What is the work done by this person if the rock does not move at all by this applied force?
A) 1000 J B) 2000 J C) 20,000 J D) 0 J E) 400 J
Answer: D
Diff: 1 Page Ref: Sec. 7-1

15) The work done by the centripetal force on an object with a mass of 1 kg moving with a constant velocity of 4 m/s into a circular path of radius 0.6 m for one full cycle is
A) 100.7 J B) 3.8 J C) 0 J D) 40 J E) 80 J
Answer: C
Diff: 1 Page Ref: Sec. 7-1

16) Does the centripetal force acting on an object do work on the object?
A) Yes, since a force acts and the object moves, and work is force times distance.
B) Yes, since it takes energy to turn an object.
C) No, because the object has constant speed.
D) No, because the object's displacement is zero.
E) No, because the force and the displacement of the object are perpendicular.
Answer: E
Diff: 1 Page Ref: Sec. 7-1

17) A person carries a mass of 10 kg and walks along the +*x*-axis for a distance of 100m with a constant velocity of 2 m/s. What is the work done by this person?
A) 0 J
B) 20 J
C) 200 J
D) 1000 J
E) None of the other choices is correct.
Answer: A
Diff: 1 Page Ref: Sec. 7-1

18) A person applies a constant force on an object of mass 20 kg that causes the object to move horizontally at a constant speed of 0.20 m/s through a distance of 0.80 m. What is the work done on the object?
A) 160 J
B) 10 J
C) 16 J
D) 0 J
E) Cannot be determined without knowing the magnitude of the applied force.
Answer: D
Diff: 1 Page Ref: Sec. 7-1

19) Two men, Joel and Jerry, push against a wall. Jerry stops after 10 min, while Joel is able to push for 5.0 min longer. Compare the work they do.
A) Joel does 75% more work than Jerry.
B) Joel does 50% more work than Jerry.
C) Jerry does 50% more work than Joel.
D) Joel does 25% more work than Jerry.
E) Neither of them do any work.
Answer: E
Diff: 1 Page Ref: Sec. 7-1

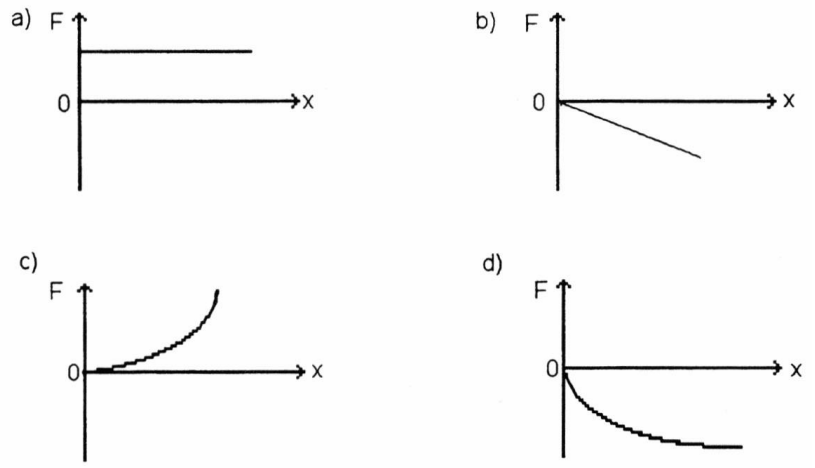
20) A stock person at the local grocery store has the job of 1) picking up boxes of tomatoes from the stockroom floor, 2) accelerating to a comfortable speed, 3) Carrying the boxes to the tomato display at constant speed, 4) decelerating to a stop, and 5) lowering the boxes slowly to the floor. During which of the five segments of the stock person's task is positive work being done on the boxes?
A) 1) and 5)
B) 1)
C) 1), 2), 4), and 5)
D) 1) and 2)
E) 2) and 3)
Answer: D
Diff: 1 Page Ref: Sec. 7-1

21) A constant force is applied to an object that causes a certain displacement. If the angle between the force and the displacement is 135°, the work done by this force is
A) positive.
B) negative.
C) 0 J.
D) Cannot be determined without knowing the magnitude of the displacement.
E) Cannot be determined without knowing the magnitude of the applied force.
Answer: B
Diff: 2 Page Ref: Sec. 7-1

22) On a force vs. position graph, the area under the curve is a representation of
A) force.
B) position.
C) kinetic energy.
D) potential energy.
E) work.
Answer: E
Diff: 1 Page Ref: Sec. 7-3

23) Consider a plot of the displacement (x) vs. applied force (F) for an ideal elastic spring. The slope of the curve would be
A) the spring constant.
B) the reciprocal of the spring constant.
C) the acceleration of gravity.
D) the reciprocal of the acceleration of gravity.
E) the reciprocal of the displacement.
Answer: B
Diff: 2 Page Ref: Sec. 7-3

FIGURE 7-1



24) Describe the type of spring "constant" needed to produce a constant restoring force like curve (a) in Fig. 7-1.
A) k must vary as the stretch squared.
B) k must be a real constant.
C) k must vary inversely with stretch.
D) k must vary proportional to stretch.
E) none of these
Answer: C
Diff: 2 Page Ref: Sec. 7-3

25) Which of the graphs in Fig. 7-1 illustrates Hooke's Law?
A) graph a
B) graph b
C) graph c
D) graph d
E) none of these
Answer: B
Diff: 2 Page Ref: Sec. 7-3

26) Which of the graphs in Fig. 7-1 represents a spring which gets less stiff the more it is stretched?
A) graph a
B) graph b
C) graph c
D) graph d
E) none of these
Answer: D
Diff: 2 Page Ref: Sec. 7-3

27) If the net work done on an object is positive, then the object's kinetic energy
A) decreases.
B) remains the same.
C) increases.
D) is zero.
E) cannot be determined without knowing the object's mass.
Answer: C
Diff: 1 Page Ref: Sec. 7-4

28) If the net work done on an object is negative, then the object's kinetic energy
A) decreases.
B) remains the same.
C) increases.
D) is zero.
E) cannot be determined without knowing the object's mass.
Answer: A
Diff: 1 Page Ref: Sec. 7-4

29) If the net work done on an object is zero, then the object's kinetic energy
A) decreases.
B) remains the same.
C) increases.
D) is zero.
E) cannot be determined without knowing the object's mass.
Answer: B
Diff: 1 Page Ref: Sec. 7-4

30) A constant force acts on a moving object. The object makes a fixed magnitude of displacement in some direction. In general, in what direction is the displacement that will result in the object traveling with the least kinetic energy after the displacement occurs?
A) The same direction as the force
B) The direction does not matter.
C) In a direction perpendicular to the plane of the force and the velocity of the object
D) The opposite direction as the force
E) Any direction perpendicular to the force
Answer: D
Diff: 1 Page Ref: Sec. 7-4

31) An object undergoes a displacement while being acted on by a constant force directed to the north. The work done on this object by the force is positive during the displacement. Which statement is necessarily true about the average velocity of the object during the displacement?
A) The average velocity is zero.
B) The average velocity is toward the south.
C) The average velocity is toward the north.
D) The average velocity has a component toward the north.
E) The average velocity has a component toward the south.
Answer: D
Diff: 1 Page Ref: Sec. 7-4

32) A 4.0 kg mass is moving with speed 2.0 m/s. A 1.0 kg mass is moving with speed 4.0 m/s. Both objects encounter the same constant braking force, and are brought to rest. Which object travels the greater distance before stopping?
A) the 4.0 kg mass
B) the 1.0 kg mass
C) Both travel the same distance.
D) Cannot be determined from the information given.
Answer: C
Diff: 2 Page Ref: Sec. 7-4

33) You slam on the brakes of your car in a panic, and skid a certain distance on a straight, level road. If you had been traveling twice as fast, what distance would the car have skidded, under the same conditions?
A) It would have skidded 4 times farther.
B) It would have skidded twice as far.
C) It would have skidded 1.4 times farther.
D) It would have skidded one half as far.
E) It is impossible to tell from the information given.
Answer: A
Diff: 2 Page Ref: Sec. 7-4

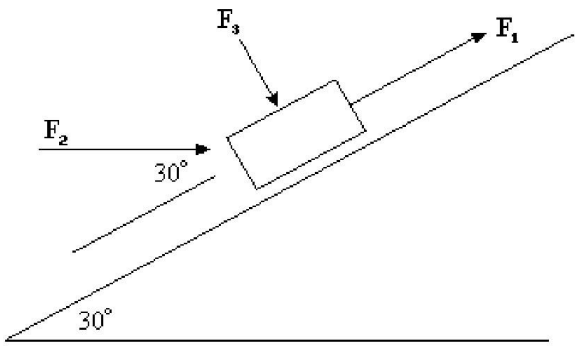
7.2 Quantitative Problems

1) A constant force of 20 N is applied to an object of mass 8.0 kg at an angle of 25° with the horizontal. What is the work done by this force on the object if it causes a displacement of 2.0 m along the horizontal direction?
A) 40 J B) 0 J C) 36 J D) 17 J E) 19 J
Answer: C
Diff: 1 Page Ref: Sec. 7-1

2) A constant force $\vec{F}$ = 2.00 N $\hat{i}$ + 3.00 N j acts on a 5.00 kg object as it moves in a straight line from the position $\vec{r}_1$ = 1.00 m $\hat{i}$ + 1.00 m j to a position $\vec{r}_2$ = 4.00 m $\hat{i}$ - 1.00 m j. Determine the work done by the force during this motion.
A) 2.00 J B) 5.00 J C) 12.7 J D) 13.0 J E) 0.00 J
Answer: E
Diff: 1 Page Ref: Sec. 7-1

3) A 5.00-kg box slides 3.00 m across the floor before coming to rest. What is the coefficient of kinetic friction between the floor and the box if the box had an initial speed of 3.00 m/s?
A) 1.50 B) 0.587 C) 0.153 D) 0.306 E) 0.200
Answer: C
Diff: 1 Page Ref: Sec. 7-1

FIGURE 7-2



Three applied forces, F_1 = 20.0 N, F_2 = 40.0 N, and F_3 = 10.0 N act on an object with a mass of 2.00 kg which can move along an inclined plane as shown in the figure. The questions refer to the instant when the object has moved 0.600 m along the surface of the inclined plane in the upward direction. Neglect friction and use g = 10.0 m/s^2.

4) Refer to Fig. 7-2. What is the amount of work done by force F_1 as the object moves up the inclined plane?
A) 10.0 J B) 11.0 J C) 12.0 J D) 16.0 J E) 0 J
Answer: C
Diff: 1 Page Ref: Sec. 7-1

5) Refer to Fig. 7-2. What is the amount of work done by force F_2 as the object moves up the inclined plane?
A) 0 J B) 12.0 J C) 16.0 J D) 24.0 J E) 20.8 J
Answer: E
Diff: 1 Page Ref: Sec. 7-1

6) Refer to Fig. 7-2. What is the amount of work done by the force F_3 as the object moves up the inclined plane?
A) 12.0 J B) 16.0 J C) 20.8 J D) 0 J E) 24.0 J
Answer: D
Diff: 1 Page Ref: Sec. 7-1

7) A student slides her 80.0-kg desk across the level floor of her dormitory room a distance 2.00 m at constant speed. If the coefficient of kinetic friction between the desk and the floor is 0.400, how much work did she do?
A) 64.0 J B) 1.57 kJ C) 26.7 J D) 628 J E) 24.0 J
Answer: D
Diff: 2 Page Ref: Sec. 7-1

8) An airplane flies 120 km at a constant altitude in a direction 30.0° north of east. A wind is blowing that results in a net horizontal force on the plane due to the air of 2.40 kN in a direction 10.0° south of west. How much work is done by the air on the plane?
A) -2.70×10^8 J
B) -0.985×10^8 J
C) -221×10^8 J
D) 221×10^8 J
E) 0.821×10^8 J
Answer: A
Diff: 2 Page Ref: Sec. 7-1

9) Determine the scalar product of $\vec{A} = 3.0\hat{i} + 4.0\,j - 2.0\,k$ and $\vec{B} = 2.0\hat{i} - 6.0\,j - 3.0\,k$.

A) $6.0\hat{i} + 24\,j + 6\,k$

B) $6.0\hat{i} - 24\,j + 6\,k$

C) -12

D) 36

E) undefined

Answer: C

Diff: 1 Page Ref: Sec. 7-2

10) Determine the angle between the directions of vector $\vec{A} = 3.00\hat{i} + 1.00\,j$ and vector $\vec{B} = 1.00\hat{i} + 3.00\,j$.

A) 36.9° B) 30.0° C) 86.6° D) 53.1° E) 45.2°

Answer: D

Diff: 1 Page Ref: Sec. 7-2

11) Which of the following vectors is perpendicular to the vector $4.0\hat{i} - 6.0\,j + 2.0\,k$?

A) $2.0\hat{i} - 3.0\,j + 1.0\,k$

B) $3.0\hat{i} - 3.0\,j + 3.0\,k$

C) $1.0\hat{i} - 2.0\,j + 1.0\,k$

D) $1.0\hat{i} + 1.0\,j + 1.0\,k$

E) $2.0\hat{i} + 1.0\,k$

Answer: D

Diff: 1 Page Ref: Sec. 7-2

12) The scalar product of vector $\vec{A} = 3.00\hat{i} + 2.00\,j$ and vector $\vec{B}$ is 12.0. Which of the following vectors could be vector $\vec{B}$?

A) $2.00\hat{i} + 4.00\,j$

B) $4.00\hat{i} + 6.00\,j$

C) $5.00\hat{i} + 4.00\,j$

D) $12.0\hat{i}$

E) $6.00\,\hat{i} + -3.00\,j$

Answer: E

Diff: 1 Page Ref: Sec. 7-2

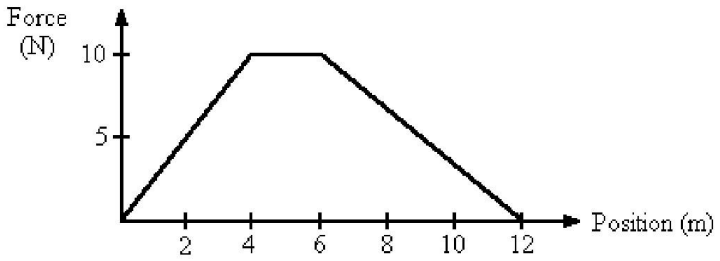
13) The angle between vector $\vec{A} = 2.00\hat{i} + 3.00\,j$ and vector $\vec{B}$ is 45.0°. The scalar product of vectors $\vec{A}$ and $\vec{B}$ is 7.00. If the x-component of vector $\vec{B}$ is positive, what is vector $\vec{B}$.

A) $4.76\hat{i} + 0.952\hat{j}$ B) $2.69\hat{i} + 0.538\hat{j}$ C) $2.96\hat{i} + 0.360\hat{j}$ D) $0.871\hat{i} + 1.75\hat{j}$ E) $3.42\hat{i} + 0.684\hat{j}$

Answer: B

Diff: 2 Page Ref: Sec. 7-2

FIGURE 7-3

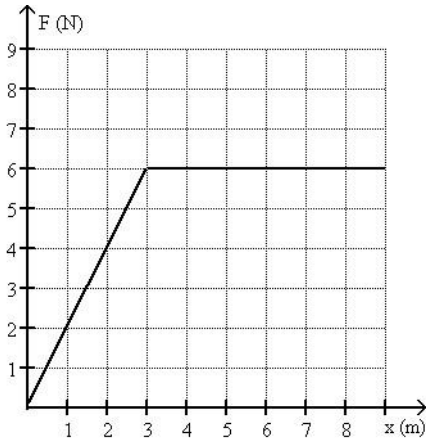


14) An object is under the influence of a force as represented by the force vs. position graph in Fig. 7-3. What is the work done as the object moves from 4 m to 6 m?
A) 20 J B) 30 J C) 0 J D) 40 J E) 70 J
Answer: A
Diff: 1 Page Ref: Sec. 7-3

15) An object is under the influence of a force as represented by the force vs. position graph in Fig. 7-3. What is the work done as the object moves from 0 m to 4 m?
A) 20 J B) 30 J C) 0 J D) 40 J E) 70 J
Answer: A
Diff: 1 Page Ref: Sec. 7-3

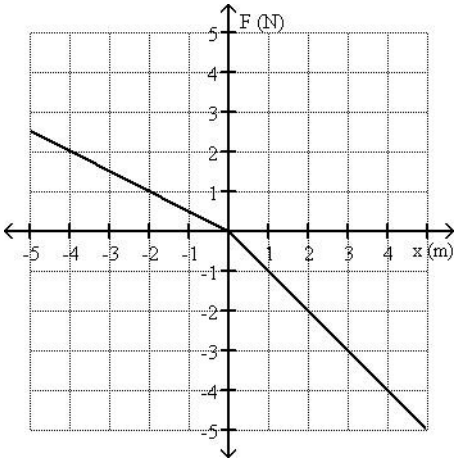
16) An object is under the influence of a force as represented by the force vs. position graph in Fig. 7-3. What is the work done as the object moves from 6 m to 12 m?
A) 20 J B) 30 J C) 0 J D) 40 J E) 70 J
Answer: B
Diff: 1 Page Ref: Sec. 7-3

FIGURE 7-4



17) The force on an object as a function of position is shown in Fig. 7-4. Determine the amount of work done by this force on an object that moves from x = 2.0 m to x = 7.0 m.
A) 29 J B) 32 J C) 24 J D) 38 J E) 33 J
Answer: A
Diff: 1 Page Ref: Sec. 7-3

FIGURE 7-5



18) The graph of a force as a function of position is shown in Fig. 7-5. Determine the amount of work done by this force for an object during a displacement from x = -2.00 m to x = 2.00 m.

A) -12.00 J B) -3.00 J C) -1.00 J D) 12.00 J E) 3.00 J

Answer: C

Diff: 1 Page Ref: Sec. 7-3

19) A spring with a spring constant of 2500 N/m. is stretched 4.00 cm. What is the work required to stretch the spring?

A) 4.00 J B) 0 J C) 1.00 J D) 3.00 J E) 2.00 J

Answer: E

Diff: 1 Page Ref: Sec. 7-3

20) 4.0 J of work are performed in stretching a spring with a spring constant of 2500 N/m. How much is the spring stretched?

A) 3.2 cm B) 3.2 m C) 0.3 cm D) 5.7 m E) 5.7 cm

Answer: E

Diff: 1 Page Ref: Sec. 7-3

21) A weight of 200 N is hung from a spring with a spring constant of 2500 N/m and lowered slowly. How much will the spring stretch?

A) 4.00 cm B) 6.00 cm C) 8.00 cm D) 10.0 cm E) 12.0 cm

Answer: C

Diff: 1 Page Ref: Sec. 7-3

22) If the work done to stretch a spring by 4.0 cm is 6.0 J, what is the spring constant?

A) 300 N/m B) 3000 N/m C) 3500 N/m D) 7500 N/m E) 6000 N/m

Answer: D

Diff: 1 Page Ref: Sec. 7-3

23) A force on a particle depends on position such that $F(x) = (3.00\ N/m^2)x^2 + (2.00\ N/m)x$ for a particle constrained to move along the x-axis. What work is done by this force on a particle that moves from x = 0.00 m to x = 2.00 m?

A) 10.0 J B) 12.0 J C) -32.0 J D) 16.0 J E) 32.0 J

Answer: B

Diff: 1 Page Ref: Sec. 7-3

24) A force is dependent on position and is given by $(4.00\ \text{N/m})x\,\hat{i} + (2.0\ \text{N/m}^2)xy\,j$. An object begins at the origin. How much work is done on the object as it moves in a straight line to x = 1.00 m, y = 0.00 m?
A) 0.00 J B) 3.00 J C) 2.50 J D) 2.00 J E) 1.50 J
Answer: D
Diff: 2 Page Ref: Sec. 7-3

25) A force is dependent on position and is given by $(4.00\ \text{N/m})x\,\hat{i} + (2.0\ \text{N/m}^2)xy\,j$. An object begins at the origin. It first moves in a straight line to x = 1.00 m, y = 0.00 m. It then moves in a straight line to x = 1.00 m, y = 1.00 m. How much work is done on the object by the force during the motion described?
A) 3.00 J B) 0.00 J C) 2.50 J D) 1.50 J E) 2.00 J
Answer: A
Diff: 3 Page Ref: Sec. 7-3

26) How much energy is needed to change the speed of a 1600 kg sport utility vehicle from 15.0 m/s to 40.0 m/s?
A) 1.10 MJ B) 10.0 kJ C) 20.0 kJ D) 40.0 kJ E) 0.960 MJ
Answer: A
Diff: 1 Page Ref: Sec. 7-4

27) An object of mass 10.0 kg is initially at rest. A 100 N force causes it to move horizontally through a distance of 6.00 m. What is the change in the kinetic energy of this object?
A) 0 J B) 200 J C) 60.0 J D) 600 J E) 1000 J
Answer: D
Diff: 1 Page Ref: Sec. 7-4

28) A 30 N-force toward the west is applied to an object. The object moves 50 m east during the time the force is applied. What is the change in kinetic energy of the object?
A) 0.0 J B) 1.7 J C) 1.0 J D) -1500 J E) 750 J
Answer: D
Diff: 1 Page Ref: Sec. 7-4

29) A man lifts a 20.0-kg bucket of concrete from the ground up to the top of a 30.0-m tall building. The bucket is initially at rest, but is traveling at 4.0 m/s when it reaches the top of the building. How much work was done by the man in lifting the bucket?
A) 5.88 kJ B) 600 J C) 760 J D) 6.04 kJ E) 160 J
Answer: D
Diff: 1 Page Ref: Sec. 7-4

30) A ball is thrown upward with a speed and direction such that it reaches a maximum height of 18.0 m above the point it was released. At its maximum height it has a speed of 20.0 m/s. With what speed was the ball released?
A) 27.4 m/s B) 24.3 m/s C) 35.1 m/s D) 31.3 m/s E) 39.0 m/s
Answer: A
Diff: 1 Page Ref: Sec. 7-4

31) A 6.00-kg block starts from rest and slides down a frictionless incline. When the block has slid a distance 2.00 m, its speed is 3.00 m/s. At what angle above horizontal is the inclined plane tilted?
A) 6.58° B) 27.3° C) 8.80° D) 5.26° E) 13.3°
Answer: E
Diff: 1 Page Ref: Sec. 7-4

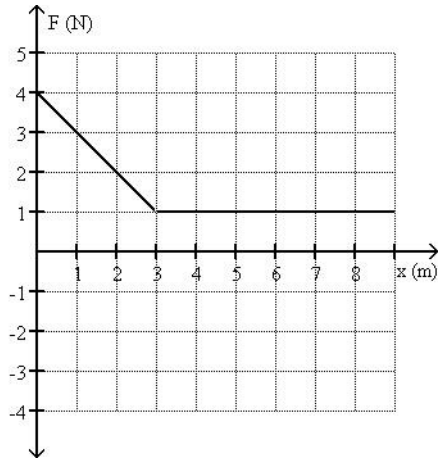
32) How large a force is required to accelerate a 1600 kg car from rest to a speed of 25 m/s in a distance of 200 m?
A) 1600 N B) 0 N C) 200 N D) 400 N E) 2500 N
Answer: E
Diff: 1 Page Ref: Sec. 7-4

33) A 10.0-kg object is initially moving with a velocity of 20.0 m/s to the north and is acted on by a constant net force. After the object moves 30.0 m to the north, its velocity is 12.0 m/s north. What is the constant net force acting on the object?
A) 66.6 N north B) 3.33 N south C) 42.7 N south D) 214 N north E) 66.6 N south
Answer: C
Diff: 2 Page Ref: Sec. 7-4

34) A 1.00-kg mass is attached to a spring hanging vertically and hangs at rest in the equilibrium position. The spring constant of the spring is 1.00 N/cm. The mass is pulled downward 2.00 cm and released. What is the speed of the mass when it is 1.00 cm above the point from which it was released?
A) 0.0443 m/s
B) 1.67 m/s
C) 0.0201 m/s
D) 1.73 m/s
E) The mass will not reach the height specified.
Answer: D
Diff: 2 Page Ref: Sec. 7-4

35) The force on a 0.500-kg particle depends on position such that $F(x) = (1.00\ \text{N/m}^2)x^2 + (4.00\ \text{N/m})x$ for a particle constrained to move along the x-axis. If the particle starts from rest at x = 0.00, what will be its speed when it reaches the position x = 4.00 m?
A) 1.65 m/s
B) 22.6 m/s
C) 14.6 m/s
D) 11.3 m/s
E) The particle will not reach the position x = 4.00 m.
Answer: C
Diff: 2 Page Ref: Sec. 7-4

FIGURE 7-6



36) The force on a 3.00-kg object as a function of position is shown in Fig. 7-6. If an object is moving at 2.50 m/s when it is located at x = 2.00 m, what will its speed be when it reaches x = 8.00 m?

A) 3.30 m/s B) 3.70 m/s C) 4.10 m/s D) 2.90 m/s E) 4.50 m/s

Answer: A

Diff: 2 Page Ref: Sec. 7-4

37) An unusual spring has a restoring force of magnitude $F = (2.0\ \text{N/m})\,x + (1.0\ \text{N/m}^2)x^2$, where x is the stretch of the spring from its equilibrium length. A 3.00 kg mass is attached to this spring and released from rest after stretching the spring 2.00 m. What is the speed of the mass when the spring returns to its equilibrium length?

A) 3.27 m/s B) 5.48 m/s C) 4.33 m/s D) 7.41 m/s E) 2.11 m/s

Answer: E

Diff: 3 Page Ref: Sec. 7-4