Chapter 8: POTENTIAL ENERGY AND CONSERVATION OF ENERGY

1. Only if a force on a particle is conservative:
   A. is its work zero when the particle moves exactly once around any closed path
   B. is its work always equal to the change in the kinetic energy of the particle
   C. does it obey Newton's second law
   D. does it obey Newton's third law
   E. is it not a frictional force

   ans: A

2. A nonconservative force:
   A. violates Newton's second law
   B. violates Newton's third law
   C. cannot do any work
   D. must be perpendicular to the velocity of the particle on which it acts
   E. none of the above

   ans: E

3. The sum of the kinetic and potential energies of a system of objects is conserved:
   A. only when no external force acts on the objects
   B. only when the objects move along closed paths
   C. only when the work done by the resultant external force is zero
   D. always
   E. none of the above

   ans: E

4. A force on a particle is conservative if:
   A. its work equals the change in the kinetic energy of the particle
   B. it obeys Newton's second law
   C. it obeys Newton's third law
   D. its work depends on the end points of every motion, not on the path between
   E. it is not a frictional force

   ans: D

5. Two particles interact by conservative forces. In addition, an external force acts on each particle. They complete round trips, ending at the points where they started. Which of the following must have the same values at the beginning and end of this trip?
   A. the total kinetic energy of the two-particle system
   B. the potential energy of the two-particle system
   C. the mechanical energy of the two-particle system
   D. the total linear momentum of the two-particle system
   E. none of the above

   ans: B

6. Two objects interact with each other and with no other objects. Initially object A has a speed of 5 m/s and object B has [illegible] their initial positions. Then A has a speed of 4 m/s and B has a speed of 7 m/s. We can conclude:
   A. the potential energy changed from the beginning to the end of the trip
   B. mechanical energy was increased by nonconservative forces
   C. mechanical energy was decreased by nonconservative forces
   D. mechanical energy was increased by conservative forces
   E. mechanical energy was decreased by conservative forces

   ans: C

7. A good example of kinetic energy is provided by:
   A. a wound clock spring
   B. the raised weights of a grandfather's clock
   C. a tornado
   D. a gallon of gasoline
   E. an automobile storage battery

   ans: C

8. No kinetic energy is possessed by:
   A. a shooting star
   B. a rotating propeller on a moving airplane
   C. a pendulum at the bottom of its swing
   D. an elevator standing at the fifth floor
   E. a cyclone

   ans: D

9. The wound spring of a clock possesses:
   A. kinetic but no potential energy
   B. potential but no kinetic energy
   C. both potential and kinetic energy in equal amounts
   D. neither potential nor kinetic energy
   E. both potential and kinetic energy, but more kinetic energy than potential energy

   ans: B

10. A body at rest in a system is capable of doing work if:
    A. the potential energy of the system is positive
    B. the potential energy of the system is negative
    C. it is free to move in such a way as to decrease its kinetic energy
    D. it is free to move in such a way as to decrease the potential energy of the system
    E. it is free to move in such a way as to increase the potential energy of the system

    ans: D

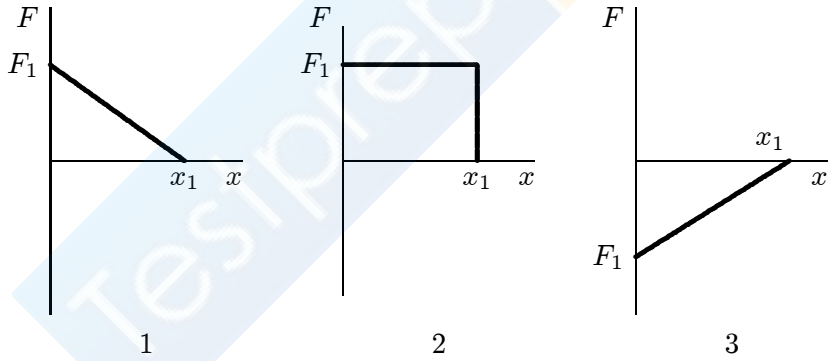
11. Which one of the following five quantities CANNOT be used as a unit of potential energy?
    A. watt·second
    B. gram·cm/s^2
    C. joule
    D. kg·m^2/s^2
    E. ft·lb

    ans: B

12. Suppose that the fundamental dimensions are taken to be: force (F), velocity (V) and time (T). The dimensions of potential energy are then:
    A. F/T
    B. FVT
    C. FV/T
    D. F/T^2
    E. FV^2/T^2

    ans: B

13. The graphs below show the magnitude of the force on a particle as the particle moves along the positive x axis from the origin to $x = x_1$. The force is parallel to the x axis and is conservative. The maximum magnitude F_1 has the same value for all graphs. Rank the situations according to the change in the potential energy associated with the force, least (or most negative) to greatest (or most positive).



    A. 1, 2, 3
    B. 1, 3, 2
    C. 2, 3, 1
    D. 3, 2, 1
    E. 2, 1, 3

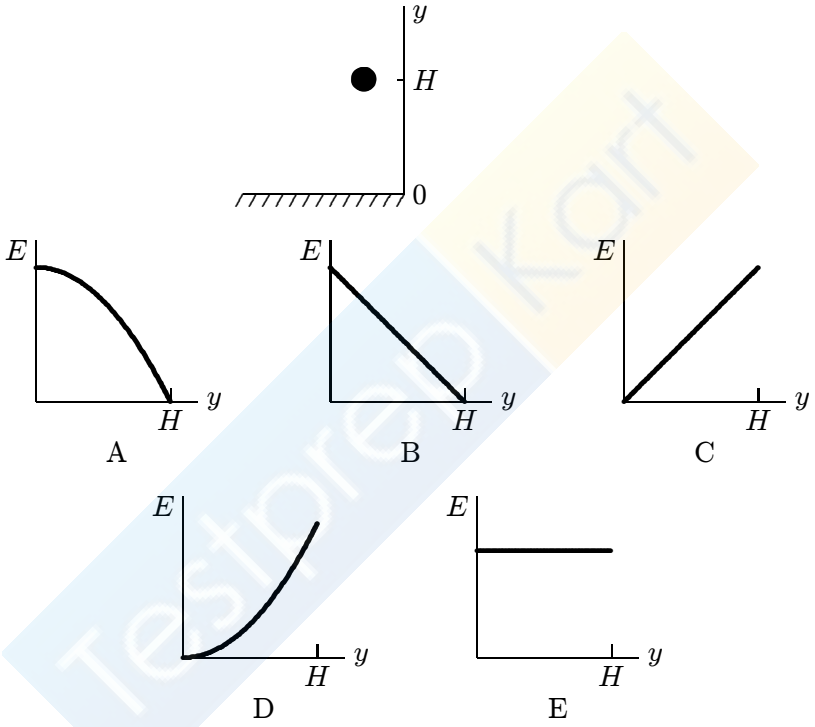
    ans: E

14. A golf ball is struck by a golf club and falls on a green three meters above the tee. The potential energy of the Earth-ball sy

A. just before the ball is struck
B. just after the ball is struck
C. just after the ball lands on the green
D. when the ball comes to rest on the green
E. when the ball reaches the highest point in its flight

ans: E

15. A ball is held at a height H above a floor. It is then released and falls to the floor. If air resistance can be ignored, which of the five graphs below correctly gives the mechanical energy E of the Earth-ball system as a function of the altitude y of the ball?



ans: E

16. A 6.0-kg block is released from rest 80 m above the ground. When it has fallen 60 m its kinetic energy is approximately:

A. 4800 J
B. 3500 J
C. 1200 J
D. 120 J
E. 60 J

ans: B

17. A 2-kg block is thrown upward from a point 20 m above Earth's surface. At what height above Earth's surface will the gra sed by 500 J?

A. 5 m
B. 25 m
C. 46 m
D. 70 m
E. 270 m

ans: C

18. An elevator is rising at constant speed. Consider the following statements:

I. the upward cable force is constant
II. the kinetic energy of the elevator is constant
III. the gravitational potential energy of the Earth-elevator system is constant
IV. the acceleration of the elevator is zero
V. the mechanical energy of the Earth-elevator system is constant

A. all five are true
B. only II and V are true
C. only IV and V are true
D. only I, II, and III are true
E. only I, II, and IV are true

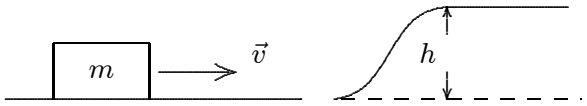
ans: E

19. A projectile of mass 0.50 kg is fired with an initial speed of 10 m/s at an angle of 60° above the horizontal. The potential energy of the projectile-Earth system (relative potential energy when the projectile is at ground level) is:

A. 25 J
B. 18.75 J
C. 12.5 J
D. 6.25 J
E. none of these

ans: B

20. For a block of mass m to slide without friction up the rise of height h shown, it must have a minimum initial kinetic energy of:



A. gh
B. mgh
C. $gh/2$
D. $mgh/2$
E. $2mgh$

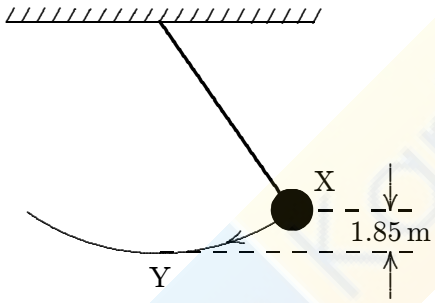
ans: B

21. A 2.2-kg block starts from rest on a rough inclined plane that makes an angle of 25° with the horizontal. The coefficient ane, the mechanical energy of the Earth-block system changes by:

A. 0
B. −9.8 J
C. 9.8 J
D. −18 J
E. 18 J

ans: B

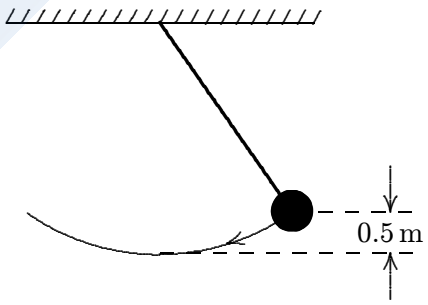
22. A simple pendulum consists of a 2.0-kg mass attached to a string. It is released from rest at X as shown. Its speed at the lowest point Y is about:



A. 0.90 m/s
B. $\sqrt{3.6}$ m/s
C. 3.6 m/s
D. 6.0 m/s
E. 36 m/s

ans: D

23. The long pendulum shown is drawn aside until the ball has risen 0.50 m. It is then given an initial speed of 3.0 m/s. The speed of the ball at its lowest position is:



A. zero
B. 0.89 m/s
C. 3.1 m/s
D. 3.7 m/s
E. 4.3 m/s

ans: E

24. A particle moves along the x axis under the influence of a stationary object. The net force on the particle is given by F $= 0$ then the potential energy is given by:

A. $(2\,\mathrm{J/m^4})x^4$
B. $(-2\,\mathrm{J/m^4})x^4$
C. $(24\,\mathrm{J/m^2}x^2$
D. $(-24\,\mathrm{J/m^2})x^2$
E. $5\,\mathrm{J} - (2\,\mathrm{J/m^4})x^4$

ans: B

25. A 0.20-kg particle moves along the x axis under the influence of a stationary object. The potential energy is given by

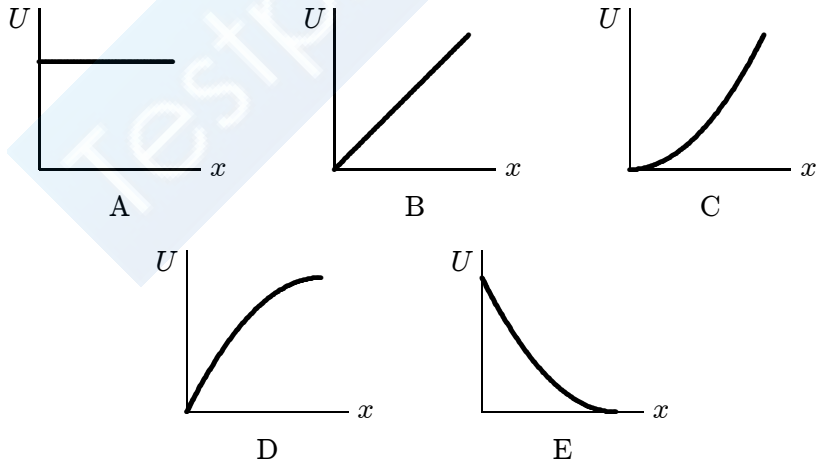
$$U(x) = (8.0\,\mathrm{J/m^2})x^2 + (2.0\,\mathrm{J/m^4})x^4\,,$$

where x is in coordinate of the particle. If the particle has a speed of 5.0 m/s when it is at $x = 1.0\,\mathrm{m}$, its speed when it is at the origin is:

A. 0
B. 2.5 m/s
C. 5.7 m/s
D. 7.9 m/s
E. 11 m/s

ans: E

26. Which of the five graphs correctly shows the potential energy of a spring as a function of its elongation x?



ans: C

27. A force of 10 N holds an ideal spring with a 20-N/m spring constant in compression. The potential energy stored in

A. 0.5 J
B. 2.5 J
C. 5 J
D. 10 J
E. 200 J

ans: B

28. An ideal spring is used to fire a 15.0-g pellet horizontally. The spring has a spring constant of 20 N/m and is initially compressed by 7.0 cm. The kinetic energy of the pellet as it leaves the spring is:

A. zero
B. 2.5×10^{-2} J
C. 4.9×10^{-2} J
D. 9.8×10^{-2} J
E. 1.4 J

ans: C

29. A 0.50-kg block attached to an ideal spring with a spring constant of 80 N/m oscillates on a horizontal frictionless surface. The total mechanical energy is 0.12 J. The greatest extension of the spring from its equilibrium length is:

A. 1.5×10^{-3} m
B. 3.0×10^{-3} m
C. 0.039 m
D. 0.054 m
E. 18 m

ans: D

30. A 0.50-kg block attached to an ideal spring with a spring constant of 80 N/m oscillates on a horizontal frictionless surface. The total mechanical energy is 0.12 J. The greatest speed of the block is:

A. 0.15 m/s
B. 0.24 m/s
C. 0.49 m/s
D. 0.69 m/s
E. 1.46 m/s

ans: D

31. A 0.50-kg block attached to an ideal spring with a spring constant of 80 N/m oscillates on a horizontal frictionless surface. When the spring is 4.0 cm longer than its equilibrium length, the speed of the block is 0.50 m/s. The greatest speed of the block is:

A. 0.23 m/s
B. 0.32 m/s
C. 0.55 m/s
D. 0.71 m/s
E. 0.93 m/s

ans: D

32. A 0.5-kg block slides along a horizontal frictionless surface at 2 m/s. It is brought to rest by compressing a very long sp ion is:

A. 0
B. 3 cm
C. 5 cm
D. 80 cm
E. 80 m

ans: C

33. A block of mass m is initially moving to the right on a horizontal frictionless surface at a speed v. It then compresses a spring of spring constant k. At the instant when the kinetic energy of the block is equal to the potential energy of the spring, the spring is compressed a distance of:

A. $v\sqrt{m/2k}$
B. $(1/2)mv^2$
C. $(1/4)mv^2$
D. $mv^2/4k$
E. $(1/4)\sqrt{mv/k}$

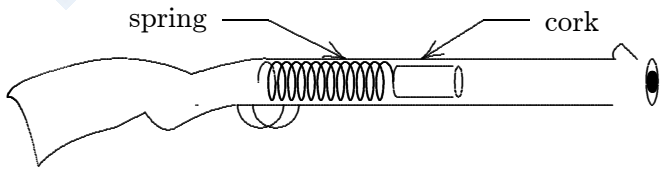
ans: A

34. A 700-N man jumps out of a window into a fire net 10 m below. The net stretches 2 m before bringing the man to rest and tossing him back into the air. The maximum potential energy of the net, compared to its unstretched potential energy, is:

A. 300 J
B. 710 J
C. 850 J
D. 7000 J
E. 8400 J

ans: E

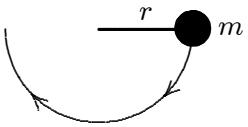
35. A toy cork gun contains a spring whose spring constant is 10.0 N/m. The spring is compressed 5.00 cm and then used to propel a 6.00-g cork. The cork, however, sticks to the spring for 1.00 cm beyond its unstretched length before separation occurs. The muzzle velocity of this cork is:



A. 1.02 m/s
B. 1.41 m/s
C. 2.00 m/s
D. 2.04 m/s
E. 4.00 m/s

ans: C

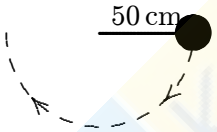
36. A small object of mass m, on the end of a light cord. is held horizontally at a distance r from a fixed support as shown. ord
when the object is at the lowest point of its swing.



A. $mg/2$
B. mg
C. $2mg$
D. $3mg$
E. mgr

ans: D

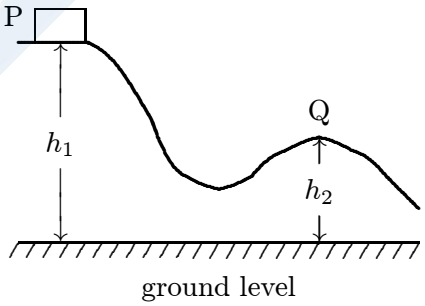
37. The string in the figure is 50 cm long. When the ball is released from rest, it swings along the dotted arc. How fast is it going at the lowest point in its swing?



A. 2.0 m/s
B. 2.2 m/s
C. 3.1 m/s
D. 4.4 m/s
E. 6.0 m/s

ans: C

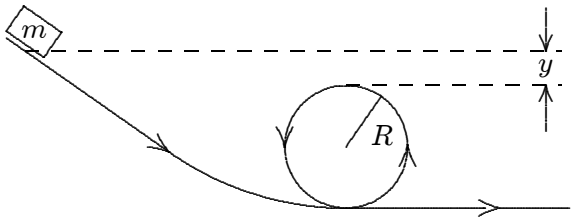
38. A block is released from rest at point P and slides along the frictionless track shown. At point Q, its speed is:



A. $2g\sqrt{h_1 - h_2}$
B. $2g(h_1 - h_2)$
C. $(h_1 - h_2)/2g$
D. $\sqrt{2g(h_1 - h_2)}$
E. $(h_1 - h_2)^2/2g$

ans: D

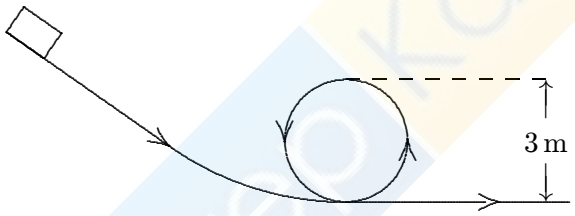
39. A small object of mass m starts from rest at the position shown and slides along the frictionless loop-the-loop track of radi lide without losing contact with the track.



A. $R/4$
B. $R/2$
C. R
D. $2R$
E. zero

ans: B

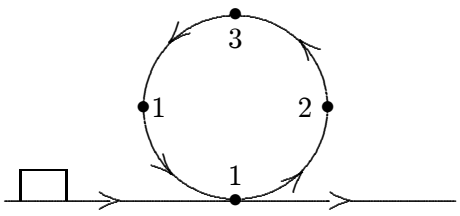
40. A small object slides along the frictionless loop-the-loop with a diameter of 3 m. What minimum speed must it have at the top of the loop?



A. 1.9 m/s
B. 3.8 m/s
C. 5.4 m/s
D. 15 m/s
E. 29 m/s

ans: B

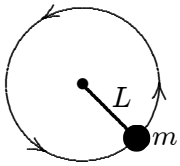
41. A rectangular block is moving along a frictionless path when it encounters the circular loop as shown. The block passes points 1, 2, 3, 4, 1 before returning to the horizontal track. At point 3:



A. its mechanical energy is a minimum
B. the forces on it are balanced
C. it is not accelerating
D. its speed is a minimum
E. it experiences a net upward force

ans: D

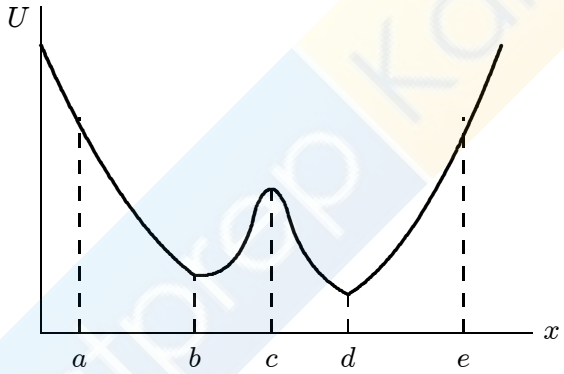
42. A ball of mass m, at one end of a string of length L, rotates in a vertical circle just fast enough to prevent the string from the bottom of the circle is:



A. $\sqrt{2gL}$
B. $\sqrt{3gL}$
C. $\sqrt{4gL}$
D. $\sqrt{5gL}$
E. $\sqrt{7gL}$

ans: D

43. A particle is released from rest at the point $x = a$ and moves along the x axis subject to the potential energy function $U(x)$ shown. The particle:



A. moves to a point to the left of $x = e$, stops, and remains at rest
B. moves to a point to $x = e$, then moves to the left
C. moves to infinity at varying speed
D. moves to $x = b$, where it remains at rest
E. moves to $x = e$ and then to $x = d$, where it remains at rest

ans: B

44. The potential energy of a particle moving along the x axis is given by

$$U(x) = (8.0\,\mathrm{J/m^2})x^2 + (2.0\,\mathrm{J/m^4})x^4\,.$$

If the total mechanical energy is 9.0 J, the limits of motion are:

A. -0.96 m; $+0.96$ m
B. -2.2 m; $+2.2$ m
C. -1.6 m; $+1.6$ m
D. -0.96 m; $+2.2$ m
E. -0.96 m; $+1.6$ m

ans: A

45. The potential energy of a 0.20-kg particle moving along the x axis is given by

$$U(x) = (3.0\,\text{J/m}^2)x^2 + (2.0\,\text{J/m}^3)x^3.$$

When the particle is at $x = 1.0\,\text{m}$ it is traveling in the positive x direction with a speed of $5.0\,\text{m/s}$. It next stops momentarily to turn around at $x =$

A. 0
B. $-1.1\,\text{m}$
C. $1.1\,\text{m}$
D. $-2.3\,\text{m}$
E. $2.3\,\text{m}$

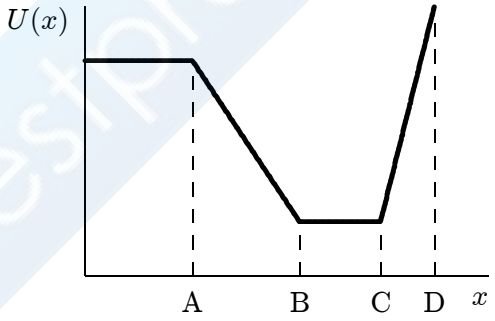
ans: C

46. Given a potential energy function $U(x)$, the corresponding force $\vec{F}$ is in the positive x direction if:

A. U is positive
B. U is negative
C. U is an increasing function of x
D. U is a decreasing function of x
E. it is impossible to obtain the direction of $\vec{F}$ from U

ans: D

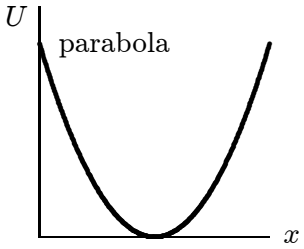
47. As a particle moves along the x axis it is acted upon by a conservative force. The potential energy is shown below as a function of the coordinate x of the particle. Rank the labeled regions according to the magnitude of the force, least to greatest.

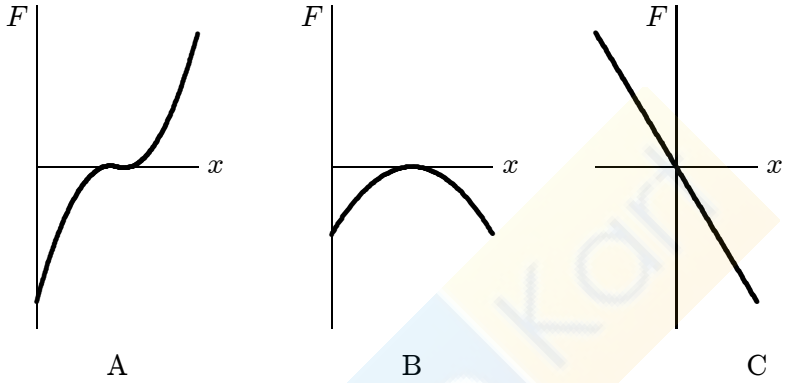


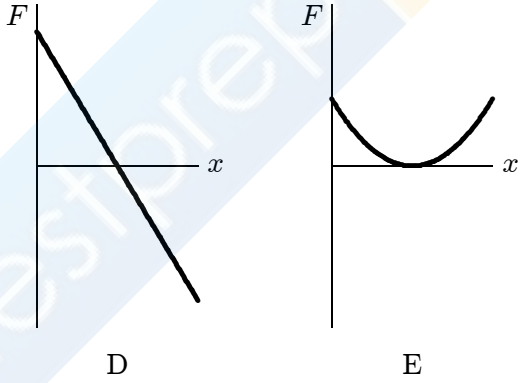
A. AB, BC, CD
B. AB, CD, BC
C. BC, CD, AB
D. BC, AB, CD
E. CD, BC, AB

ans: D

48. The first graph shows the potential energy $U(x)$ for a particle moving on the x axis. Which of the other five graphs corre

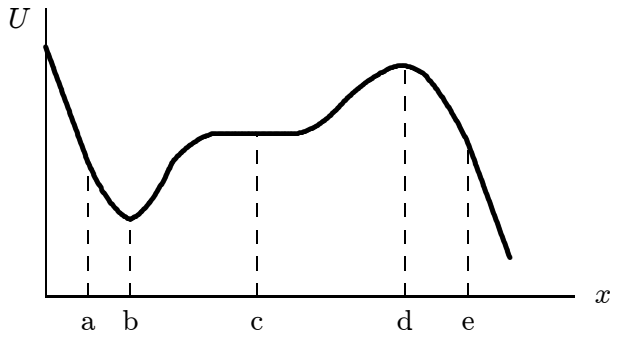






ans: D

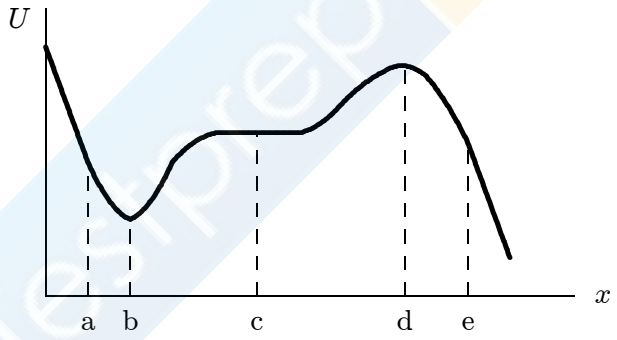
49. The diagram shows a plot of the potential energy as a function of x for a particle moving along the x axis. The points of s



A. only a
B. only b
C. only c
D. only d
E. b and d

ans: B

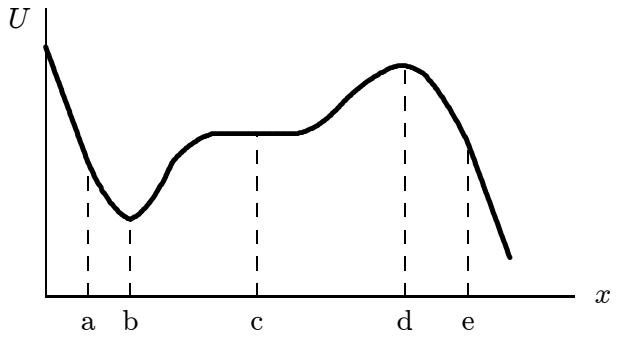
50. The diagram shows a plot of the potential energy as a function of x for a particle moving along the x axis. The points of unstable equilibrium are:



A. only a
B. only b
C. only c
D. only d
E. b and d

ans: D

51. The diagram shows a plot of the potential energy as a function of x for a particle moving along the x axis. Of the labeled



A. only a
B. only b
C. only c
D. only d
E. b and d

ans: C

52. The potential energy of a body of mass m is given by $U = -mgx + \frac{1}{2}kx^2$. The corresponding force is:

A. $-mgx^2/2 + kx^3/6$
B. $mgx^2/2 - kx^3/6$
C. $-mg + kx/2$
D. $-mg + kx$
E. $mg - kx$

ans: E

53. The potential energy of a 0.20-kg particle moving along the x axis is given by

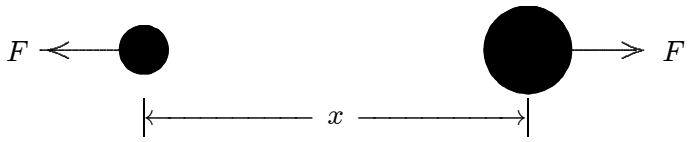
$$U(x) = (8.0\,\mathrm{J/m^2})x^2 + (2.0\,\mathrm{J/m^4})x^4\,.$$

When the particle is at $x = 1.0\,\mathrm{m}$ the magnitude of its acceleration is:

A. 0
B. $-8\,\mathrm{m/s^2}$
C. $8\,\mathrm{m/s^2}$
D. $-40\,\mathrm{m/s^2}$
E. $40\,\mathrm{m/s^2}$

ans: D

54. The potential energy for the interaction between the two atoms in a diatomic molecule is $U = A/x^{12} - B/x^6$, where [illegible]. The magnitude of the force of one atom on the other is:



A. $12A/|x|^{13} - 6B/|x|^7$
B. $-13A/|x|^{13} + 7B/|x|^7$
C. $-11A/|x|^{11} + 5B/|x|^5$
D. $72A/|x|^{12} - 72B/|x|^6$
E. $A/|x|^{13} - B/|x|^7$

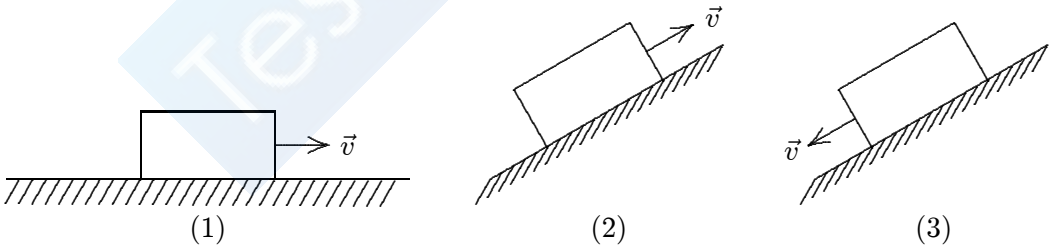
ans: A

55. The thermal energy of a system consisting of a thrown ball, Earth, and the air is most closely associated with:

A. the gravitational interaction of Earth and the ball
B. the kinetic energy of the ball as a whole
C. motions of the individual particles within the ball
D. motions of individual particles within the ball and the air
E. the kinetic energy of Earth as a whole

ans: D

56. Three identical blocks move either on a horizontal surface, up a plane, or down a plane, as shown below. They start with different speeds and continue to move until brought to rest by friction. They all move the same distance. Rank the three situations according to the initial speeds, least to greatest.



A. The same for all cases
B. 1, 2, 3
C. 1, then 2 and 3 tie
D. 3, 1, 2
E. 2, 1, 3

ans: D

57. Objects A and B interact with each other via both conservative and nonconservative forces. Let K_A and K_B be the ki mal energy. If no external agent does work on the objects then:

A. $K_A + U$ is conserved
B. $K_A + U + E_{\text{int}}$ is conserved
C. $K_A + K_B + E_{\text{int}}$ is conserved
D. $K_A + K_B + U$ is conserved
E. $K_A + K_B + U + E_{\text{int}}$ is conserved

ans: E

58. A block slides across a rough horizontal table top. The work done by friction changes:

A. only the kinetic energy
B. only the potential energy
C. only the internal energy
D. only the kinetic and potential energies
E. only the kinetic and internal energies

ans: E

59. A 25-g ball is released from rest 80 m above the surface of Earth. During the fall the total internal energy of the ball and air increases by 15 J. Just before it hits the surface its speed is

A. 19 m/s
B. 36 m/s
C. 40 m/s
D. 45 m/s
E. 53 m/s

ans: A

60. A 5-kg projectile is fired over level ground with a velocity of 200 m/s at an angle of 25° above the horizontal. Just before it hits the ground its speed is 150 m/s. Over the entire trip the change in the internal energy of the projectile and air is:

A. +19,000 J
B. −19,000 J
C. +44,000 J
D. −44,000 J
E. 0

ans: C

61. A 0.75-kg block slides on a rough horizontal table top. Just before it hits a horizontal ideal spring its speed is 3.5 m/s. It compresses the spring 5.7 cm before coming to rest. If the spring constant is 1200 N/m, the internal energy of the block and the table top must have:

A. not changed
B. decreased by 1.9 J
C. decreased by 2.6 J
D. increased by 1.9 J
E. increased by 2.6 J

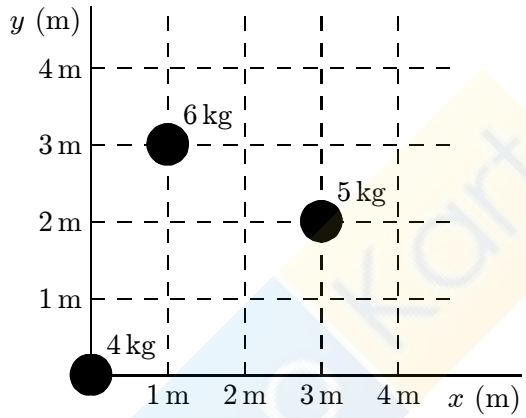
ans: C

Chapter 9: CENTER OF MASS AND LINEAR MOMENTUM

1. Which one of the following statements is true:
   A. the center of mass of an object must lie within the object
   B. all the mass of an object is actually concentrated at its center of mass
   C. the center of mass of an object cannot move if there is zero net force on the object
   D. the center of mass of a cylinder must lie on its axis
   E. none of the above

   ans: E

2. The x and y coordinates of the center of mass of the three-particle system shown below are:



   A. $0, 0$
   B. 1.3 m, 1.7 m
   C. 1.4 m, 1.9 m
   D. 1.9 m, 2.5 m
   E. 1.4 m, 2.5 m

   ans: C

3. The center of mass of a uniform disk of radius R is located:
   A. on the rim
   B. a distance $R/2$ from the center
   C. a distance $R/3$ from the center
   D. a distance $2R/3$ from the center
   E. at the center

   ans: E

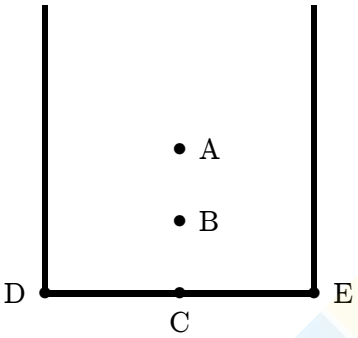
4. The center of mass of the system consisting of Earth, the Sun, and the planet Mars is:
   A. closer to Earth than to either of the other bodies
   B. closer to the Sun than to either of the other bodies
   C. closer to Mars than to either of the other bodies
   D. at the geometric center of the triangle formed by the three bodies
   E. at the center of the line joining Earth and Mars

   ans: B

5. The center of mass of Earth's atmosphere is:
   A. a little less than halfwa ıere
   B. near the surface of Earth
   C. near the outer boundary of the atmosphere
   D. near the center of Earth
   E. none of the above

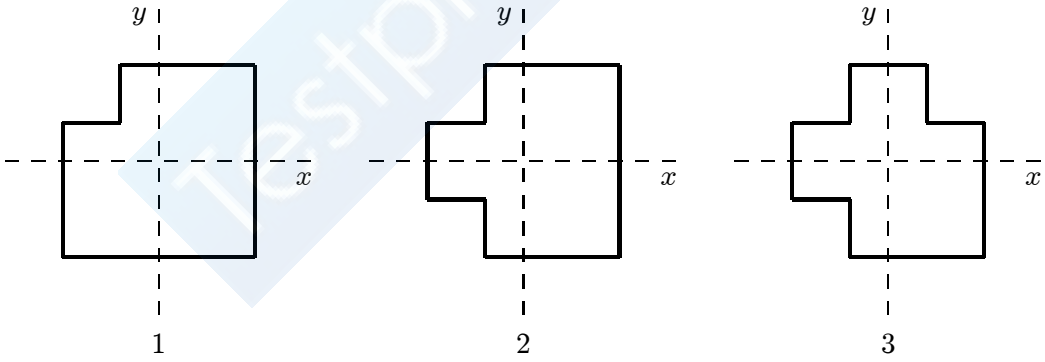
   ans: D

6. A thick uniform wire is bent into the shape of the letter "U" as shown. Which point indicates the location of the center of mass of this wire?



   ans: B

7. A machinist starts with three identical square plates but cuts one corner from one of them, two corners from the second, and three corners from the third. Rank the three plates according to the x coordinate of their centers of mass, from smallest to largest.



   A. 1, 2, 3
   B. 1 and 2 tie, then 3
   C. 1, then 2 and 3 tie
   D. 3, 2, 1
   E. 1 and 3 tie, then 2

   ans: E

8. Block A, with a mass of 4 kg, is moving with a speed of 2.0 m/s while block B, with a mass of 8 kg, is moving in the opp[illegible] two block-system is moving with a velocity of:

   A. 1.3 m/s in the same direction as A
   B. 1.3 m/s in the same direction as B
   C. 2.7 m/s in the same direction as A
   D. 1.0 m/s in the same direction as B
   E. 5.0 m/s in the same direction as A

   ans: B

9. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass each other without colliding. At the end of 2.0 s the height above Earth's surface of the center of mass of the two-ball system is:

   A. 2.9 m
   B. 4.0 m
   C. 5.0 m
   D. 7.1 m
   E. 10.4 m

   ans: D

10. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass without colliding. At the end of 2.0 s the velocity of the center of mass of the two-ball system is:

    A. 11 m/s, down
    B. 11 m/s, up
    C. 15 m/s, down
    D. 15 m/s, up
    E. 20 m/s, down

    ans: C

11. At the same instant that a 0.50-kg ball is dropped from 25 m above Earth, a second ball, with a mass of 0.25 kg, is thrown straight upward from Earth's surface with an initial speed of 15 m/s. They move along nearby lines and pass without colliding. At the end of 2.0 s the magnitude of the acceleration of the center of mass of the two-ball system is:

    A. $0.25g$
    B. $0.50g$
    C. $0.75g$
    D. g
    E. $g/0.75$

    ans: D

12. A light rope passes over a light frictionless pulley attached to the ceiling. An object with a large mass is tied to one end and [illegible]om rest the heavier object moves downward and the lighter object moves upward with the same magnitude acceleration. Which of the following statements is true for the system consisting of the two masses?
    A. The center of mass remains at rest.
    B. The net external force is zero.
    C. The velocity of the center of mass is a constant.
    D. The acceleration of the center of mass is g, downward.
    E. None of the above statements are true.

    ans: E

13. Two 4.0-kg blocks are tied together with a compressed spring between them. They are thrown from the ground with an initial velocity of 35 m/s, 45° above the horizontal. At the highest point of the trajectory they become untied and spring apart. About how far below the highest point is the center of mass of the two-block system 2.0 s later, before either fragment has hit the ground?
    A. 12 m
    B. 20 m
    C. 31 m
    D. Can't tell because the velocities of the fragments are not given.
    E. Can't tell because the coordinates of the highest point are not given.

    ans: B

14. The center of mass of a system of particles has a constant velocity if:
    A. the forces exerted by the particles on each other sum to zero
    B. the external forces acting on particles of the system sum to zero
    C. the velocity of the center of mass is initially zero
    D. the particles are distributed symmetrically around the center of mass
    E. the center of mass is at the geometric center of the system

    ans: B

15. The center of mass of a system of particles remains at the same place if:
    A. it is initially at rest and the external forces sum to zero
    B. it is initially at rest and the internal forces sum to zero
    C. the sum of the external forces is less than the maximum force of static friction
    D. no friction acts internally
    E. none of the above

    ans: A

16. A man sits in the back of a canoe in still water. He then moves to the front of the canoe and sits there. Afterwards the canoe:
    A. is forward of its original position and moving forward
    B. is forward of its original position and moving backward
    C. is rearward of its original position and moving forward
    D. is rearward of its original position and moving backward
    E. is rearward of its original position and not moving

    ans: E

17. A 640-N hunter gets a rope around a 3200-N polar bear. They are stationary, 20 m apart, on frictionless level ice. When e:

A. 1.0 m
B. 3.3 m
C. 10 m
D. 12 m
E. 17 m

ans: B

18. Two boys, with masses of 40 kg and 60 kg, respectively, stand on a horizontal frictionless surface holding the ends of a light 10-m long rod. The boys pull themselves together along the rod. When they meet the 60-kg boy will have moved what distance?

A. 4 m
B. 5 m
C. 6 m
D. 10 m
E. need to know the forces they exert

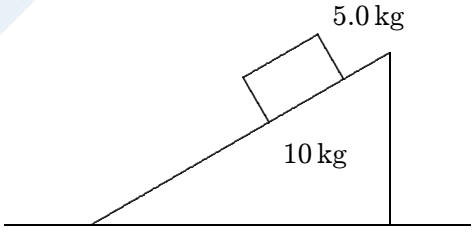
ans: A

19. The center of mass of a system of particles obeys an equation similar to Newton's second law $\vec{F} = m\vec{a}_{\text{com}}$, where:

A. $\vec{F}$ is the net internal force and m is the total mass of the system
B. $\vec{F}$ is the net internal force and m is the mass acting on the system
C. $\vec{F}$ is the net external force and m is the total mass of the system
D. $\vec{F}$ is the force of gravity and m is the mass of Earth
E. $\vec{F}$ is the force of gravity and m is the total mass of the system

ans: C

20. A large wedge with a mass of 10 kg rests on a horizontal frictionless surface, as shown. A block with a mass of 5.0 kg starts from rest and slides down the inclined surface of the wedge, which is rough. At one instant the vertical component of the block's velocity is 3.0 m/s and the horizontal component is 6.0 m/s. At that instant the velocity of the wedge is:



A. 3.0 m/s to the left
B. 3.0 m/s to the right
C. 6.0 m/s to the right
D. 6.0 m/s to the left
E. 17 m/s to the right

ans: B

21. A 2.0-kg block is attached to one end of a spring with a spring constant of 100 N/m and a 4.0-kg block is attached to [illegible] less surface and set into motion. At one instant the 2.0-kg block is observed to be traveling to the right with a speed of 0.50 m/s and the 4.0-kg block is observed to be traveling to the left with a speed of 0.30 m/s. Since the only forces on the blocks are the force of gravity, the normal force of the surface, and the force of the spring, we conclude that:

A. the spring is compressed at the time of the observation
B. the spring is not compressed at the time of observation
C. the motion was started with the masses at rest
D. the motion was started with at least one of masses moving
E. the motion was started by compressing the spring

ans: D

22. A 2.0-kg mass is attached to one end of a spring with a spring constant of 100 N/m and a 4.0-kg mass is attached to the other end. The masses are placed on a horizontal frictionless surface and the spring is compressed 10 cm. The spring is then released with the masses at rest and the masses oscillate. When the spring has its equilibrium length for the first time the 2.0-kg mass has a speed of 0.36 m/s. The mechanical energy that has been lost to the instant is:

A. zero
B. 0.31 J
C. 0.61 J
D. 0.81 J
E. 1.2 J

ans: B

23. Momentum may be expressed in:

A. kg/m
B. gram·s
C. N·s
D. kg/(m·s)
E. N/s

ans: C

24. The momentum of an object at a given instant is independent of its:

A. inertia
B. mass
C. speed
D. velocity
E. acceleration

ans: E

25. Two bodies, A and B, have equal kinetic energies. The mass of A is nine times that of B. The ratio of the momentum of

A. 1:9
B. 1:3
C. 1:1
D. 3:1
E. 9:1

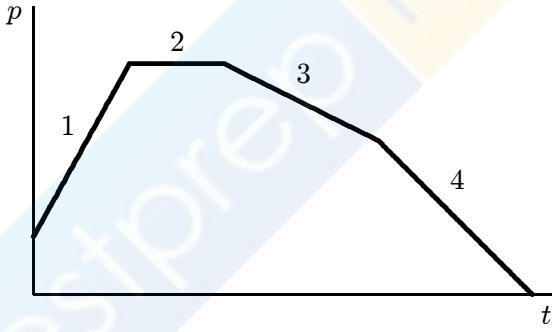
ans: D

26. Two objects, P and Q, have the same momentum. Q has more kinetic energy than P if it:

A. weighs more than P
B. is moving faster than P
C. weighs the same as P
D. is moving slower than P
E. is moving at the same speed as P

ans: B

27. A particle moves along the x axis. Its momentum is graphed below as a function of time. Rank the numbered regions according to the magnitude of the force acting on the particle, least to greatest.



A. 1, 2, 3, 4
B. 2, 3, 4, 1
C. 1, 4, 3, 2
D. 1, 3, 4, 2
E. 2, 4, 3, 1

ans: B

28. A 1.0-kg ball moving at 2.0 m/s perpendicular to a wall rebounds from the wall at 1.5 m/s. The change in the momentum of the ball is:

A. zero
B. 0.5 N · s away from wall
C. 0.5 N · s toward wall
D. 3.5 N · s away from wall
E. 3.5 N · s toward wall

ans: D

29. If the total momentum of a system is changing:
    A. particles of the system
    B. the system must be under the influence of gravity
    C. the center of mass must have constant velocity
    D. a net external force must be acting on the system
    E. none of the above

    ans: D

30. When you step on the accelerator to increase the speed of your car, the force that accelerates the car is:
    A. the force of your foot on the accelerator
    B. the force of friction of the road on the tires
    C. the force of the engine on the drive shaft
    D. the normal force of the road on the tires
    E. none of the above

    ans: B

31. A 2.5-kg stone is released from rest and falls toward Earth. After 4.0 s, the magnitude of its momentum is:
    A. $98\,\text{kg} \cdot \text{m/s}$
    B. $78\,\text{kg} \cdot \text{m/s}$
    C. $39\,\text{kg} \cdot \text{m/s}$
    D. $24\,\text{kg} \cdot \text{m/s}$
    E. zero

    ans: A

32. A 64-kg woman stands on frictionless level ice with a 0.10-kg stone at her feet. She kicks the stone with her foot so that she acquires a velocity of 0.0017 m/s in the forward direction. The velocity acquired by the stone is:
    A. 1.1 m/s forward
    B. 1.1 m/s backward
    C. 0.0017 m/s forward
    D. 0.0017 m/s backward
    E. none of these

    ans: B

33. A man is marooned at rest on level frictionless ice. In desperation, he hurls his shoe to the right at 15 m/s. If the man weighs 720 N and the shoe weighs 4.0 N, the man moves to the left with a speed of:
    A. 0
    B. $2.1 \times 10^{-2}\,\text{m/s}$
    C. $8.3 \times 10^{-2}\,\text{m/s}$
    D. 15 m/s
    E. $2.7 \times 10^{3}\,\text{m/s}$

    ans: C

34. Two spacemen are floating together with zero speed in a gravity-free region of space. The mass of spaceman A is 120 kg a om him with B attaining a final speed of 0.5 m/s. The final recoil speed of A is:

A. zero
B. 0.38 m/s
C. 0.5 m/s
D. 0.67 m/s
E. 1.0 m/s

ans: B

35. A projectile in flight explodes into several fragments. The total momentum of the fragments immediately after this explosion:

A. is the same as the momentum of the projectile immediately before the explosion
B. has been changed into kinetic energy of the fragments
C. is less than the momentum of the projectile immediately before the explosion
D. is more than the momentum of the projectile immediately before the explosion
E. has been changed into radiant energy

ans: A

36. A rifle of mass M is initially at rest but free to recoil. It fires a bullet of mass m and velocity v (relative to the ground). After firing, the velocity of the rifle (relative to the ground) is:

A. $-mv$
B. $-Mv/m$
C. $-mv/M$
D. $-v$
E. mv/M

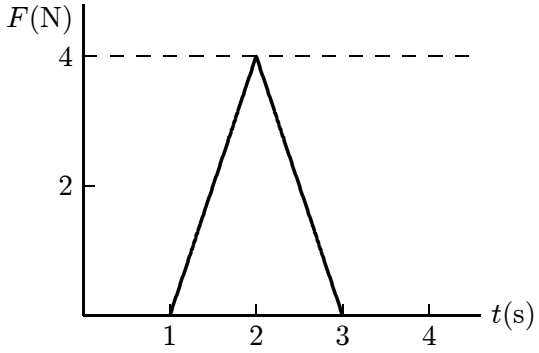
ans: C

37. Bullets from two revolvers are fired with the same velocity. The bullet from gun #1 is twice as heavy as the bullet from gun #2. Gun #1 weighs three times as much as gun #2. The ratio of the momentum imparted to gun #1 to that imparted to gun #2 is:

A. 2:3
B. 3:2
C. 2:1
D. 3:1
E. 6:1

ans: C

38. A 5-kg object can move along the x axis. It is subjected to a force $\vec{F}$ in the positive x direction; a graph of F as a functio the change in the velocity of the object is.



A. 0.8 m/s
B. 1.1 m/s
C. 1.6 m/s
D. 2.3 m/s
E. 4.0 m/s

ans: A

39. Force:

A. equals the negative integral (with respect to distance) of the potential energy function
B. is the ability to do work
C. is the rate of change of doing work
D. equals the time rate of change of momentum
E. has dimensions of momentum multiplied by time

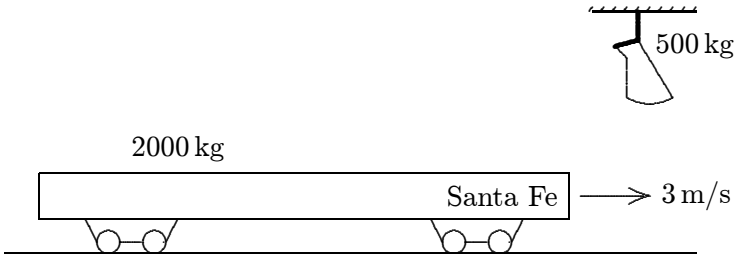
ans: D

40. Cart A, with a mass of 0.20 kg, travels on a horizontal air track at 3.0 m/s and hits cart B, which has a mass of 0.40 kg and is initially traveling away from A at 2.0 m/s. After the collision the center of mass of the two cart system has a speed of:

A. zero
B. 0.33 m/s
C. 2.3 m/s
D. 2.5 m/s
E. 5.0 m/s

ans: B

41. A 500-kg sack of coal is dropped on a 2000-kg railroad flatcar which was initially moving at 3 m/s as shown. After the



A. 0.6 m/s
B. 1.2 m/s
C. 1.8 m/s
D. 2.4 m/s
E. 3.6 m/s

ans: D

42. A cart loaded with sand slides forward along a horizontal frictionless track. As the cart moves, sand trickles out at a constant rate through a hole in the back of the cart. The acceleration of the cart is:

A. constant and in the forward direction
B. constant and in the backward direction
C. variable and in the forward direction
D. variable and in the backward direction
E. zero

ans: E

43. The thrust of a rocket is:

A. a gravitational force acting on the rocket
B. the force of the exiting fuel gases on the rocket
C. any force that is external to the rocket-fuel system
D. a force that arises from the reduction in mass of the rocket-fuel system
E. none of the above

ans: B:

44. At one instant of time a rocket is traveling in outer space at 2500 m/s and is exhausting fuel at a rate of 100 kg/s. If the speed of the fuel as it leaves the rocket is 1500 m/s, relative to the rocket, the thrust is:

A. 0
B. 1.0×10^5 N
C. 1.5×10^5 N
D. 2.9×10^5 N
E. 2.5×10^5 N

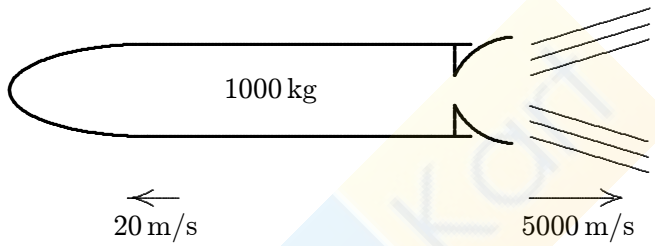
ans: C

45. A rocket exhausts fuel with a velocitv of 1500 m/s. relative to the rocket. It starts from rest in outer space with fuel cc een exhausted its speed is:

A. 3600 m/s
B. 2400 m/s
C. 1200 m/s
D. 880 m/s
E. 400 m/s

ans: B

46. A 1000-kg space probe is motionless in space. To start moving, its main engine is fired for 5 s during which time it ejects exhaust gases at 5000 m/s. At the end of this process it is moving at 20 m/s. The approximate mass of the ejected gas is:



A. 0.8 kg
B. 4 kg
C. 5 kg
D. 20 kg
E. 25 kg

ans: B

47. The physical quantity "impulse" has the same dimensions as that of:

A. force
B. power
C. energy
D. momentum
E. work

ans: D

48. The law of conservation of momentum applies to a system of colliding objects only if:

A. there is no change in kinetic energy of the system
B. the coefficient of restitution is one
C. the coefficient of restitution is zero
D. the net external impulse is zero
E. the collisions are all elastic

ans: D

49. Sphere X, of mass 2 kg, is moving to the right at 10 m/s. Sphere Y, of mass 4 kg, is moving to the left at 10 m/s. The tw n Y is:

A. twice the magnitude of the impulse of Y on X
B. half the magnitude of the impulse of Y on X
C. one-fourth the magnitude of the impulse of Y on X
D. four times the magnitude of the impulse of Y on X
E. the same as the magnitude of the impulse of Y on X

ans: E

50. Two bodies of unequal mass, placed at rest on a frictionless surface, are acted on by equal horizontal forces for equal times. Just after these forces are removed, the body of greater mass will have:

A. the greater speed
B. the greater acceleration
C. the smaller momentum
D. the greater momentum
E. the same momentum as the other body

ans: E

51. A 0.2-kg rubber ball is dropped from the window of a building. It strikes the sidewalk below at 30 m/s and rebounds up at 20 m/s. The impulse on the ball during the collision is:

A. 10 N · s upward
B. 10 N · s downward
C. 2.0 N · s upward
D. 2.0 N · s downward
E. 9.8 N · s upward

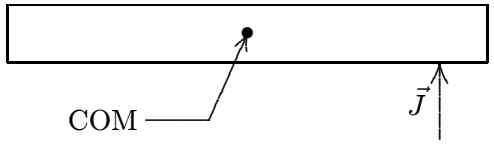
ans: A

52. A 10-kg block of ice is at rest on a frictionless horizontal surface. A 1.0-N force is applied in an easterly direction for 1.0 s. During this time interval, the block:

A. acquires a speed of 1 m/s
B. moves 10 cm
C. acquires a momentum of 1.0 kg · m/s
D. acquires a kinetic energy of 0.1 J
E. none of the above

ans: C

53. A uniform narrow bar, resting on ice, is given a transverse horizontal impulse $\vec{J}$ at one end as shown. The center of mass



A. remain at rest
B. move in a circle
C. move in a straight line
D. move in a parabola
E. move along some other curve

ans: C

54. What magnitude impulse will give a 2.0-kg object a momentum change of magnitude + 50 kg · m/s?

A. $+25\,\text{N}\cdot\text{s}$
B. $-25\,\text{N}\cdot\text{s}$
C. $+50\,\text{N}\cdot\text{s}$
D. $-50\,\text{N}\cdot\text{s}$
E. $+100\,\text{N}\cdot\text{s}$

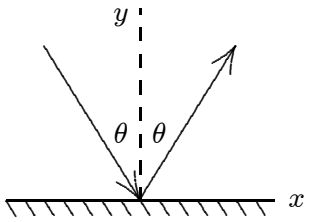
ans: C

55. A student's life was saved in an automobile accident because an airbag expanded in front of his head. If the car had not been equipped with an airbag, the windshield would have stopped the motion of his head in a much shorter time. Compared to the windshield, the airbag:

A. causes a much smaller change in momentum
B. exerts a much smaller impulse
C. causes a much smaller change in kinetic energy
D. exerts a much smaller force
E. does much more work

ans: D

56. A ball hits a wall and rebounds with the same speed, as diagramed below. The changes in the components of the momen



A. $\Delta p_x > 0$, $\Delta p_y > 0$
B. $\Delta p_x < 0$, $\Delta p_y > 0$
C. $\Delta p_x = 0$, $\Delta p_y > 0$
D. $\Delta p_x = 0$, $\Delta p_y < 0$
E. $\Delta p_x > 0$, $\Delta p_y < 0$

ans: C

57. A golf ball of mass m is hit by a golf club so that the ball leaves the tee with speed v. The club is in contact with the ball for time T. The magnitude of the average force on the club on the ball during the time T is:

A. mvT
B. mv/T
C. $(1/2)mv^2T$
D. $mv^2/(2T)$
E. $mT^2/(2v)$

ans: B

58. A 640-N acrobat falls 5.0 m from rest into a net. The net tosses him back up with the same speed he had just before he hit the net. The magnitude of the average upward force exerted on him by the net during this collision is:

A. 32 N
B. 64 N
C. 320 N
D. 640 N
E. impossible to determine from given data

ans: E

59. Whenever an object strikes a stationary object of equal mass:

A. the two objects cannot stick together
B. the collision must be elastic
C. the first object must stop
D. momentum is not necessarily conserved
E. none of the above

ans: E

60. For a two-body collision involving objects with different masses, a frame of reference which has the same velocity relative s:

A. a frame for which the momentum of the incident object is zero
B. a frame for which the momentum of the target object is zero
C. a frame for which the average momentum of the two objects is zero
D. a frame for which the total momentum of the two objects is zero
E. none of the above

ans: D

61. An inelastic collision is one in which:

A. momentum is not conserved but kinetic energy is conserved
B. total mass is not conserved but momentum is conserved
C. neither kinetic energy nor momentum is conserved
D. momentum is conserved but kinetic energy is not conserved
E. the total impulse is equal to the change in kinetic energy

ans: D

62. A 4.0-N puck is traveling at 3.0 m/s. It strikes a 8.0-N puck, which is stationary. The two pucks stick together. Their common final speed is:

A. 1.0 m/s
B. 1.5 m/s
C. 2.0 m/s
D. 2.3 m/s
E. 3.0 m/s

ans: A

63. A 3.00-g bullet traveling horizontally at 400 m/s hits a 3.00-kg wooden block, which is initially at rest on a smooth horizontal table. The bullet buries itself in the block without passing through. The speed of the block after the collision is:

A. 1.33 m/s
B. 0.40 m/s
C. 12.0 m/s
D. 40.0 m/s
E. 160 m/s

ans: B

64. A 2-kg cart, traveling on a horizontal air track with a speed of 3 m/s, collides with a stationary 4-kg cart. The carts stick together. The impulse exerted by one cart on the other has a magnitude of:

A. 0
B. 4 N · s
C. 6 N · s
D. 9 N · s
E. 12 N · s

ans: B

65. A 3-g bullet is fired horizontally into a 10-kg block of wood suspended by a rope from the ceiling. The block swings [illegible] the bullet was:

A. unknown since the heat generated in the collision was not given
B. 8.0×10^2 m/s
C. 24.0 m/s
D. 8.00 m/s
E. 2.4×10^4 m/s

ans: B

66. A 3.0-kg and a 2.0-kg cart approach each other on a horizontal air track. They collide and stick together. After the collision their total kinetic energy is 40 J. The speed of their center of mass is:

A. zero
B. 2.8 m/s
C. 4.0 m/s
D. 5.2 m/s
E. 6.3 m/s

ans: C

67. Blocks A and B are moving toward each other. A has a mass of 2.0 kg and a velocity of 50 m/s, while B has a mass of 4.0 kg and a velocity of -25 m/s. They suffer a completely inelastic collision. The kinetic energy lost during the collision is:

A. 0
B. 1250 J
C. 3750 J
D. 5000 J
E. 5600 J

ans: C

68. For a completely inelastic two-body collision the kinetic energy retained by the objects is the same as:

A. the total kinetic energy before the collision
B. the difference in the kinetic energies of the objects before the collision
C. $\frac{1}{2}Mv_{\text{com}}^2$, where M is the total mass and v_{com} is the velocity of the center of mass
D. the kinetic energy of the more massive body before the collision
E. the kinetic energy of the less massive body before the collision

ans: C

69. A 75-kg man is riding in a 30-kg cart at 2.0 m/s. He jumps off in such a way as to land on the ground with no horizontal velocity. The resulting change in speed of the cart is:

A. zero
B. 2.0 m/s
C. 3.0 m/s
D. 5.0 m/s
E. 7.0 m/s

ans: D

70. An elastic collision is one in which:
A. momentum is not cons
B. total mass is not conserved but momentum is conserved
C. kinetic energy and momentum are both conserved
D. momentum is conserved but kinetic energy is not conserved
E. the total impulse is equal to the change in kinetic energy
ans: C

71. Object A strikes the stationary object B head-on in an elastic collision. The mass of A is fixed, you may choose the mass of B appropriately. Then:
A. for B to have the greatest recoil speed, choose $m_B = m_A$
B. for B to have the greatest recoil momentum, choose $m_B \ll m_A$
C. for B to have the greatest recoil kinetic energy, choose $m_B \ll m_A$
D. for B to have the least recoil speed, choose $m_B = m_A$
E. for B to have the greatest recoil kinetic energy, choose $m_B = m_A$
ans: E

72. Block A, with a mass of 2.0 kg, moves along the x axis with a velocity of 5.0 m/s in the positive x direction. It suffers an elastic collision with block B, initially at rest, and the blocks leave the collision along the x axis. If B is much more massive than A, the speed of A after the collision is:
A. 0
B. +5.0 m/s
C. −5.0 m/s
D. +10 m/s
E. −10 m/s
ans: C

73. A very massive object traveling at 10 m/s strikes a very light object, initially at rest, and the light object moves off in the direction of travel of the heavy object. If the collision is elastic, the speed of the lighter object is:
A. 5.0 m/s
B. 10 m/s
C. 15 m/s
D. 20 m/s
E. Can't tell from the information given.
ans: D

74. Sphere A has mass m and is moving with velocity v. It makes a head-on elastic collision with a stationary sphere B of mass $2m$. After the collision their speeds (v_A and v_B) are:
A. 0, $v/2$
B. $-v/3$, $2v/3$
C. $-v$, v
D. $-2v/3$, $v/3$
E. none of these
ans: B

75. Blocks A and B are moving toward each other along the x axis. A has a mass of 2.0 kg and a velocity of 50 m/s, while [illegible] an elastic collision and move on along the x axis. The kinetic energy transferred from A to B during the collision is:

A. 0
B. 2500 J
C. 5000 J
D. 7500 J
E. 10000 J

ans: A

76. When a particle suffers a head-on elastic collision with another particle, initially at rest, the greatest fraction of kinetic energy is transferred if:

A. the incident particle is initially traveling very fast
B. the incident particle is traveling very slowly
C. the incident particle is much more massive than the target particle
D. the incident particle is much less massive than the target particle
E. the incident and target particle have the same mass

ans: E

77. Two objects, X and Y, are held at rest on a horizontal frictionless surface and a spring is compressed between them. The mass of X is 2/5 times the mass of Y. Immediately after the spring is released, X has a kinetic energy of 50 J and Y has a kinetic energy of:

A. 20 J
B. 8 J
C. 310 J
D. 125 J
E. 50 J

ans: D

78. Two carts (A and B), having spring bumpers, collide as shown. Cart A has a mass of 2 kg and is initially moving to the right. Cart B has a mass of 3 kg and is initially stationary. When the separation between the carts is a minimum:

A. cart B is still at rest
B. cart A has come to rest
C. the carts have the same momentum
D. the carts have the same kinetic energy
E. the kinetic energy of the system is at a minimum

ans: E

79. Two identical carts travel at 1 m/s in opposite directions on a common horizontal surface. They collide head-on and are rej

A. momentum was not conserved; therefore, the report must be false
B. if some other form of energy were changed to kinetic during the collision, the report could be true
C. if the collision were elastic, the report could be true
D. if friction were present, the report could be true
E. if the duration of the collision were long enough, the report could be true

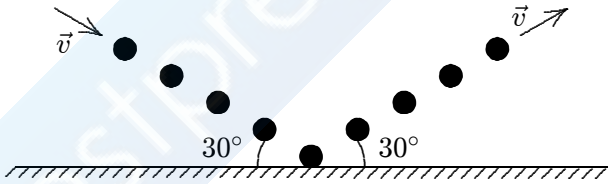
ans: B

80. A block moves at 5.0 m/s in the positive x direction and hits an identical block, initially at rest. A small amount of gunpowder had been placed on one of the blocks. The explosion does not harm the blocks but it doubles their total kinetic energy. After the explosion the blocks move along the x axis and the incident block has a speed in of:

A. 1.8 m/s
B. 5.0 m/s
C. 6.8 m/s
D. 7.1 m/s
E. 11.8 m/s

ans: A

81. A stream of gas consists of n molecules. Each molecule has mass m and speed v. The stream is reflected elastically from a rigid surface as shown. The magnitude of the change in the total momentum of the stream is:



A. $2mnv$
B. $2mnv \sin 30°$
C. $mnv \sin 30°$
D. $mnv \cos 30°$
E. mnv

ans: B