PHY1211: INTRODUCTION TO MECHANICS

250 EXERCISE MLTIPLE CHOICE

1. The momentum of a body is defined to be the product of its mass and its velocity. If the mass of an air-track glider is known to be 225 g and its velocity is measured to be 3.1 cm/s, its momentum should be reported as
   A) 697.5 g · cm/s
   B) 698 g · cm/s
   C) 7.0×10^2 g · cm/s
   D) 6.98×10^2 g · cm/s
   E) 6.975×10^2 g · cm/s

2. Vectors $\vec{A}$, $\vec{B}$, $\vec{C}$, and $\vec{D}$ have the following components:

	$\vec{A}$	$\vec{B}$	$\vec{C}$	$\vec{D}$
x component	+2.5 units	+6.1 units	–3.6 units	–1.5 units
y component	+4.3 units	–2.1 units	+1.0 units	–7.3 units

   The magnitude of the resultant is
   A) – 4.6 units
   B) 5.4 units
   C) 29 units
   D) 3.5 units
   E) 7.3 units

3. The density of seawater was measured to be 1.07 g/cm^3. This density in SI units is
   A) 1.07×10^{-3} kg/m^3
   B) $(1/1.07) \times 10^3$ kg/m^3
   C) 1.07×10^3 kg
   D) 1.07×10^{-3} kg
   E) 1.07×10^3 kg/m^3

4. Three vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$ are added together. Which statement below best describes the additive property of the three vectors?
   A) $(\vec{A}+\vec{B})+\vec{C}$
   B) $\vec{A}+(\vec{B}+\vec{C})$
   C) $\vec{C}+\vec{B}+\vec{A}$
   D) $\vec{C}+\vec{A}+\vec{B}$
   E) all the other statements

5. A particle moves from x_1 = 30 cm to x_2 = – 40 cm. The displacement of this particle is
   A) 30 cm
   B) 40 cm
   C) 70 cm
   D) –70 cm
   E) – 40 cm

6. A Ford truck enters a highway and travels at a uniform speed of 50 mph. Half an hour later a Jaguar enters the highway at the same junction and heads in the same direction at 55 mph. How long after the Ford entered the highway does the Jaguar catch up with the truck?
   A) 5.0 hrs
   B) 6.0 hrs
   C) 1.0 hrs
   D) 1.6 hrs
   E) 5.5 hrs

7. On a graph that shows position on the vertical axis and time on the horizontal axis, a parabolic curve that opens downward represents
   A) a constant positive acceleration.
   B) a constant negative acceleration.
   C) no acceleration.
   D) a positive followed by a negative acceleration.
   E) a negative followed by a positive acceleration.

8. The relationship between the velocity of a body moving along the x axis and time is given by $v = 3t^2 - 2t$, where the units are SI units. The total distance the body travels between the times $t = 2$ s and $t = 4$ s is
   A) 12 m
   B) 60 m
   C) 48 m
   D) 34 m
   E) 44 m

9. A projectile was fired at 35º above the horizontal. At the highest point in its trajectory its speed was 200 m/s. If air resistance is ignored, the initial velocity had a horizontal component of
   A) zero
   B) 200 cos (35º) m/s
   C) 200 sin (35º) m/s
   D) 200/cos (35º) m/s
   E) 200 m/s

10. A river is 0.76 km wide. The banks are straight and parallel. The current is 5.0 km/h and is parallel to the banks. A boat has a maximum speed of 3 km/h in still water. The pilot of the boat wishes to travel on a straight line from A to B, where AB is perpendicular to the banks. The pilot should
    A) head directly across the river.
    B) head 68º upstream from the line AB.
    C) head 22º upstream from the line AB.
    D) give up. The trip from A to B is not possible with this boat.
    E) do none of these.

11. The position vector locating the point $P(12,-5)$ relative to the origin is
    A) $12\hat{i}+5\hat{j}$
    B) $-5\hat{i}-12\hat{j}$
    C) $5\hat{i}+12\hat{j}$
    D) $12\hat{i}+5\hat{j}$
    E) $13\hat{i}-13\hat{j}$

12. The maximum horizontal range of a rock which is thrown at the same speed but different angles with the horizon and which lands at a level, H, below the initial level occurs when the angle is
    A) less than 0°
    B) 0°
    C) greater than 0° and less than 45° (actual value depends on the value of H)
    D) 45°
    E) greater than 45°

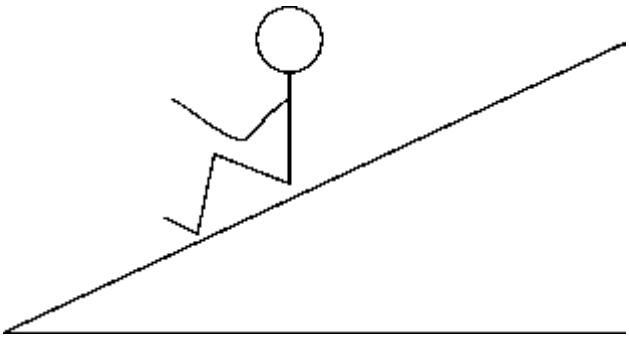
13. An unknown force $\vec{F}$ is applied to two unknown masses M_A and M_B. Their accelerations $\vec{a}_A$ and $\vec{a}_B$ are measured. From these data we can determine
    A) the magnitude of $\vec{F}$ only.
    B) M_A and M_B only.
    C) the magnitudes of $\vec{F}$, M_A, and M_B only.
    D) the ratio of M_A to M_B only.
    E) M_A, M_B, and the weights of M_A and M_B.

14. A horse harnessed to a wagon refuses to pull, citing Newton's third law, which states that for every force there is an equal but opposite reaction force. The horse, incorrect in its reasoning, *can* pull the wagon because
    A) after it gives a jerk and the wagon is moving, its pulling force will be greater than the reaction to this force.
    B) the law applies only to static cases.
    C) the wagon cannot possibly pull back with a force equal in magnitude to the pulling force.
    D) the action and reaction forces are acting on different bodies.
    E) after friction is overcome, the reaction force is less than the pulling force.

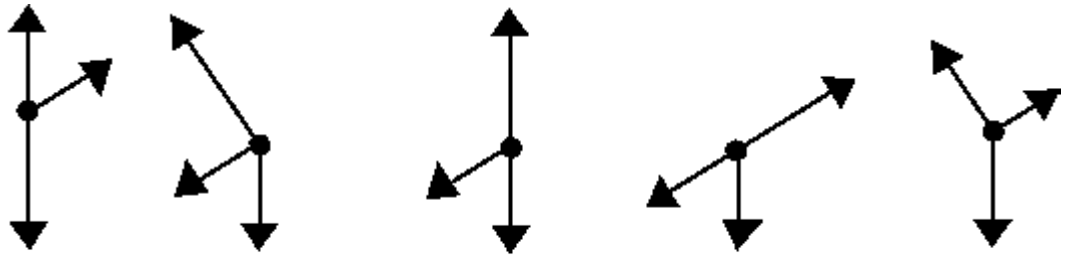
15. A large (15,000-kg) military helicopter lifts a 6000-kg truck straight up out of a danger zone with an acceleration of 4 m/s^2. Calculate the tension in the lifting cable.
    A) 3.5×10^4 N
    B) 8.3×10^4 N
    C) 2.1×10^2 N
    D) 5.9×10^4 N
    E) 2.4×10^4 N

16. A cricket batsman hits a ball with a bat. If the force with which the bat hits the ball is considered the action force, what is the reaction force?
    A) the force the bat exerts on the batsman's hands
    B) the force on the ball exerted by the hand of the person who catches it
    C) the force the ball exerts on the bat
    D) the force the bowler exerts on the ball in throwing it
    E) friction as the ball rolls to a stop

17.



The free-body diagram that best represents the forces acting on the student at rest on the incline is



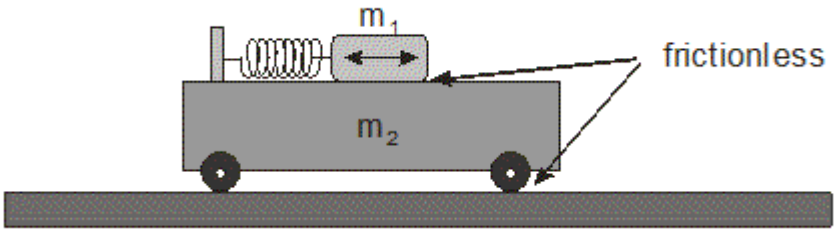
(1) (2) (3) (4) (5)

    A) 1
    B) 2
    C) 3
    D) 4
    E) 5

18. An object with a mass of 5.5 kg is allowed to slide from rest down an inclined plane. The plane makes an angle of 30º with the horizontal and is 72 m long. The coefficient of friction between the plane and the object is 0.35. The speed of the object at the bottom of the plane is
    A) 5.3 m/s
    B) 15 m/s
    C) 24 m/s
    D) 17 m/s
    E) 11 m/s

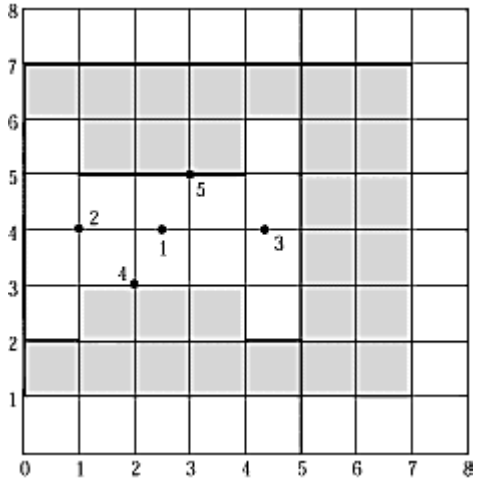
Use the following to answer question 19:

A mass, m_1, attached to a spring is placed on a cart with mass m_2, which moves freely and without friction on a table. m_1 slides without friction on the cart and is ¼ the mass of m_2.



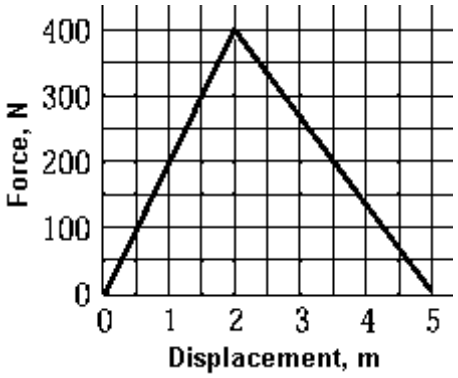
19. When m_1 moves with a displacement of 1 cm in the +x direction, what is the displacement of m_2?
    A) m_2 does not move
    B) m_2 moves $\frac{1}{4}$ cm in the +x direction
    C) m_2 moves 1 cm in the +x direction
    D) m_2 moves $\frac{1}{4}$ cm in the -x direction
    E) m_2 moves 1 cm in the -x direction

20. The shaded area in the figure represents a uniformly thick sheet of metal. The center of mass of the sheet is closest to point



    A) 1
    B) 2
    C) 3
    D) 4
    E) 5

21.



In pushing a load, a woman exerts a force as given by the graph. What was the total work done by the woman?

A) 400 J
B) 200 J
C) 2000 J
D) 1000 J
E) 500 J

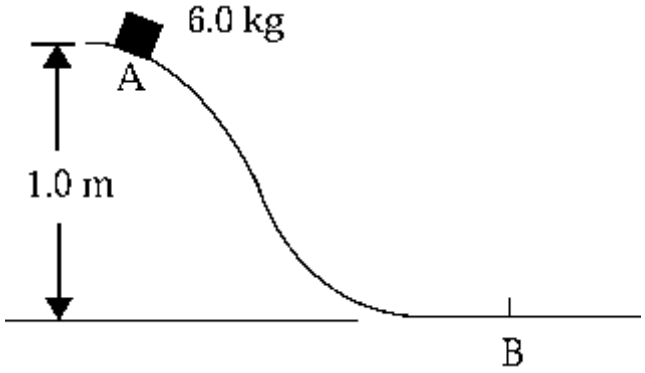
22. The human heart is essentially a pump for moving blood around the body. If its average power output (over many beats) is about 2.0 W and it pumps blood at an overall average speed of 0.3 m/s into the output aorta channel, calculate the average force with which the heart moves the blood into the aorta.

A) 0.60 N
B) 6.7 N
C) 22 N
D) 66 N
E) 0.18 N

23. What is the power output needed from a motor to lift, in the absence of friction, a mass of 1.5×10^4 kg 25 m in 6.0 s at constant speed?

A) 2.0×10^6 W
B) 6.1×10^5 W
C) 2.2×10^4 W
D) 8.3×10^5 W
E) 3.1×10^5 W

24.



A 6.0-kg block slides from rest at position A down a frictionless incline to position B. The speed of the block at B is

A) 3.1 m/s
B) 4.4 m/s
C) 11 m/s
D) 1.8 m/s
E) 20 m/s

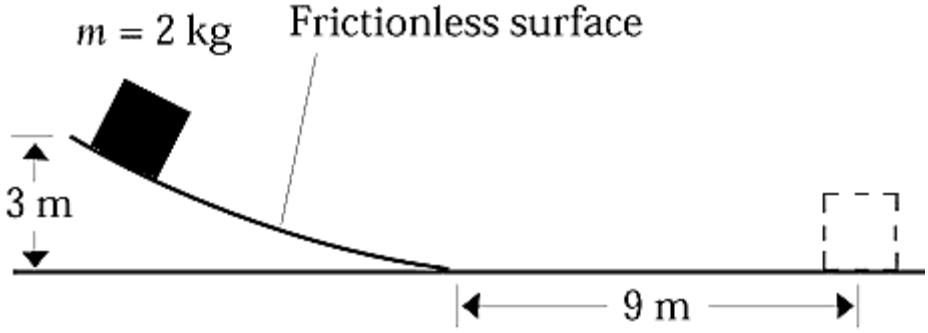
25. The rest mass of an electron is 9.11×10^{-31} kg. From this information one can conclude that the rest energy of an electron is

A) 8.20×10^{-14} MeV
B) 0.512 MeV
C) 2.73×10^{-22} J
D) 0.00171 MeV
E) 0.171 MeV

26. A woman on a bicycle traveling at 10 m/s on a horizontal road stops pedaling as she starts up a hill inclined at 3.0º to the horizontal. If friction forces are ignored, how far up the hill does she travel before stopping?

A) 5.1 m
B) 30 m
C) 97 m
D) 10 m
E) The answer depends on the mass of the woman.

27.

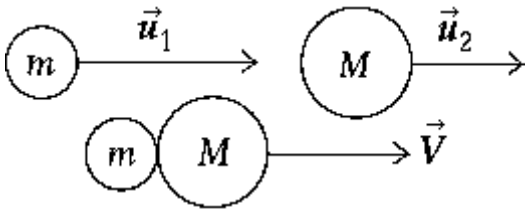


The block shown in the figure is sliding on a frictionless surface. Its speed when it reaches the level portion of the surface on which it is sliding will be

A) 3.14 m/s
B) 7.67 m/s
C) 9.81 m/s
D) 13.3 m/s
E) None of these is correct.

28. When a hydrogen atom absorbs a photon with E = 4.089×10^{-19} J, what is the frequency of the photon?
    A) 6.17×10^{14} Hz
    B) 2.45×10^{18} Hz
    C) 2.55×10^{8} Hz
    D) 6.623×10^{34} Hz
    E) None of these is correct.

29. An 1810-kg truck traveling eastward at 64.4 km/h collides at an intersection with a 905-kg automobile traveling northward at 96.5 km/h. The vehicles lock together and immediately after the collision are headed in which direction?
    A) 30° N of E
    B) 37° N of E
    C) 45° N of E
    D) 53° N of E
    E) 67° N of E

30. 

$m < M$

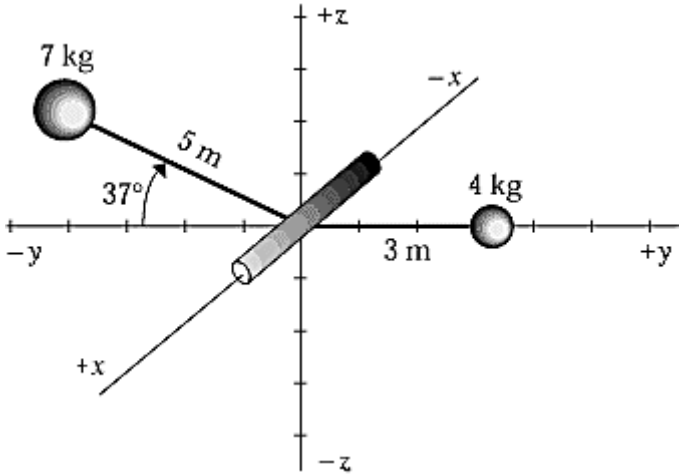
$\vec{u}_2 < \vec{V} < \vec{u}_1$

A ball of mass *m* and velocity $\vec{u}_1$ collides with and sticks to a ball of mass *M* and velocity $\vec{u}_2$. If the pair moves on with velocity $\vec{V}$, the impulse given the ball of mass *m* during the collision must have been
    A) $m(\vec{V} - \vec{u}_1)$
    B) $m(\vec{V} + \vec{u}_1)$
    C) $(m + M)\vec{V}$
    D) $(m + M)(\vec{V} - \vec{u}_2)$
    E) zero

31. A particle with speed $v_1 = 2.64 \times 10^6$ m/s makes a glancing elastic collision with another particle that is at rest. Both particles have the same mass. After the collision, the struck particle moves off at 45° to v_1. The speed of the struck particle after the collision is approximately
    A) 3.4×10^6 m/s
    B) 1.3×10^6 m/s
    C) 0.53×10^6 m/s
    D) 1.9×10^6 m/s
    E) 6.4×10^6 m/s

32. A toy car of mass 2.0 kg moving to the right with a speed of 8.0 m/s collides perfectly inelastically with another toy car of mass 3.0 kg that is moving to the left with a speed of 2.0 m/s. Immediately after the collision the velocity of the system is
A) 4.4 m/s to the right.
B) 2.0 m/s to the right.
C) 0 m/s
D) –2.0 m/s to the right.
E) 10 m/s to the right.

33. A 7-kg mass and a 4-kg mass are mounted on a spindle that is free to turn about the *x* axis as shown. Assume the mass of the arms and the spindle to be negligible. If the system is free to rotate and is released from rest, there will initially be a resultant torque in which of the following directions?



A) *z*
B) *–z*
C) *y*
D) *–x*
E) *x*

34. A disc with moment of inertia $I_1 = 40$ kg·m^2 and angular velocity $\omega_1 = 20$ rad/s is dropped on to a stationary second disc along the axis of rotation. The second disc has moment of inertia $I_2 = 60$ kg·m^2. How much rotational kinetic energy is lost?
A) 3200 J
B) 4800 J
C) 8000 J
D) 11300 J
E) 15000 J

35. The angular momentum of a flywheel about its axis is 925 kg · m^2/s. If its moment of inertia about the same axis is 2.50 kg · m^2, its angular velocity is
A) 370 rev/min
B) 62 rev/min
C) 36 rev/min
D) 2210 rad/s
E) 370 rad/s

36. Two wheels with identical moments of inertia are rotating about the same axle. The first is rotating clockwise at 2.0 rad/s, and the second is rotating counterclockwise at 6.0 rad/s. If the two wheels are brought into contact so that they rotate together, their final angular velocity will be
A) 2.0 rad/s, counterclockwise.
B) 3.0 rad/s, clockwise.
C) 4.0 rad/s, counterclockwise.
D) 5.0 rad/s, clockwise.
E) 6.0 rad/s, clockwise.

37. If the mass of a planet is doubled with no increase in its size, the escape speed for that planet is
A) increased by a factor of 1.4.
B) increased by a factor of 2.
C) not changed.
D) reduced by a factor of 1.4.
E) reduced by a factor of 2.

38. What is the escape speed from the sun, beginning (from rest relative to the sun) at the orbit of Earth, $R = 1.50 \times 10^8$ km. (Given: $G = 6.67 \times 10^{-11}$ N · m^2/kg^2; mass of the sun $= 2.0 \times 10^{30}$ kg.)
A) 3.0×10^4 m/s
B) 2.1×10^4 m/s
C) 1.3×10^6 m/s
D) 9.4×10^5 m/s
E) 4.2×10^4 m/s

39. According to Newton's law of universal gravitation, if the distance between two bodies is tripled, the gravitational force between them is
A) unchanged.
B) halved.
C) doubled.
D) reduced to 1/3 its previous value.
E) None of these is correct.

40. A satellite with a mass m is in a stable circular orbit about a planet with a mass M. The universal gravitational constant is G. The radius of the orbit is R. The ratio of the potential energy of the satellite to its kinetic energy is
A) $-2R$
B) $+2G$
C) $-2G/R$
D) -2
E) $2G/R$

41. The fundamental physical quantities are
A) mass, length, time, temperature, amount of a substance, current, and luminous intensity.
B) weight, length, time, temperature, amount of a substance, current, and luminous intensity.
C) mass, length, time, temperature, force, current, and luminous intensity.
D) mass, length, time, force, momentum, amount of a substance, and current.
E) weight, length, time, temperature, amount of a substance, potential energy, and luminous intensity.

42. The components of a vector

A) are not unique.
B) depend on the axes chosen.
C) can have one of the components equal to zero.
D) can be negative.
E) All of the above.

43. Evaluate:

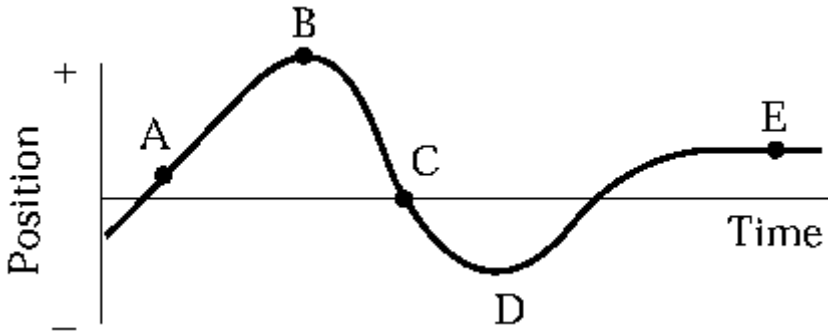
$$\frac{(2\pi \times 10^3)(3.0 \times 10^7)}{(4.2 \times 10^5)^2}$$

A) 1.1×10^5
B) 1.7×10^{-4}
C) 3.6×10^{-8}
D) 4.5×10^5
E) 1.1

44. In doing a calculation, you arrive at an expression in which the numerator is in kilometers and the denominator is in meters per second. When the calculation is completed, the result will be in units of
A) meters, if you divide by 1000.
B) meters, if you multiply by 1000.
C) seconds, if you divide by 1000.
D) seconds, if you multiply by 1000.
E) meters squared per second, if you multiply by 1000.

45. A particle moves from $x_1 = -50$ cm to $x_2 = 30$ cm. The displacement of this particle is
A) –50 cm
B) 30 cm
C) 80 cm
D) –30 cm
E) –80 cm

46.



An object moves along the *x* axis as shown in the diagram. At which point or points is the object instantaneously at rest?
A) A and E
B) B, D, and E
C) C only
D) E only
E) None of these is correct.

47. A Lamborghini sports car can accelerate from zero to 60 mph in 4 seconds. It can decelerate from 60 mph to rest in 120 ft. What is the ratio of average acceleration over average deceleration? (1 mile = 5280 ft)

A) 1.74×10^{-5}
B) 1.47
C) 0.682
D) 0.0114
E) 0.688

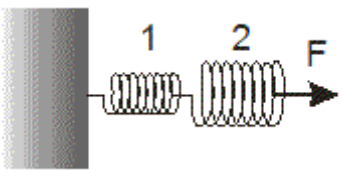
48. The relationship between the velocity of a body moving along the *x* axis and time is given by $v = 3t^2 - 2t$, where the units are SI units. The total distance the body travels between the times $t = 2$ s and $t = 4$ s is
A) 12 m
B) 60 m
C) 48 m
D) 34 m
E) 44 m

49. A ball is whirled in a horizontal circle of radius r and speed v. The radius is increased to 2r keeping the speed of the ball constant. The period of the ball changes by a factor of
A) Half
B) One
C) Two
D) Three
E) Four

50. A car is at position $(x_1, y_1) = (4\text{ m}, 5\text{ m})$ at time $t_1 = 1$ s. If 10 seconds later the car moving in a straight line is at position $(x_2, y_2) = (204\text{ m}, 305\text{ m})$, find the (size of the) component of the average velocity along the *x*-axis.
A) 30.0 m/s
B) 36.1 m/s
C) 20.0 m/s
D) 18.2 m/s
E) 22.2 m/s

51. The initial path of a rocket is 30º above the horizontal, and the horizontal component of the rocket's velocity is 326 m/s. The initial vertical component of the rocket's velocity is
A) 188 m/s
B) 330 m/s
C) 380 m/s
D) 280 m/s
E) 250 m/s

52. Two springs with different spring constants, k_1 and k_2, are connected as shown in the figure below.



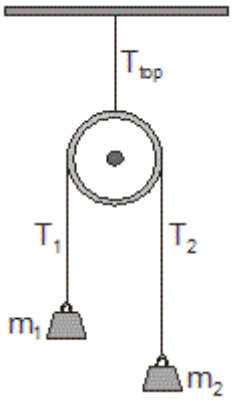
A force F is applied to one end. The force exerted by the wall on the spring is (take + to the right)
A) 0
B) $-k_1 \Delta x_1$
C) $-k_2 \Delta x_2$
D) F
E) -F

53. Three forces, $\vec{X}$, $\vec{Y}$, and $\vec{Z}$, act on a mass of 4.2 kg. The forces are

$\vec{X}$ = 2.0 N acting to the east,
$\vec{Y}$ = 5.0 N acting 45º to the north of east, and
$\vec{Z}$ = 4.0 N acting 30º to the north of west.

The magnitude of the net acceleration of the mass is
A) 2.9 m/s^2
B) 5.3 m/s^2
C) 1.4 m/s^2
D) 0.0 m/s^2
E) 18 m/s^2

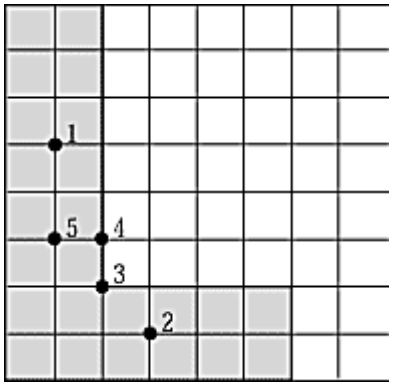
54. A frictionless pulley of negligible mass is hung from the ceiling using a rope, also of negligible mass. Two masses, m_1 and m_2 ($m_1 < m_2$) are connected to the rope over the pulley. The masses are free to drop. The magnitude of the tension T_{top} is ____ the sum of the weights $W_1 = m_1g$ and $W_2 = m_2g$.



A) less than
B) equal to
C) greater than
D) unable to tell
E) depends on T_1 and T_2.

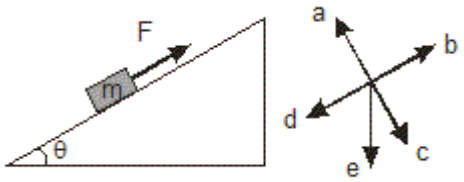
55. Spiral springs A and B are identical. When a weight of 12 N is fastened to the hook on A, the hook is lowered 2 cm. If a weight of 18 N is fastened to the hook on B, that hook is lowered
A) 8 cm
B) 6 cm
C) 3 cm
D) 4 cm
E) 5 cm

56. An L-shaped piece, represented by the shaded area on the figure, is cut from a metal plate of uniform thickness. The point that corresponds to the center of mass of the L-shaped piece is



A) 1
B) 2
C) 3
D) 4
E) 5

57. A mass m is placed on a rough incline at an angle θ to the horizon. A force F is applied up the incline, to prevent the mass from sliding down the incline, and it is just enough to prevent the mass from sliding down the incline. Using the compass rose, the direction of the frictional force is along



A) (a)
B) (b)
C) (c)
D) (d)
E) (e)

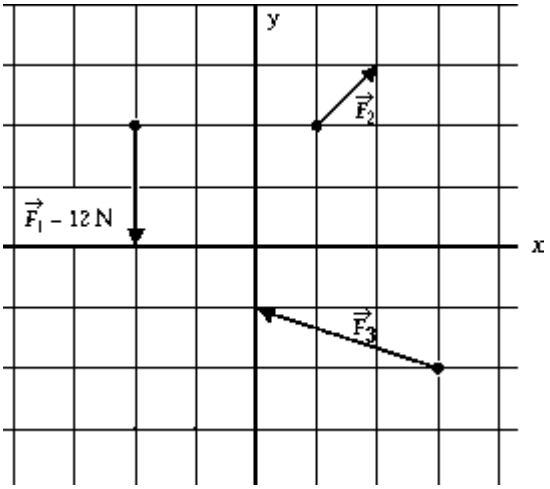
58. A particle is moving uniformly in a circle with radius 50 cm. The linear speed of the particle is 60 cm/s. The acceleration of the particle has a magnitude of

A) Zero
B) 36 m/s^2
C) 1.8×10^5 cm/s^2
D) 72 cm/s^2
E) 3.6 m/s^2

59. Which of the following statements is NOT true about friction?

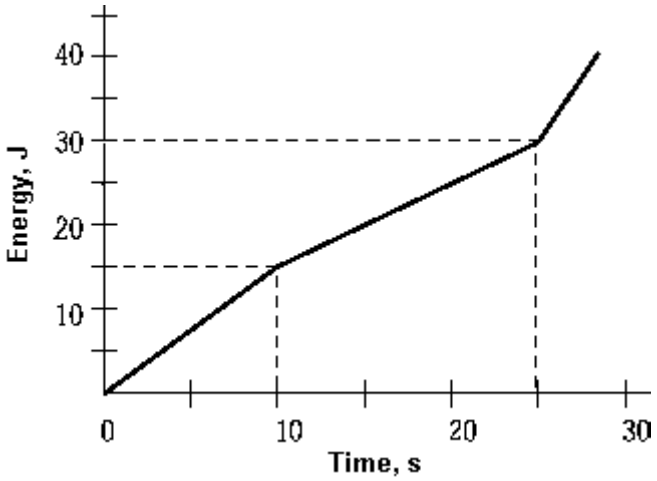
A) μ_k is less than μ_s
B) μ_k is independent of the relative speed of the surfaces in the range of about 1 cm/s to several meters per second.
C) μ_k depends on the relative speed of the surfaces at speeds over several meters per second.
D) The coefficients of friction depend on the nature of the surfaces.
E) The force of static friction depends on the area of contact between the two surfaces.

60. Three particles having a total mass of 6 kg are subjected to three forces, as shown in the figure. The magnitude of one force is presented to furnish the scale factor for the others. What is the acceleration of the center of mass of the system?



A) It is knowable only if the mass of each particle is given.
B) 6.6 m/s^2
C) Zero
D) –2 m/s^2 $\hat{j}$
E) –2 m/s^2 $\hat{i}$

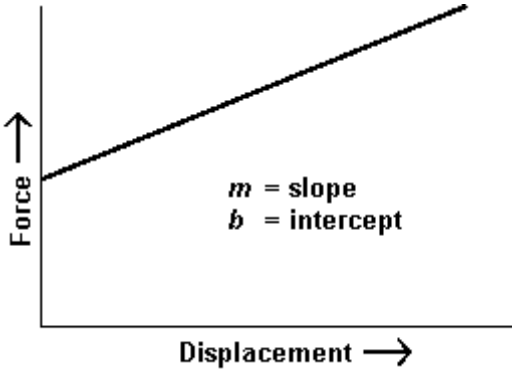
61.



An electrical appliance expends energy as shown in the graph. The power developed in the appliance between *t* = 15 s and *t* = 25 s is
A) 0.34 kW
B) 0.11 kW
C) 20 W
D) 1.3 kW
E) 1.0 W

62. A 5-kg object undergoes a displacement $\Delta\vec{s} = 2\hat{i} + 3\hat{j}$. During the displacement, a constant force $\vec{F} = 4\hat{i} - 2\hat{j}$ acts on the object. All values are given in SI units. The work done by the force $\vec{F}$ on this object is
A) 8 J
B) –6 J
C) 2 J
D) 14 J
E) –2 J

63.



The graph represents the force acting on a body plotted against the displacement of the body in the direction of the force. The total work done by the force from $x = 0$ to $x = x$ is

A) M
B) $mx^2 + b$
C) $\frac{1}{2} \cdot mx^2 + b$
D) $mx + b$
E) $\frac{1}{2} \cdot mx^2 + bx$

64. The weight of an object on the moon is one-sixth its weight on Earth. A body moving with a given speed on the moon has kinetic energy equal to _____ it would have if it were moving at the same speed on Earth.

A) the kinetic energy
B) 1/36 the kinetic energy
C) 1/6 the kinetic energy
D) 6 times the kinetic energy
E) 36 times the kinetic energy

65. Susana ascends a mountain via a short, steep trail. Sean ascends the same mountain via a long, gentle trail. Which of the following statements is true?

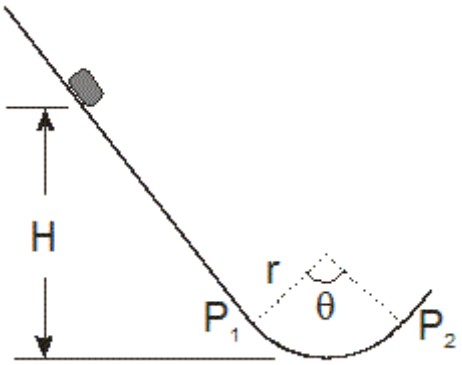
A) Susana gains more gravitational potential energy than Sean.
B) Susana gains less gravitational potential energy than Sean.
C) Susana gains the same gravitational potential energy as Sean.
D) To compare energies, we must know the height of the mountain.
E) To compare energies, we must know the lengths of the two trails.

66. A child is sitting on the seat of a swing with ropes 10 m long. Her father pulls the swing back until the ropes make a 37º angle with the vertical and then releases the swing. If air resistance is neglected, what is the speed of the child at the bottom of the arc of the swing when the ropes are vertical?

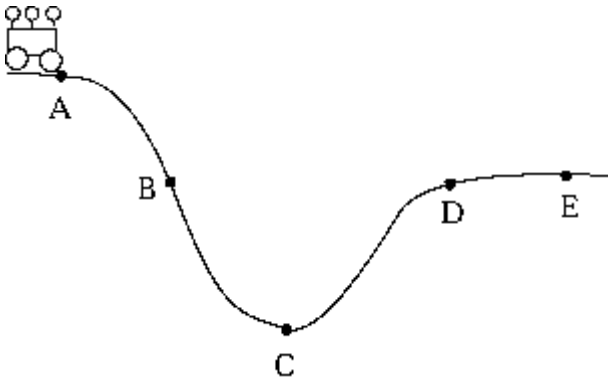
A) 11 m/s
B) 8.8 m/s
C) 14 m/s
D) 6.3 m/s
E) 12 m/s

Use the following to answer question 27:

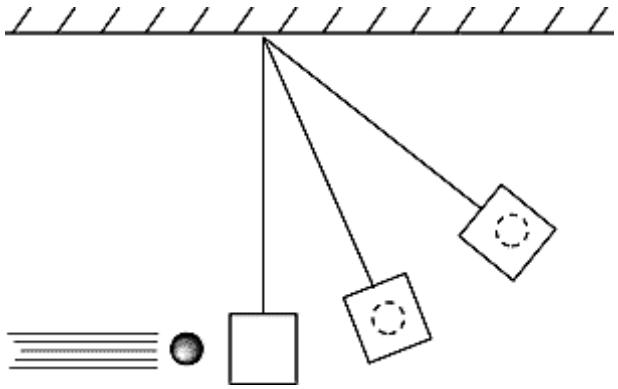
An object of mass m = 200 g slides down a frictionless ramp from a height H = 60 cm. Near the bottom of the ramp, the path changes into an arc of a circle with radius r = 20 cm. The arc has coefficient of kinetic friction $\mu_k = 0.4$. The angle $\theta = 120°$ and points P_1 and P_2 which are the ends of the arc, are at the same height.



67. What is the speed of the object at point P_1?
A) 1.1 m/s
B) 2.5 m/s
C) 3.1 m/s
D) 3.4 m/s
E) 4.1 m/s

68.


A roller coaster starts from rest at point A. If you ignore friction and take the zero of potential energy to be at C,
A) the kinetic energy of the coaster at D will be equal to its potential energy at A.
B) the kinetic energy of the coaster at E will be equal to its potential energy at C.
C) the kinetic energy of the coaster at C will be equal to its potential energy at B.
D) the kinetic energy of the coaster at B will be equal to its potential energy at C.
E) None of these is correct.

69.


The figure shows a ballistic pendulum in three states. The system (considered to be the ball and the pendulum) will move in such a way that
A) the kinetic energy is conserved during the collision.
B) the linear momentum is conserved after the collision.
C) the linear momentum is not conserved during the collision.
D) the total mechanical energy is conserved during the collision.
E) the total mechanical energy is conserved after the collision.

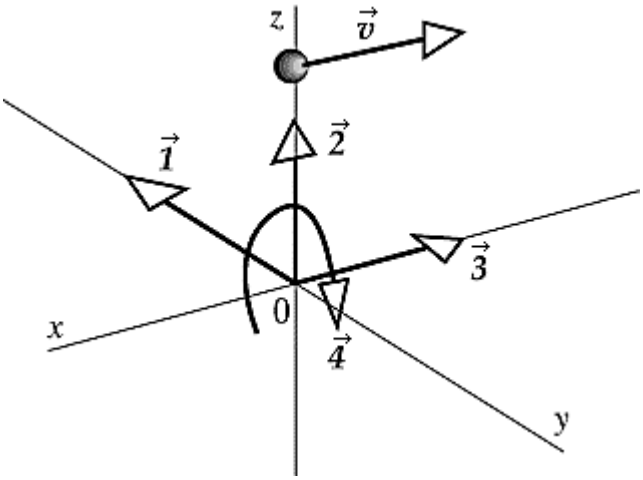
70. You shoot an arrow with a mass of 0.54 kg at 45º above the horizontal. The bow exerts a force of 125 N for 0.65 s. With no air resistance, the maximum height the arrow reaches is
A) 1.2 km
B) 5.4 m
C) 0.57 km
D) 0.29 km
E) 0.61 km

71. A particle with speed $v_1 = 2.64 \times 10^6$ m/s makes a glancing elastic collision with another particle that is at rest. Both particles have the same mass. After the collision, the struck particle moves off at 45º to v_1. The speed of the struck particle after the collision is approximately
A) 3.4×10^6 m/s
B) 1.3×10^6 m/s
C) 0.53×10^6 m/s
D) 1.9×10^6 m/s
E) 6.4×10^6 m/s

72. A 7000-kg coal car of a train coasts at 7.0 m/s on a frictionless track when a 3000-kg load of coal is dropped vertically onto the car. The coal car's speed after the coal is added is
A) 2.1 m/s
B) 3.0 m/s
C) 4.9 m/s
D) 7.0 m/s
E) 16 m/s

73. A disc with moment of inertia $I_1 = 40$ kg·m^2 and angular velocity $\omega_1 = 20$ rad/s is dropped on to a stationary second disc along the axis of rotation. The second disc has moment of inertia $I_2 = 60$ kg·m^2. What is the angular velocity of the two discs?
A) 4 rad/s
B) 6 rad/s
C) 8 rad/s
D) 12 rad/s
E) 20 rad/s

74. As a particle with a velocity $\vec{v}$ in the negative *x* direction passes through the point (0, 0, 1), it has an angular velocity relative to the origin that is best represented by vector

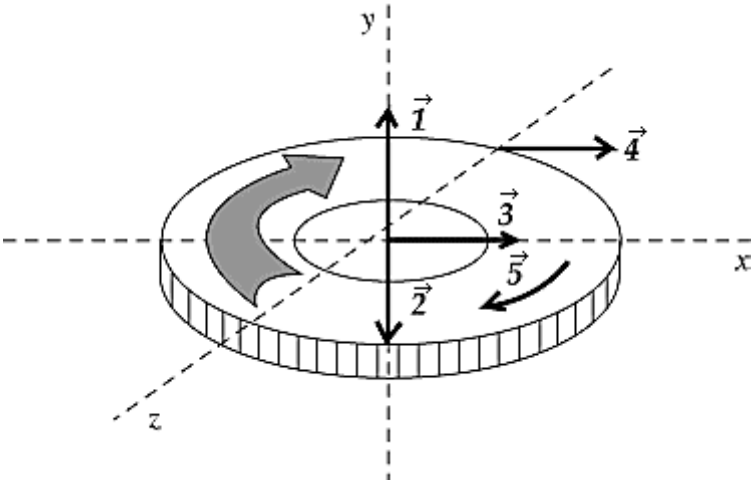


A) $\vec{1}$
B) $\vec{2}$
C) $\vec{3}$

D) $\vec{4}$
E) Zero

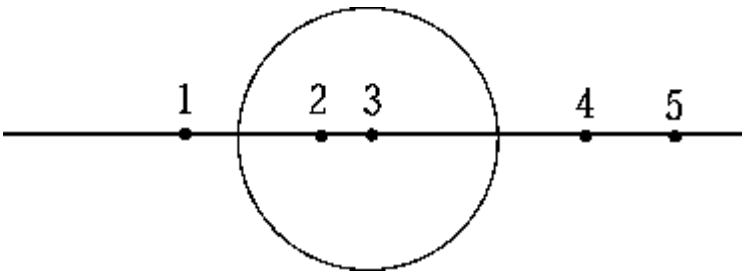
75. Let us compare the angular momentum of Mars (L_M) in its orbit around the Sun to that of Earth (L_E). The mean orbital speed of Mars is 24 km/s, whereas that of Earth is 30 km/s. The mean orbital radius of Mars is 228×10^6 km, whereas that of Earth is 150×10^6 km. If the mass of Mars is 11% that of Earth, calculate the ratio L_M / L_E.
A) 0.21
B) 0.090
C) 7.7
D) 11
E) 0.13

76. A phonograph turntable in the *xz* plane is rotating clockwise as viewed from above. The vector that represents the torque with which the motor turns the table is



A) $\vec{1}$
B) $\vec{2}$
C) $\vec{3}$
D) $\vec{4}$
E) $\vec{5}$

77.



Test masses are used to measure the gravitational field at various positions in and near a *solid sphere of uniform density.* The gravitational field will have its least value at point
A) 1
B) 2
C) 3
D) 4
E) 5

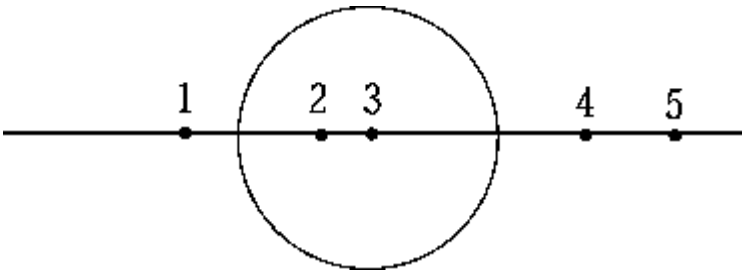
78. A certain object weighs 22.2 N on the surface of Earth. If the radius of the moon is 0.276 times the radius of Earth and the mass of the moon is 0.0123 times the mass of Earth, the object's weight on the surface of the moon is approximately
A) 0.365 N
B) 3.58 N
C) 9.79 N

D) 22.2 N
E) 133 N

79. A satellite of 1000 kg is in a circular orbit at a height of R_E above the surface of Earth. Calculate the minimum energy required to put such a satellite into this orbit. ($R_E = 6.38 \times 10^6$ m, $M_E = 5.98 \times 10^{24}$ kg, $G = 6.67 \times 10^{-11}$ N·m^2/kg^2)
A) 3.13×10^{10} J
B) 8.34×10^{10} J
C) 4.69×10^{10} J
D) 6.25×10^{10} J
E) 1.56×10^{10} J

80. The acceleration due to gravity at the surface of Earth is *g*. The radius of Earth is R_E. The distance from the center of Earth to a point where the acceleration due to gravity is *g*/9 is
A) R_E
B) $9R_E$
C) $R_E/3$
D) $3R_E$
E) None of these is correct.

81.



Test masses are used to measure the gravitational field at various positions in and near a *solid sphere of uniform density*. The gravitational field will have its greatest value at point
A) 1
B) 2
C) 3
D) 4
E) 5

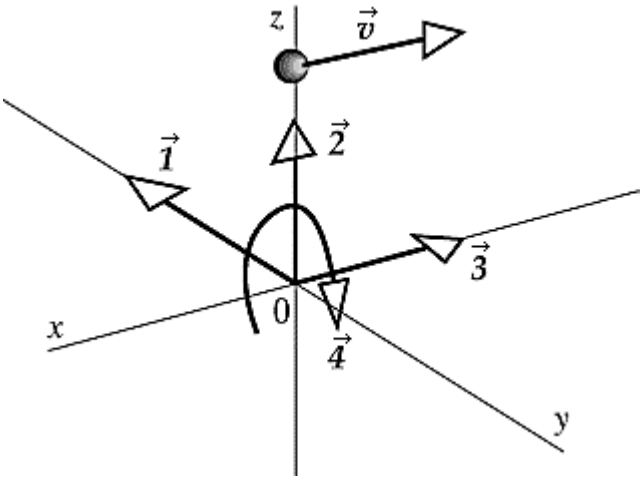
82. What is the force of gravity between the proton and electron in a hydrogen atom, given that $G = 6.67 \times 10^{-11}$ N·m^2/kg^2, mass of a proton = 1.67×10^{-27} kg, mass of an electron = 9.1×10^{-31} kg, and average radius of the electron's orbit in the hydrogen atom = 0.0529 nm?
A) 1.9×10^{-57} N
B) 1.9×10^{-54} N
C) 3.6×10^{-53} N
D) 3.6×10^{-47} N
E) 3.6×10^{-41} N

83. The moon has a period of 27.3 d and is an average distance from Earth of 3.84×10^5km. A communications satellite is placed in an Earth orbit at 4.23×10^4 km from the center of Earth. What is the period of this satellite?
A) 0.87 h
B) 1.0 d
C) 3.0 d
D) 6.3 d
E) 8.0 h

84. In the absence of air resistance, the least speed with which a body must be projected vertically upward from Earth's surface ($m_e = 5.99 \times 10^{24}$ kg, $r_e = 6.37 \times 10^6$ m) if it is to reach an altitude of 800 km is
A) ~1.39×10^7 m/s
B) ~3.73×10^3 m/s
C) ~1.57×10^7 m/s
D) ~3.96×10^3 m/s
E) None of these is correct.

85. Spin $-\frac{1}{2}$ particles
A) are called bosons.
B) have spin angular momenta that can be changed by applying a net torque to them.
C) can have angular momenta that change continuously from one value to another.
D) can very accurately be thought of as spinning spheres.
E) are described by none of the above.

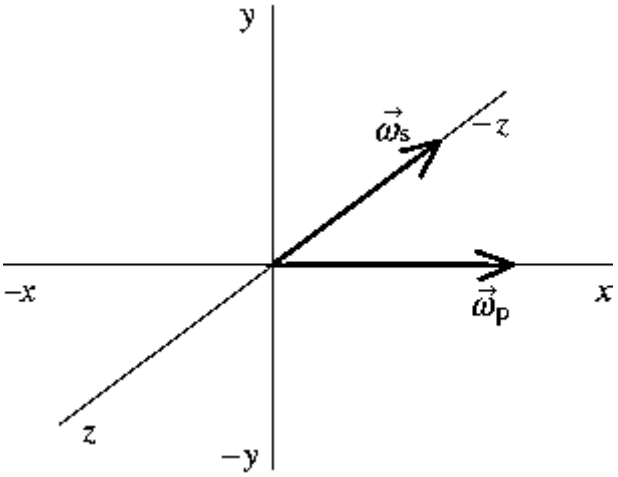
86. As a particle with a velocity $\vec{v}$ in the negative *x* direction passes through the point (0, 0, 1), it has an angular velocity relative to the origin that is best represented by vector



A) $\vec{1}$
B) $\vec{2}$
C) $\vec{3}$
D) $\vec{4}$
E) zero

87. Which of the following statements is true?
A) Stable matter consists of electrons, protons, and neutrons.
B) Electrons, protons, and neutrons have an intrinsic angular momentum that is called spin.
C) Bosons have zero spin or integral spin.
D) The spin angular momentum of a particle is a fundamental property of the particle and as such cannot be changed.
E) All of these are correct.

88. The figure shows vectors representing the angular velocity of precession ω_p and the spin velocity ω_s. The associated torque vector points along which of the axes?

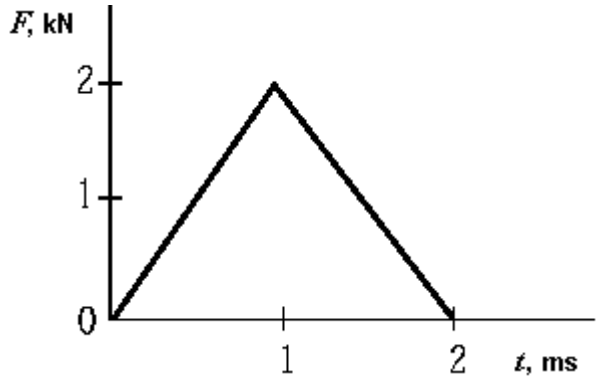


A) $-x$
B) y
C) z
D) $-z$
E) None of these is correct.

89. Water is fired horizontally out of a 7-cm diameter hose directly onto a wall at a speed of 7m/s. Assuming that the water after impact falls straight down the wall, the average force on the wall is (density of water = 1000 kg/m^3)
A) 27 N
B) 190 N
C) 47 N
D) 60 N
E) 94 N

90. Two particles, each of mass m, are moving with velocity $-\vec{v}$ and $2\vec{v}$. The kinetic energy at the center-of-mass is
A) $\frac{1}{2}$ mv^2
B) mv^2
C) $\frac{1}{2}$ mv^2
D) 2mv^2
E) 4mv^2

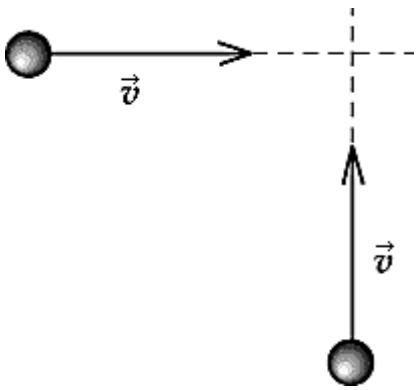
91.



Using a mallet, you strike a ball of mass 0.50 kg that is initially at rest. The force F on the ball as a function of time is plotted in the figure. At t = 2.0 ms, the speed of the ball is

A) 10 m/s
B) 8.0 m/s
C) 6.0 m/s
D) 4.0 m/s
E) 2.0 m/s

92.



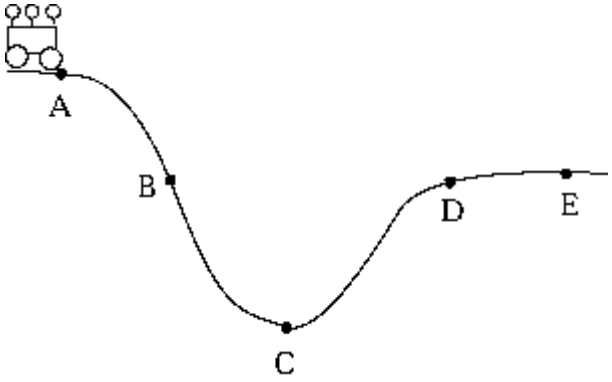
Two identical bodies of mass M move with equal speeds v. The direction of their velocities is illustrated above. The magnitude of the linear momentum of the system is

A) $2Mv$
B) Mv
C) $4Mv$
D) $\sqrt{2}\,Mv$
E) $4\sqrt{2}\,Mv$

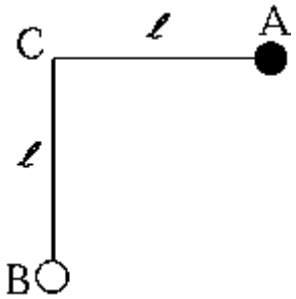
93. When a hydrogen atom absorbs a photon with E = 4.089×10^{-19} J, what is the frequency of the photon?

A) 6.17×10^{14} Hz
B) 2.45×10^{18} Hz
C) 2.55×10^{8} Hz
D) 6.623×10^{34} Hz
E) None of these is correct.

94. If you drive at the posted speed limit of 70 mph on the interstate, what is the fraction of your speed compared to the speed of light?
A) 6.48×10^{-8}
B) 1.04×10^{-7}
C) 2.33×10^{-7}
D) 3.73×10^{-7}
E) None of these is correct.

95.


A roller coaster starts from rest at point A. If you ignore friction and take the zero of potential energy to be at C,
A) the kinetic energy of the coaster at D will be equal to its potential energy at A.
B) the kinetic energy of the coaster at E will be equal to its potential energy at C.
C) the kinetic energy of the coaster at C will be equal to its potential energy at B.
D) the kinetic energy of the coaster at B will be equal to its potential energy at C.
E) None of these is correct.

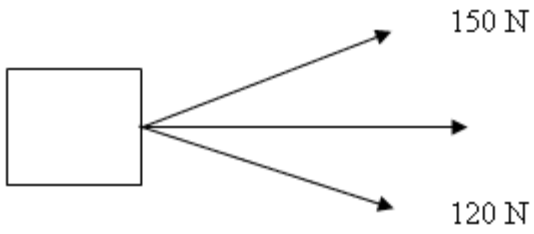
96.


A simple pendulum has a bob of mass *M*. The bob is on a light string of length ℓ. The string is fixed at C. At position A, the string is horizontal and the bob is at rest. The bob is released from A and swings to B, where the string is vertical. The tension in the string when the bob first reaches B is
A) $\dfrac{M\sqrt{\ell / g}}{2\pi}$
B) $2Mg$
C) $Mg\ell$
D) Mg
E) None of these is correct.

97. If the average power output of a car engine is the same as a 100-W light bulb, how long would it take a 1200-kg car to go from zero to 96 km/h (60 mph)?
A) 8.5×10^3 s
B) 5.5×10^4 s
C) 65 s
D) 160 s
E) 4.3×10^3 s

98. A donkey is attached by a rope to a wooden cart at an angle of 23° to the horizontal. The tension in the rope is 210 N. If the cart is dragged horizontally along the floor with a constant speed of 6 km/h, calculate how much work the donkey does in 35 minutes.
A) 740 kJ
B) 290 kJ
C) 680 kJ
D) 11 kJ
E) 0.70 kJ

99.



Two parents moving into a new house attempt to pull a large crate down a large hallway. One parent applies a force of magnitude 150 N directed 45 degrees to the direction of motion, while the other parent applies a force of 120 N on the other side of the direction of motion. If they move the crate 15 m and perform work at 2.6 kJ, at what angle to the direction of motion did the second parent pull on the crate?
A) 54 degrees
B) 30 degrees
C) 60 degrees
D) 34 degrees
E) 56 degrees

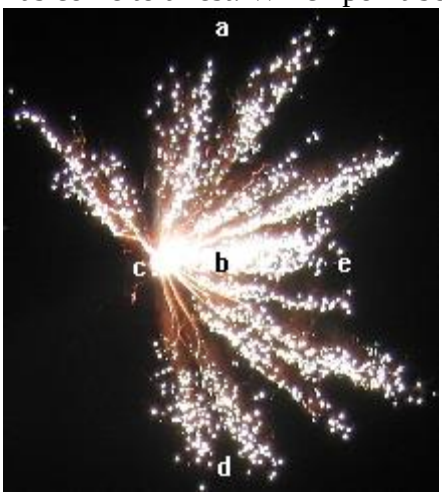
100. Power P is required to lift a body a distance d at a constant speed v. What power is required to lift the body a distance $2d$ at constant speed $3v$?
A) P
B) $2P$
C) $3P$
D) $6P$
E) $3P/2$

101. In the equation $F = bv$, F is the force on an object that is moving in a viscous medium, b is a constant, and v is the speed of the falling object. The SI units of the constant b are
A) m/s
B) kg · s
C) kg/s
D) kg · m
E) m/s^2

102. A horizontal force $\vec{F}$ acts on a mass *m* that lies on a horizontal surface. The acceleration of *m* is $\vec{a}$. The coefficient of kinetic friction μ_k between mass *m* and the surface can be calculated from

A) $\mu_k = a/g$
B) $\mu_k = (F/mg) - (a/g)$
C) $\mu_k = (F/mg) + (a/g)$
D) $\mu_k = 0$
E) None of these is correct.

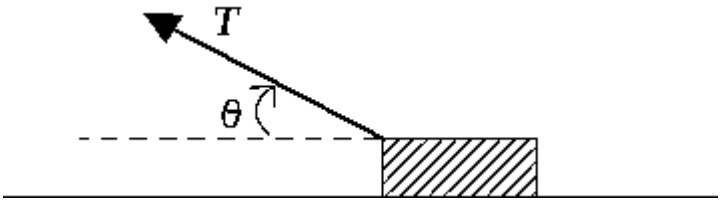
103. The picture below shows an exploding firework high up in the air, just after the firework has come to a rest. Which point best describe the center of mass of the explosion?



Picture by H.K. Ng

A) a
B) b
C) c
D) d
E) e

104. A block of mass *m* is pulled in the direction shown in the figure across a rough surface with a constant acceleration $\vec{a}$. The magnitude of the frictional force is



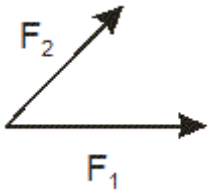
A) $\mu_k mg$
B) $T \cos\theta - ma$
C) $\mu_k(T - mg)$
D) $\mu_k T \sin\theta$
E) $\mu_k(mg + \sin\theta)$

105. The concept of a *field*

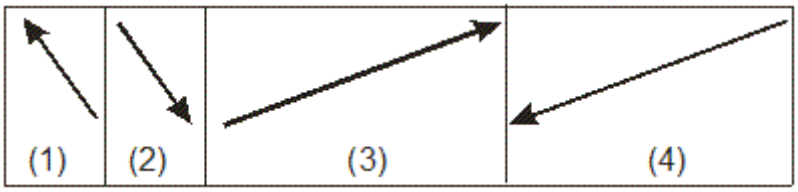
A) provides us with a way to understand how a body's presence is known over great distances.
B) is a useful alternative to action at a distance for explaining gravitational forces.
C) is that of space distorted by the presence of an object.
D) is useful in describing electromagnetic interactions as well as gravitational interactions.
E) is described by all of these.

Use the following to answer question 26:

The figure below shows two forces, F_1 and F_2, acting on an object.



Use the vector diagrams to answer the question(s) below.



106. Which force vector best represents the resultant force on the object?
A) (1)
B) (2)
C) (3)
D) (4)
E) none of the vectors

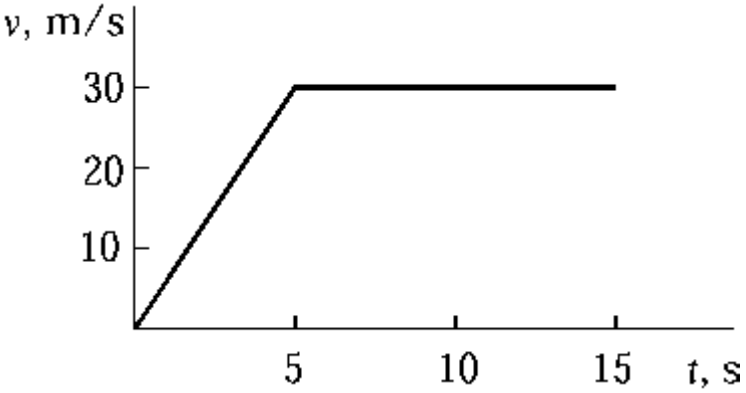
107. The weight of an object is
A) the same as the mass of the object.
B) the quantity of matter in the object.
C) the mass of the object multiplied by the acceleration due to gravity at sea level, regardless of where the object is located.
D) the result of the gravitational force acting on the object.
E) the reading on a spring scale attached to the object.

108. If a force *F* is required to extend a spring a distance 5*y*, how far will it be extended by force 3*F*?
A) 5*y*
B) (3/5)*y*
C) (5/3)*y*
D) 15*y*
E) (3/8)*y*

109. A vehicle is traveling in the +x direction to x = 100 m. It then reverses direction. At the instant when it changes direction, the acceleration of the vehicle is
A) positive.
B) negative.
C) zero.
D) positive then negative.
E) negative then positive.

110. The displacement of an object for a round trip between two locations
A) is always greater than zero.
B) is always less than zero.
C) is zero.
D) can be greater than or less than but not equal to zero.
E) can have any value.

111.



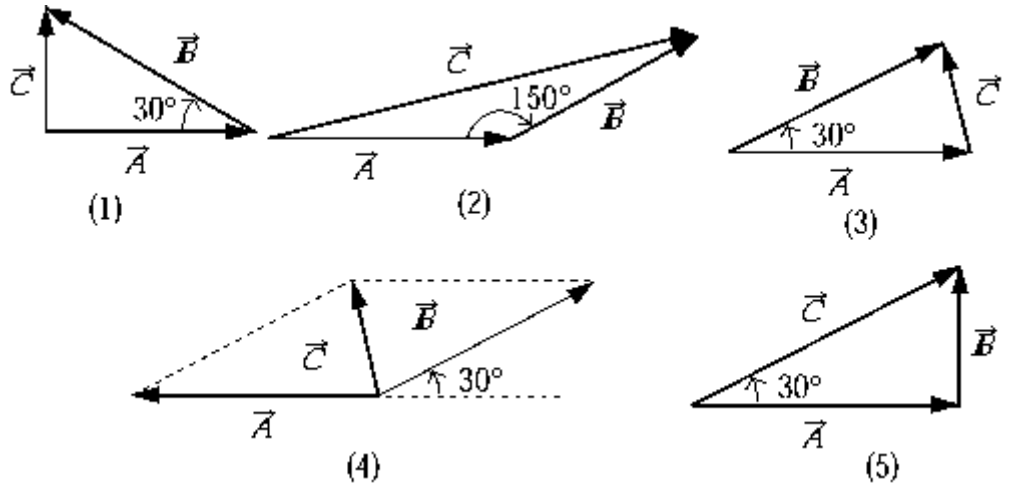
The graph shows the instantaneous velocity of a car during 15 s of its motion. The distance traveled by this car during this 15-s interval is
A) 30 m
B) 450 m
C) 300 m
D) 75 m
E) 375 m

112. A Lamborghini sports car can accelerate from zero to 60 mph in 4 seconds. It can decelerate from 60 mph to rest in 120 ft. What is the ratio of average acceleration over average deceleration? (1 mile = 5280 ft)
A) 1.74×10^{-5}
B) 1.47
C) 0.682
D) 0.0114
E) 0.688

113. If x and t represent position and time, respectively, the B in $x = A \cos Bt$ must
A) have the dimensions L/T.
B) have the dimensions $1/T$.
C) have the dimensions L.
D) have the dimensions L^2/T^2.
E) be dimensionless.

114. Compute:
$(12 \times 10^6 - 2 \times 10^7) / (-12 \times 10^7 + 7 \times 10^6)$
A) 7.1×10^{-2}
B) 7.0×10^6
C) 2.0×10^{-8}
D) -7.1×10^{-2}
E) 2×10^5

115. Estimate the number of raindrops needed to fill a volume of 1m × 1m × 1cm.
A) 10^3
B) 10^5
C) 10^7
D) 10^9
E) 10^{11}

116.


The angle between vectors $\vec{A}$ and $\vec{B}$ is 30º, and their sum is $\vec{C}$. Which vector diagram correctly describes the vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$?
A) 1
B) 2
C) 3
D) 4
E) 5

117. A projectile was fired at 35º above the horizontal. At the highest point in its trajectory its speed was 200 m/s. If air resistance is ignored, the initial velocity had a horizontal component of
A) zero
B) 200 cos (35º) m/s
C) 200 sin (35º) m/s
D) 200/cos (35º) m/s
E) 200 m/s

118. A river is 0.76 km wide. The banks are straight and parallel. The current is 5.0 km/h and is parallel to the banks. A boat has a maximum speed of 3 km/h in still water. The pilot of the boat wishes to travel on a straight line from A to B, where AB is perpendicular to the banks. The pilot should
A) head directly across the river.
B) head 68º upstream from the line AB.
C) head 22º upstream from the line AB.
D) give up. The trip from A to B is not possible with this boat.
E) do none of these.

119. The position vector locating the point $P(12,-5)$ relative to the origin is
A) $12\hat{i}+5\hat{j}$
B) $-5\hat{i}-12\hat{j}$
C) $5\hat{i}+12\hat{j}$
D) $12\hat{i}+5\hat{j}$
E) $13\hat{i}-13\hat{j}$

120. The maximum horizontal range of a rock which is thrown at the same speed but different angles with the horizon and which lands at a level, H, below the initial level occurs when the angle is
A less than 0°
)
B 0°
)
C greater than 0° and less than 45° (actual value depends on the value of H)
)
D 45°
)
E greater than 45°
)

121. Which of the following is a fundamental unit of the SI system of units?
A) kilometer
B) joule
C) kilogram
D) gram
E) newton

122. Which of the following prefixes does NOT represent a fractional part of a whole unit?
A) nano
B) micro
C) kilo
D) milli
E) deci

123. Compute:

$$\frac{(3\times10^{8})(8\times10^{4})}{(6\times10^{5})}$$

A) 1×10^{17}
B) 6×10^{7}
C) 8×10^{17}
D) 4×10^{7}
E) None of these is correct.

124. Which of the following prefixes does NOT represent a quantity larger than a single unit?
A) kilo
B) mega
C) giga
D) tera
E) femto

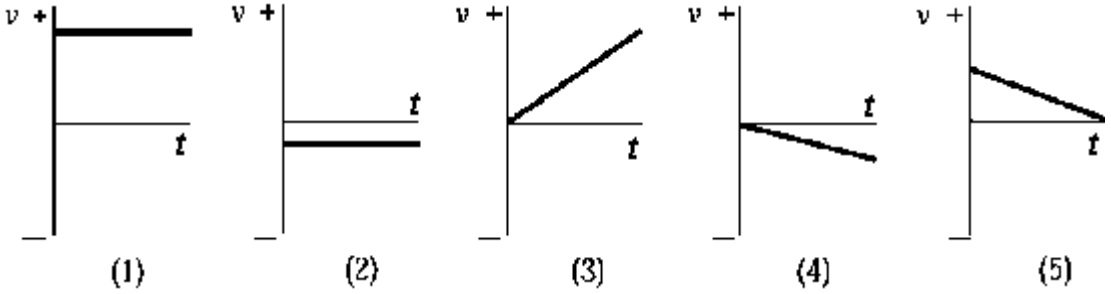
125. A particle moves from $x_1 = -50$ cm to $x_2 = 30$ cm. The displacement of this particle is
A) –50 cm

B) 30 cm
C) 80 cm
D) –30 cm
E) –80 cm

126. The relationship between the velocity of a body moving along the x axis and time is given by $v = 3t^2 - 2t$, where the units are SI units. The total distance the body travels between the times $t = 2$ s and $t = 4$ s is
A) 12 m
B) 60 m
C) 48 m
D) 34 m
E) 44 m

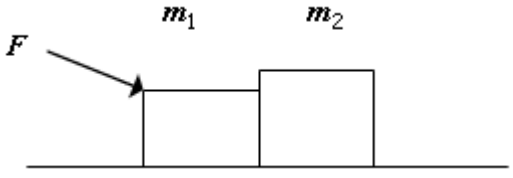
127. An object is thrown upward with a velocity of 32 ft/s from a stationary balloon which is 48 ft above the ground. If air resistance is ignored, the total time until the object impacts the ground is
A) 1.0 s
B) 2.0 s
C) 3.0 s
D) 4.0 s
E) 6.0 s

Use the following to answer question 8:



128. In which graph of v versus t does the particle end up farthest from its starting point?
A) 1
B) 2
C) 3
D) 4
E) 5

129. A force of $F = 90$ N is exerted on mass m_1 as shown. Both m_1 and m_2 accelerate to the right at 3 m/s^2 along the frictionless surface. The force F makes an angle of 25 degrees to the horizontal. Calculate the force that the horizontal surface exerts on mass m_1. (m_2 = 10 kg)



A) 2.5×10^2 N
B) 1.5×10^2 N
C) 82 N

D) 3.5×10^2 N
E) 2.1×10^2 N

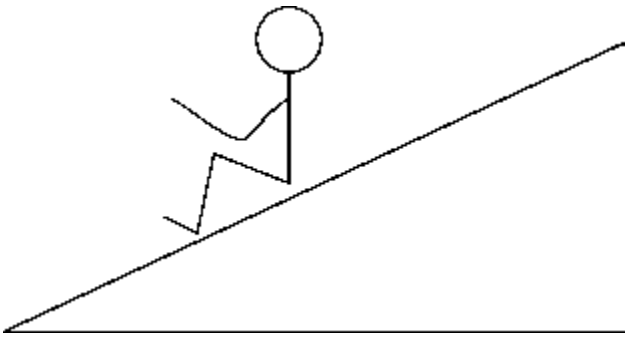
130. A large (15,000-kg) military helicopter lifts a 6000-kg truck straight up out of a danger zone with an acceleration of 4 m/s^2. Calculate the tension in the lifting cable.
A) 3.5×10^4 N
B) 8.3×10^4 N
C) 2.1×10^2 N
D) 5.9×10^4 N
E) 2.4×10^4 N

131. Which fundamental force holds the atoms together in a block of wood?
A) gravitational force
B) electromagnetic force
C) weak nuclear force
D) strong nuclear force
E) all the four forces

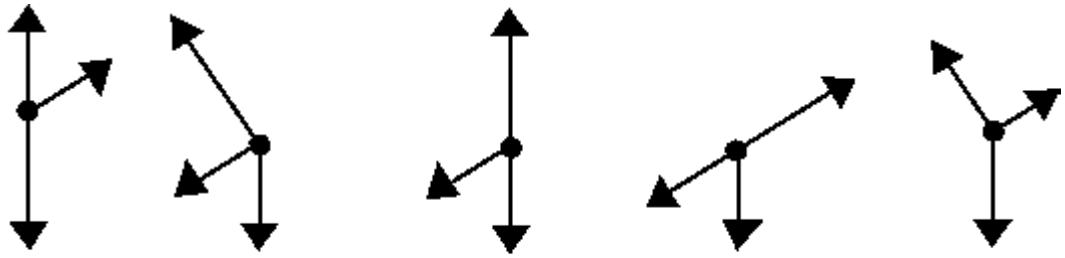
132. Which of the following is a unit of force?
A) m^2/s^2
B) kg · s^2/m
C) kg · m/s^2
D) N · s
E) N/kg

133. An object with a mass of 5.5 kg is allowed to slide from rest down an inclined plane. The plane makes an angle of 30º with the horizontal and is 72 m long. The coefficient of friction between the plane and the object is 0.35. The speed of the object at the bottom of the plane is
A) 5.3 m/s
B) 15 m/s
C) 24 m/s
D) 17 m/s
E) 11 m/s

134.



The free-body diagram that best represents the forces acting on the student at rest on the incline is



(1) (2) (3) (4) (5)

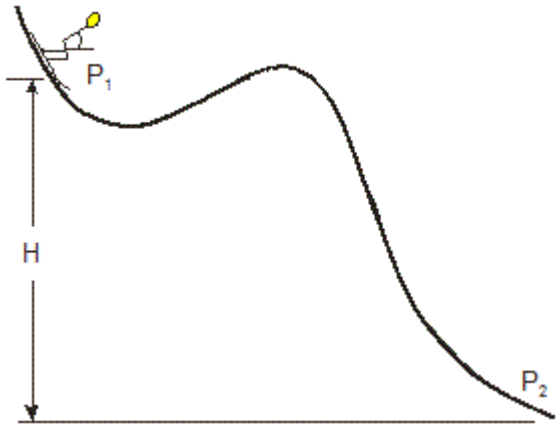
A) 1
B) 2
C) 3
D) 4
E) 5

135. A tired worker pushes a heavy (100-kg) crate that is resting on a thick pile carpet. The coefficients of static and kinetic friction are 0.6 and 0.4, respectively. The worker pushes with a force of 500 N. The frictional force exerted by the surface is
A) 1000 N
B) 600 N
C) 500 N
D) 400 N
E) 100 N

136. In drag racing, the driver deploys a parachute at the end of the $\frac{1}{4}$ mile run. The parachute works well because
A) the dragster does not have any brakes to save weight.
B) the drag force due to the parachute is large at high speeds.
C) there is no rolling friction at high speeds.
D) the driver has no time to apply the brakes.
E) the deployment of the parachute is part of the show.

137. If a fighter jet doubles its speed, by what factor should the power from the engine change?
A) by half
B) unchanged
C) doubled
D) quadrupled
E) 8 times

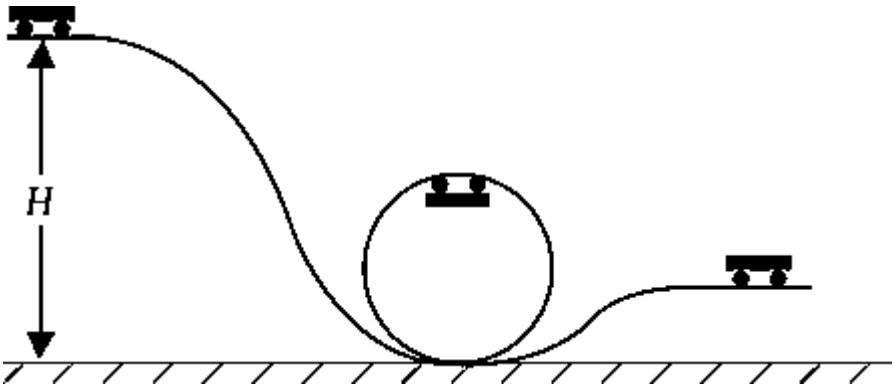
138. A skier of mass 50 kg is moving at speed 10 m/s at point P_1 down a ski slope with negligible friction. What is the skier's kinetic energy when she is at point P_2, 20 m below P_1?



A) 2500 J
B) 9800 J
C) 12300 J
D) 13100 J
E) 15000 J

139. Consider two engines. The larger is rated at 2 W and the smaller at 1 W. The smaller one can do a certain quantity of work in 2 h. The larger can do twice as much work in a time of
A) 30 min
B) 1 h
C) 2 h
D) 4 h
E) 1.4 h

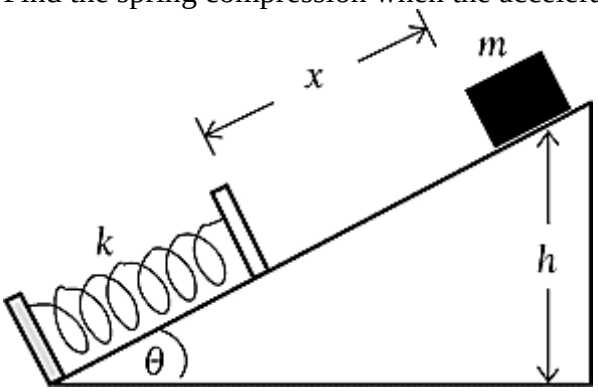
140. A bullet with a mass of 12 g moving horizontally strikes a fixed block of wood and penetrates a distance of 5.2 cm. The speed of the bullet just before the collision is 640 m/s. The average force that the wood exerted on the bullet was
A) 4.7×10^4 N
B) 74 N
C) 4.7×10^6 N
D) unknown; the mass of the wood is required
E) None of these is correct.

141.


You ride a roller coaster car of mass 1500 kg down a frictionless track a distance H = 23m above the bottom of a loop as shown. If the loop is 15 m in diameter, the downward force of the rails on your car when it is upside down at the top of the loop is
A) 4.6×10^4 N
B) 3.1×10^4 N
C) 1.7×10^4 N
D) 0.98 kN
E) 1.6×10^3 N

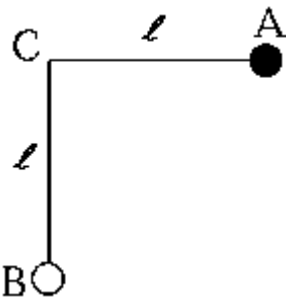
142. A woman runs up a flight of stairs. The gain in her gravitational potential energy is *U*. If she runs up the same stairs with twice the speed, what is her gain in potential energy?
A) U
B) $2U$
C) $\frac{1}{2}U$
D) $4U$
E) $\frac{1}{4}U$

143. A mass, *m*, slides down a frictionless incline and hits a spring with spring constant k. Find the spring compression when the acceleration of the mass is zero.



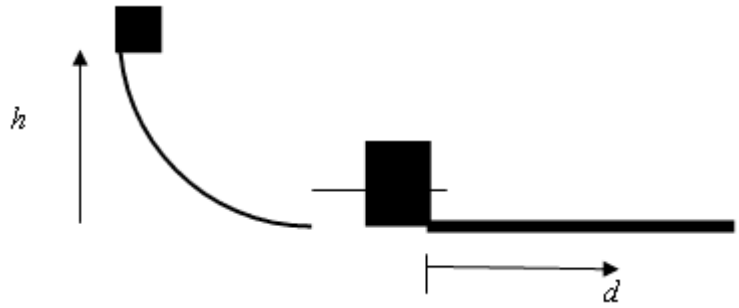
A) mg/k
B) mg cos θ/k
C) mg sin θ/k
D) mgh sin θ/(kx)
E) None of the above statements is correct.

144.



A simple pendulum has a bob of mass *M*. The bob is on a light string of length ℓ. The string is fixed at C. At position A, the string is horizontal and the bob is at rest. The bob is released from A and swings to B, where the string is vertical. The tension in the string when the bob first reaches B is
A) $\frac{M\sqrt{\ell / g}}{2\pi}$
B) $2Mg$
C) $Mg\ell$
D) Mg
E) None of these is correct.

145.



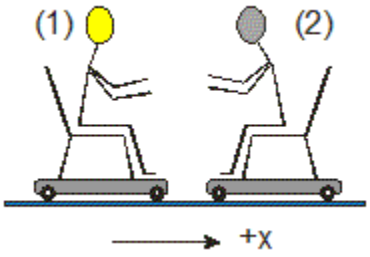
A block of mass 5 kg slides down a frictionless track from a height of 1.5 m. It collides with a second mass of 8 kg. The two blocks stick together and after the impact they begin to slide on a rough surface with a coefficient of kinetic friction of 0.65 until coming to rest. Calculate how far, *d*, the blocks slide on the rough surface.

A) 3.4 m
B) 0.22 m
C) 2.3 m
D) 0.34 m
E) 0.16 m

146. In an elastic collision of two objects,

A) momentum is not conserved.
B) momentum is conserved, and the kinetic energy after the collision is less than its value before the collision.
C) momentum is conserved, and the kinetic energy after the collision is the same as the kinetic energy before the collision.
D) momentum is not conserved, and the kinetic energy of the system after the collision differs from the kinetic energy of the system before the collision.
E) the kinetic energy of the system after the collision depends on the masses of the objects.

147. Two students, sitting on frictionless carts, push against each other. Both are initially at rest and the mass of student 1 and the cart is M, and that of student 2 and the cart is 1.5M. If student 1 pushes student 2 so that she recoils with velocity $-\vec{v}$, what is the change in momentum of the two students?



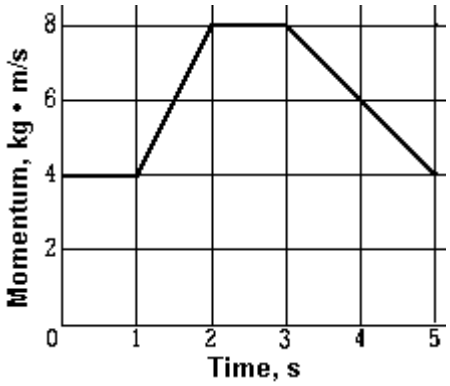
A) $-2.5M\vec{v}$
B) $-\frac{2}{3}M\vec{v}$
C) 0
D) $+2.5M\vec{v}$
E) $+\frac{2}{3}M\vec{v}$

148. In any and all collisions of short duration and for which it is true that no external forces act on the collision participants,

A) kinetic energy is conserved.
B) both momentum and kinetic energy are conserved.

C) neither momentum nor kinetic energy is conserved.
D) the relative velocities before and after impact are equal and oppositely directed.
E) momentum is conserved.

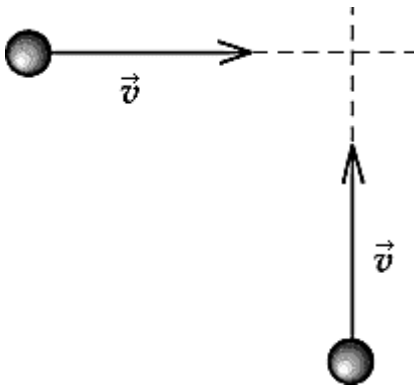
149.



The graph shows the momentum of a body as a function of time. The time at which the force acting on the body is greatest is
A) 0.5 s
B) 2.5 s
C) 4.0 s
D) 1.5 s
E) 5.0 s

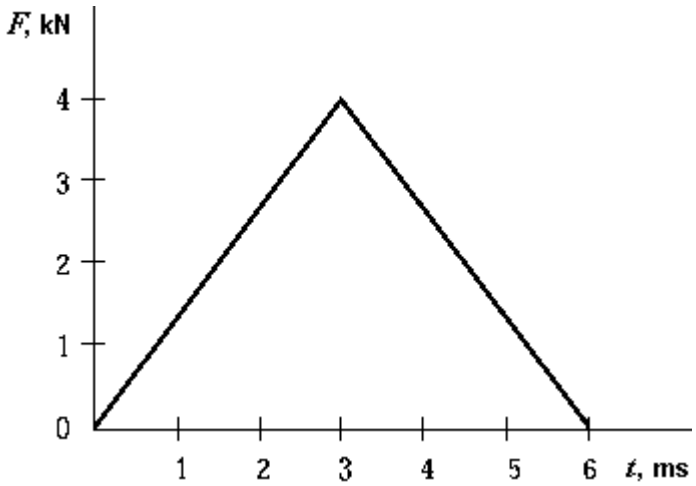
150. A 20-g bullet is fired into a 2.0-kg block of wood placed on a horizontal surface. The bullet stops in the block. The impact moves the block (+ bullet) a distance of 5 m before it comes to rest. If the coefficient of kinetic friction between the block and surface is 0.25, calculate the speed of the block (+ bullet) system immediately after impact.
A) 20 m/s
B) 3.5 m/s
C) 25 m/s
D) 5.0 m/s
E) 2.2 m/s

151.



Two identical bodies of mass *M* move with equal speeds *v*. The direction of their velocities is illustrated above. The magnitude of the linear momentum of the system is
A) 2*Mv*
B) *Mv*
C) 4*Mv*
D) $\sqrt{2}\,Mv$
E) $4\sqrt{2}\,Mv$

152.



A 4.0-kg block, initially at rest, experiences a force that varies with time as shown in the figure. When t = 6.0 ms, the speed of the block is

A) 3.0 m/s
B) 5.0 m/s
C) 6.0 m/s
D) 12 m/s
E) 6.0 km/s

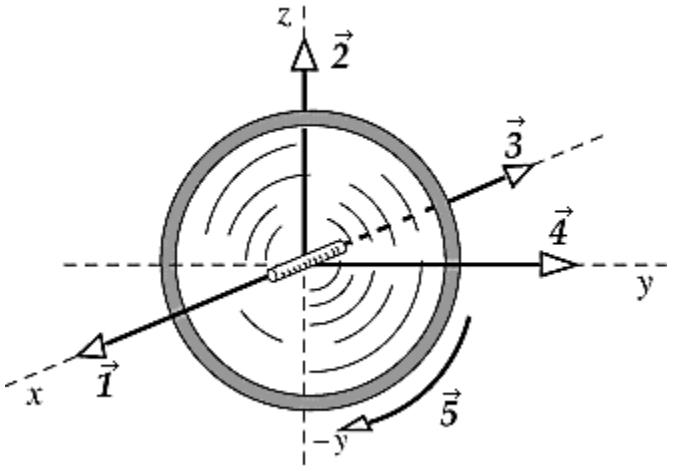
153. A disc with moment of inertia I_1 = 40 kg·m^2 and angular velocity ω_1 = 20 rad/s is dropped on to a stationary second disc along the axis of rotation. The second disc has moment of inertia I_2 = 60 kg·m^2. What is the angular velocity of the two discs?

A) 4 rad/s
B) 6 rad/s
C) 8 rad/s
D) 12 rad/s
E) 20 rad/s

154. The velocity a planet of mass m with circular orbit is given by $\vec{v} = v_o(-\sin\omega t\ \hat{i} + \cos\omega t\ \hat{j})$ where v_o in m/s is a constant, and ω is the angular velocity. Its position vector is $\vec{r} = r_o(\cos\omega t\ \hat{i} + \sin\omega t\ \hat{j})$. The angular momentum of the planet about the center of the orbit is

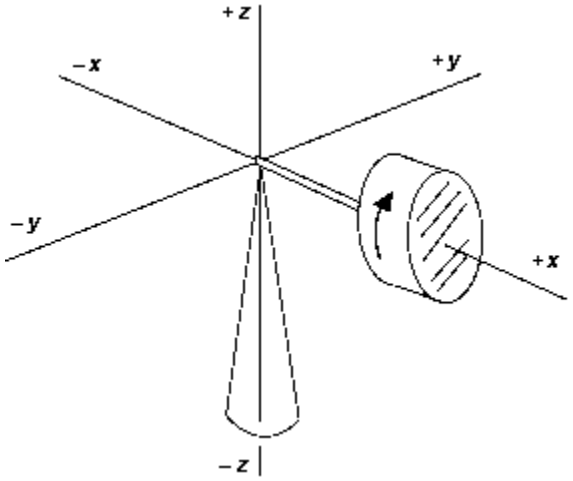
A) $-mv_o r_o\ \hat{k}$
B) $mv_o r_o\ \hat{k}$
C) $mv_o r_o\ (2 \sin\omega t \cos\omega t)\hat{k}$
D) $-mv_o r_o\ (2 \sin\omega t \cos\omega t)\hat{k}$
E) none of the above

155. A wheel is rotating clockwise on a fixed axis perpendicular to the page (x). A torque that causes the wheel to slow down is best represented by the vector



A) $\vec{1}$
B) $\vec{2}$
C) $\vec{3}$
D) $\vec{4}$
E) $\vec{5}$

156. A gyroscopic wheel spins clockwise as shown. The set of vectors that correctly describes the directions of the torque $\vec{T}$, angular momentum $\vec{L}$, and angular velocity of precession $\vec{\omega}_p$, is



A) $\vec{T}(+z);\vec{L}(-x);\vec{\omega}(+y)$
B) $\vec{T}(-z);\vec{L}(+x);\vec{\omega}(-y)$
C) $\vec{T}(+y);\vec{L}(-x);\vec{\omega}(+z)$
D) $\vec{T}(-y);\vec{L}(-z);\vec{\omega}(-x)$
E) $\vec{T}(+y);\vec{L}(-x);\vec{\omega}(-z)$

157. In a distant galaxy, a planet orbits its sun at a distance of 1.8×10^{12} m with a period of 10^8s. A second planet orbits the same sun at a distance of 9×10^{11} m. What is the period of the second planet?
A) 5×10^7 s
B) 2×10^8 s
C) 0.35×10^8 s
D) 2.8×10^8 s
E) 5×10^8 s

158. A body experiences a gravitational force with a magnitude of 200 N in a region of space

where the magnitude of the gravitational field is 10 m/s^2. The mass of the body is
A) 0.2 kg
B) 100 kg
C) 5 kg
D) 20 kg
E) 2000 kg

Use the following to answer question 39:

NASA's "Weightless Wonder" flights can simulate "zero-g" or some other extraterrestrial gravity by flying a C-9 jet plane in a parabolic path. One path the plane takes is expressed as $y = y_o + 0.8\ x - 1.02 \times 10^{-4}\ x^2$ where y_o is the highest point, and x and y are the horizontal and vertical coordinates (in m).

159. Suppose y_o = 10000 m and the lowest height is 2000 m, how long is the flight with a simulated lunar gravity g_{Moon} = 1.62 m/s^2?
A) 44 s
B) 100 s
C) 40 s
D) 60 s
E) 66 s

160. Which of the following statements is one of Kepler's three laws of planetary motion?
A) A line joining any planet to the sun sweeps out equal areas in equal times.
B) Only an odd number of planets can orbit the sun.
C) The period of any planet about the sun is proportional to the planet's distance from the sun.
D) All planets move in elliptical orbits with Earth at one focus.
E) $F = GMm/R^2$

161. The prefix "pico" means
A) 10^{-12}
B) 10^{-6}
C) 10^{-3}
D) 10^{6}
E) 10^{9}

162. If K has dimensions ML^2/T^2, the k in $K = kmv^2$ must
A) have the dimensions ML/T^2.
B) have the dimensions M.
C) have the dimensions L/T^2.
D) have the dimensions L^2/T^2.
E) be dimensionless.

163. To convert a quantity from g/cm^3 to kg/m^3, you must
A) multiply by 0.01.
B) multiply by 100.
C) multiply by 1000.
D) multiply by 0.001.
E) multiply by 1,000,000.

164. Three vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ have the following x and y components:

	$\vec{A}$	$\vec{B}$	$\vec{C}$
x component	+6	–3	+2
y component	–3	+4	+5

The angle that the resultant makes with the positive direction of the x axis is
A) 1.2º
B) 36º
C) 50º
D) 40º
E) 70º

165. You are traveling at a speed of 80 km/hr. Your speed in mph is approximately
A) 30
B) 40
C) 50
D) 60
E) 70

166. What is the least number of non-zero vectors that can be added to give a resultant equal to zero?
A) 2
B) 3
C) 4
D) 5
E) It cannot be done.

167. Vectors $\vec{A}$ and $\vec{B}$ have the following components:

A_x = 5 units A_y = 2 units
B_x = 3 units B_y = 4 units

The angle between the positive x axis and the vector $\vec{A}-\vec{B}$ is
A) –45º
B) 194º
C) 37º
D) –54º
E) 86º

168. A vector of magnitude 5 points in the +y direction. Another vector of magnitude 4 is subtracted from the first vector. The smallest possible magnitude of the sum is
A) 1
B) 4
C) 5
D) 9
E) 10

169. What is the order of magnitude of Earth's tallest mountain heights?
A) 10^8 m
B) 10^4 m
C) 10^6 m
D) 10^3 m
E) 10^5 m

170. The mass of an electron is of the order of 10^{-30} kg and the mass of the universe is believed to be of the order of 10^{52} kg. From this information you can conclude that
A) the mass of Earth is 52 orders of magnitude greater than that of the electron.
B) the mass of Earth is 30 orders of magnitude greater than that of the electron.
C) the mass of the electron is 82 orders of magnitude greater than that of Earth.
D) the mass of Earth is 82 orders of magnitude greater than that of the electron.
E) the mass of the electron is 30 orders of magnitude greater than that of Earth.

171. On a graph that shows position on the vertical axis and time on the horizontal axis, a parabolic curve that opens upward represents
A) a constant positive acceleration.
B) a constant negative acceleration.
C) no acceleration.
D) a positive followed by a negative acceleration.
E) a negative followed by a positive acceleration.

172. The velocity of a particle is given by v(t) = 3t. The average velocity for the particle between t = 2 and 4 s is
A) 4 m/s
B) 6 m/s
C) 9 m/s
D) 12 m/s
E) 18 m/s

173. It takes the Mars rover 4.5 minutes to send information via a radio signal traveling at the speed of light back to Mission Control on Earth. How far away is the rover?
A) 8.1×10^{10} km
B) 1.35×10^{9} m
C) 8.10×10^{10} m
D) 1.35×10^{9} km
E) 1.62×10^{11} m

174. The displacement of an object for a round trip between two locations
A) is always greater than zero.
B) is always less than zero.
C) is zero.
D) can be greater than or less than but not equal to zero.
E) can have any value.

175. A ball is dropped from the top of a building. In the absence of air resistance, the ball will hit the ground with a speed of 49 m/s. The height of the building is
A) 25 m
B) 5 m
C) 240 m
D) 120 m
E) 10 m

176. A baseball is thrown vertically up to a height of 30 m on Earth. If the same ball is thrown up on the moon with the same initial speed how much further will it travel up? (Assume $g_{moon} = g_{earth}/6$)

A) 5.0 m
B) 25 m
C) 12 m
D) 180 m
E) 150 m

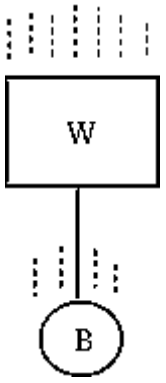
177. You drive for 30 min at 100 km/h and then stop for 15 min. You then drive for 45 min at 80 km/h. Your average speed for the entire trip is
A) 73 km/h.
B) 83 km/h.
C) 88 km/h.
D) 90 km/h.
E) 97 km/h.

178. A particle initially at rest undergoes rectilinear (i.e., straight line) motion with an acceleration that is constant in magnitude and direction. The velocity of the particle
A) is constant in magnitude and direction.
B) is constant in direction only.
C) is constant in magnitude only.
D) can change in magnitude and direction.
E) is described by none of these.

179. If we assume that a spaceship could accelerate from rest at a constant rate of 9.81 m/s^2, then how long would it take to reach 1% of the speed of light? (Assume the speed of light = 3.0×10^8 m/s)
A) 1.8 days
B) 3.5 days
C) 3.1×10^4 s
D) 3.1×10^6 s
E) 7.1 days

180. You drive for 30 min for 30 km East and then another 30 min for 40 km North. Your average velocity for the entire trip is
A) 40 km/h.
B) 50 km/h.
C) 60 km/h.
D) 70 km/h.
E) 80 km/h.

181. The system in the figure consists of a steel ball attached by a cord to a large block of wood. If the system is dropped in a vacuum, the force in the cord is



A) zero.
B) equal to the difference of the masses of B and W.

C) equal to the difference of the weights of B and W.
D) equal to the weight of B.
E) equal to the sum of the weights of B and W.

182. A ball of mass 2.0 kg is acted on by two forces, $\vec{F}_1 = 3.0N\,\hat{i} + 4.0N\,\hat{j}$ and $\vec{F}_2 = -5.0N\,\hat{i} + 6.0N\,\hat{j}$. The magnitude of the acceleration is
A) 2.5 m/s^2
B) 3.9 m/s^2
C) 4.6 m/s^2
D) 5.1 m/s^2
E) 5.8 m/s^2

183. You are going up in an elevator that is accelerating upwards on Earth. Suppose you were to do the same thing on Mars. Your weight on Mars will be ___ your weight on Earth.
A) less than
B) equal to
C) greater than
D) unable to tell
E) depends on what g is on Mars

184. A horse exerts a force *F* on a cart, causing the cart to move with increasing speed. What force does the cart exert on the horse?
A) zero
B) *F*
C) greater than *F*
D) less than *F*
E) The force cannot be determined unless the acceleration is given.

185. A mass *m* is traveling at an initial speed v_0 = 25.0 m/s. It is brought to rest in a distance of 62.5 m by a force of 15.0 N. The mass is
A) 37.5 kg
B) 3.00 kg
C) 1.50 kg
D) 6.00 kg
E) 3.75 kg

186. A boy holds a bird in his hand. The reaction force to the normal force exerted on the bird by the boy's hand is the force of:
A) the Earth on the bird.
B) the bird on the Earth.
C) the hand on the bird.
D) the bird on the hand.
E) the Earth on the hand.

187. The acceleration due to gravity on the moon is only about 1/6 of that on Earth. An astronaut whose weight on Earth is 600 N travels to the lunar surface. His mass as measured on the moon is
A) 600 kg
B) 100 kg
C) 61.2 kg

D) 10.0 kg
E) 360 kg

188. A body moves with constant speed in a straight line. Which of the following statements must be true?
A) No force acts on the body.
B) A single constant force acts on the body in the direction of motion.
C) A single constant force acts on the body in the direction opposite to the motion.
D) A net force of zero acts on the body.
E) A constant net force acts on the body in the direction of motion.

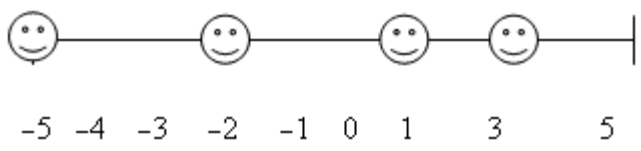
189. If a force F is required to extend a spring a distance $5y$, how far will it be extended by force $3F$?
A) $5y$
B) $(3/5)y$
C) $(5/3)y$
D) $15y$
E) $(3/8)y$

190. If two metal blocks of different masses slide freely down the same frictionless incline, which one of the following is true?
A) They have equal accelerations
B) They have unequal accelerations, but the forces acting on them are equal.
C) The more massive block reaches the bottom first.
D) The less massive block reaches the bottom first.
E) None of these is correct.

191. An object traveling in a circle at constant speed
A) is moving with constant velocity.
B) may be slowing down or picking up speed.
C) experiences no acceleration.
D) experiences an acceleration toward the center of the circle.
E) is described by none of the above statements.

192. Which of the following statements is NOT true about friction?
A) μ_k is less than μ_s
B) μ_k is independent of the relative speed of the surfaces in the range of about 1 cm/s to several meters per second.
C) μ_k depends on the relative speed of the surfaces at speeds over several meters per second.
D) The coefficients of friction depend on the nature of the surfaces.
E) The force of static friction depends on the area of contact between the two surfaces.

193. Four smiley faces are situated along the x axis as follows: m_1 = 5 kg at –5.0 m, m_2 = 3 kg at –2.0 m, m_3 = 3 kg at 1.0 m, and m_4 = 2 kg at 3.0 m. Where is the center of mass situated?



A) 3.1 m
B) 0.0 m

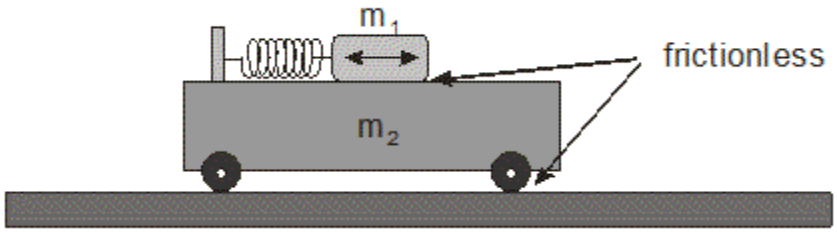
C) –1.7 m
D) –0.80 m
E) –3.1 m

194. A professor likes to demonstrate centripetal force by swinging a bucket of water in the vertical direction. What is the minimum speed he must swing the bucket at the top of the circle if he is not to get drenched? (Assume that his arm is 1 m long.)
A) 1.1 m/s
B) 2.1 m/s
C) 3.1 m/s
D) 4.1 m/s
E) 5.1 m/s

195. A mass M = 5.6 kg on a horizontal table is pulled by a horizontal string that passes over a frictionless pulley to a free-hanging mass m = 3.4 kg. The coefficient of friction between M and the table is 0.28. The acceleration of M is
A) 3.7 m/s^2
B) 2.0 m/s^2
C) 2.2 m/s^2
D) 0.20 m/s^2
E) 0.49 m/s^2

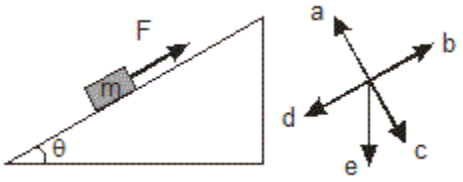
Use the following to answer question 36:

A mass, m_1, attached to a spring is placed on a cart with mass m_2, which moves freely and without friction on a table. m_1 slides without friction on the cart and is ¼ the mass of m_2.



196. When m_1 is allowed to oscillate along m_2, what is the motion of m_2?
A) m_2 does not move
B) m_2 moves in the same direction as m_1
C) m_2 moves in the opposite direction of m_1
D) Depends on the spring constant
E) None of the above

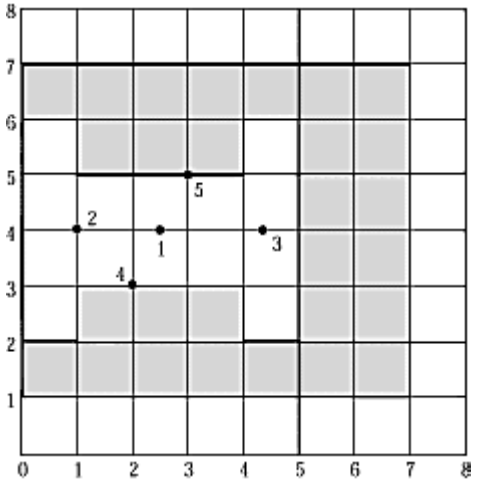
197. A mass m is placed on a rough incline at an angle θ to the horizon. A force F is applied up the incline so that the mass slides up the incline. Using the compass rose, the direction of the frictional force is along



A) (a)
B) (b)
C) (c)
D) (d)

E) (e)

198. The shaded area in the figure represents a uniformly thick sheet of metal. The center of mass of the sheet is closest to point



A) 1
B) 2
C) 3
D) 4
E) 5

199. A car of mass 3.0×10^3 kg traveling at a speed of 20 $\frac{\text{m}}{\text{s}}$ is passing a truck of mass 7.5×10^3 kg traveling at a speed of 16 $\frac{\text{m}}{\text{s}}$ in the same direction. What is the speed of the center of mass of this system?

A) 16 $\frac{\text{m}}{\text{s}}$
B) 17 $\frac{\text{m}}{\text{s}}$
C) 18 $\frac{\text{m}}{\text{s}}$
D) 19 $\frac{\text{m}}{\text{s}}$
E) 20 $\frac{\text{m}}{\text{s}}$

200. A boy is standing at the stern (back) of a boat that is 8.0 m long. There is no friction between the boat and the water. The boy has a mass of 63 kg and the boat has a mass of 780 kg. The bow (front) of the boat is touching a dock and the fore-and-aft axis of the boat is perpendicular to the dock. The boy walks from the stern of the boat to the bow. When he reaches the bow, his distance from the dock is

A) 7.6 m
B) 0.65 m
C) 0.51 m
D) 0.56 m
E) 1.3 m

201. Kids love to crash their toy cars together. One such collision involves a 0.5 kg car moving at 0.3 m/s colliding with a stationary toy car of mass 0.3 kg. The two toys stick together and move away from the collision point at 0.188 m/s. By what factor is the

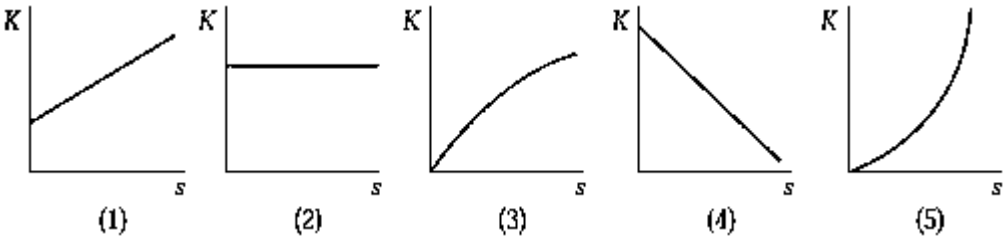
initial kinetic energy greater than the final kinetic energy?
A) 0.63
B) 1.6
C) 2.5
D) 4.2
E) 1.0 The kinetic energy stays the same.

202. If mechanical work is done on a body, the body must
A) accelerate.
B) be in equilibrium.
C) not exert any force.
D) have no friction force exerted on it.
E) move.

203. What is the difference in work needed to push a 100 kg crate (at constant speed) a distance of 2 m along an inclined plane that is at an angle of 20 degrees with the horizontal, if the coefficient of kinetic friction was equal to 0.20 or zero?
A) 670 N
B) 1040 N
C) no difference
D) 370 N
E) 134 N

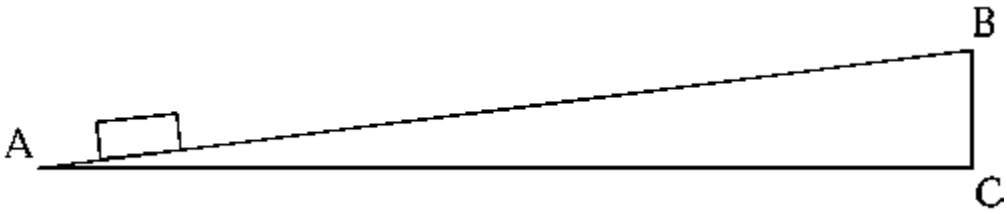
204. A force $\vec{F}$ acts on a body and produces an acceleration $\vec{a}$. The body undergoes a displacement $\vec{s}$ and attains a velocity $\vec{v}$ in time *t*. The instantaneous power being developed at time *t* is given by
A) $\vec{F} \cdot \vec{v}$
B) $\vec{F} \cdot \frac{1}{2} at^2$
C) $\vec{F} \cdot \vec{a}$
D) $(\vec{F} \cdot 2\vec{s}) / t^2$
E) $\vec{F} \cdot \vec{s}$

205.



You release an object from rest at a high altitude. If air resistance is considered, the curve that best represents the kinetic energy of the body as a function of the distance fallen is
A) 1
B) 2
C) 3
D) 4
E) 5

206.



The object in the figure has a mass of 3.45 kg and is pulled up a slope AB, which is 36 m long; the height BC is 3.00 m. There is no friction and the acceleration is constant. The speed v_1 at A is 3.5 m/s whereas the speed v_2 at B is 5.5 m/s. The average power developed by the motor pulling the object is

A) 17 W
B) 3.9 W
C) 13 W
D) 0.13 kW
E) 43 W

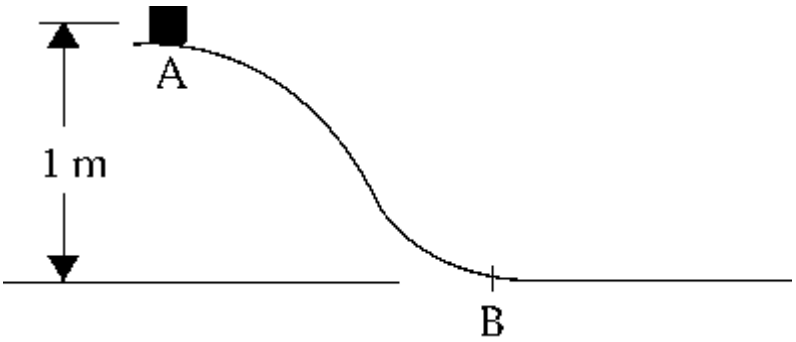
207. Car drag racing takes place over a distance of a $\frac{1}{4}$ mile (402 m) from a standing start. If a car (mass 1500 kg) could be propelled forward with a pulling force equal to that of gravity, what would be the change in kinetic energy and the terminal speed of the car (in mph) at the end of the race be? (For comparison, a modern, high-performance sports car may reach a terminal speed of just over 100 mph = 44.7 m/s.)

A) 604 kJ and 28.4 m/s
B) 5.92 kJ and 88.9 m/s
C) 5.92 MJ and 7900 m/s
D) 3680 kJ and 70.0 m/s
E) 5.92 MJ and 88.9 m/s

208. A particle moves halfway around a circle of radius *R*. It is acted on by a radial force of magnitude *F*. The work done by the radial force is

A) Zero
B) FR
C) $F\pi R$
D) $2FR$
E) $2\pi R$

209.

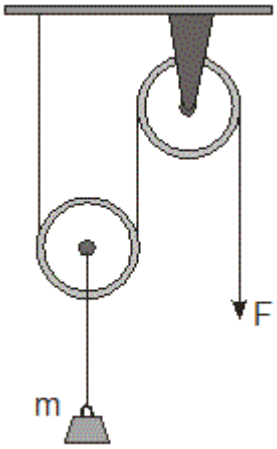


A 6.0-kg block slides from point A down a frictionless curve to point B. After the block passes point B, a friction force opposes the motion of the block so that it comes to a stop 2.5 m from B. Calculate the coefficient of kinetic friction between the block and the surface after position B.

A) 2.5
B) 0.40
C) >0.40
D) 0.40 N
E) 2.5 N

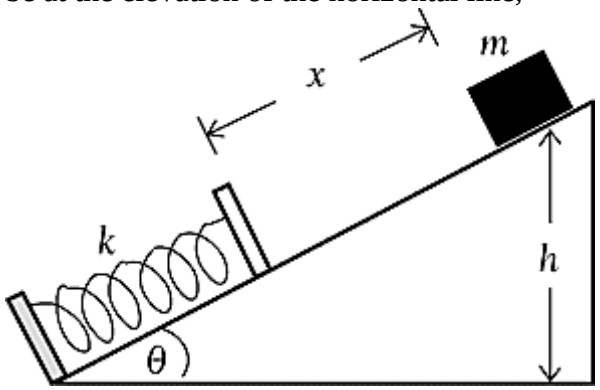
Use the following to answer question 50:

A light rope runs through two frictionless pulleys of negligible mass. A mass, *m*, is hung from one of the pulleys and a force, *F* is applied to one end of the rope so that the mass moves at a constant speed.



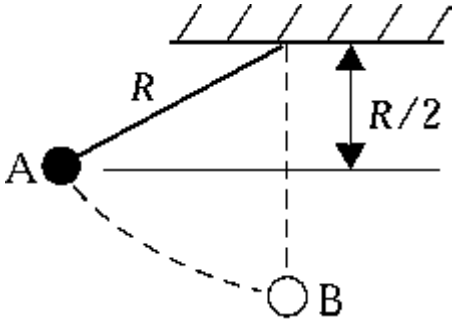
210. What is the force needed to move the mass at a constant speed?
A) 0
B) $\frac{1}{2}$ mg
C) mg
D) 2mg
E) 4mg

211. Assuming the incline to be frictionless and the zero of gravitational potential energy to be at the elevation of the horizontal line,



A) the kinetic energy of the block just before it collides with the spring will be equal to *mgh.*
B) the kinetic energy of the block when it has fully compressed the spring will be equal to *mgh.*
C) the potential energy of the block when it has fully compressed the spring will be zero.
D) the energy stored in the spring plus the gravitational potential energy of the block when it has fully compressed the spring will be equal to *mgh.*
E) None of the above statements will be true.

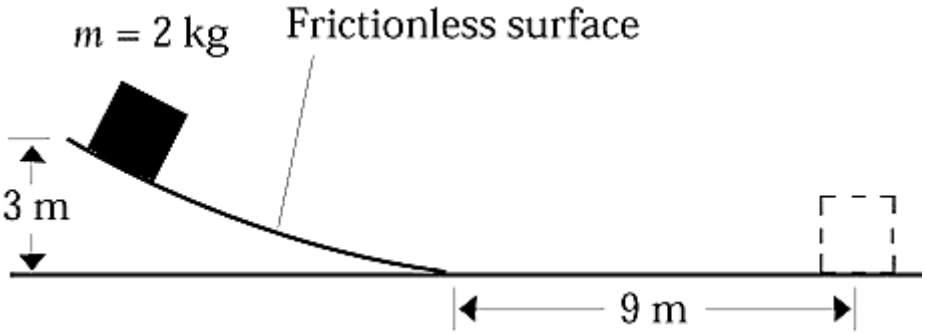
212.



Release mass *m* on a string from rest at point A. As it passes the lowest point B, the tension in the string is

A) impossible to determine; the answer depends on the length of the string.
B) *mg*
C) 2*mg*
D) 3*mg*
E) None of these is correct.

213.



The block shown in the figure is sliding on a frictionless surface. Its speed when it has traveled 9 m along the horizontal surface will be

A) 3.14 m/s
B) 7.67 m/s
C) 9.81 m/s
D) 13.3 m/s
E) None of these is correct.

214. A 5200-kg cable car in Hong Kong is pulled a distance of 360 m up a hill inclined at 12° from the horizontal. The change in the potential energy of the car is

A) 1.8×10^7 J
B) 1.2×10^7 J
C) 3.8×10^6 J
D) 6.0×10^7 J
E) 1.8×10^6 J

215. A spring with force constant k = 300 N/m is compressed 9.0 cm. What is the potential energy in the spring?

A) 1.2×10^4 J
B) 2.4 J
C) 2.7×10^4 J
D) 27 J
E) 1.2 J

216. Which of the following statements is NOT correct?

A) The work done by a conservative force on an object is independent on the path taken.

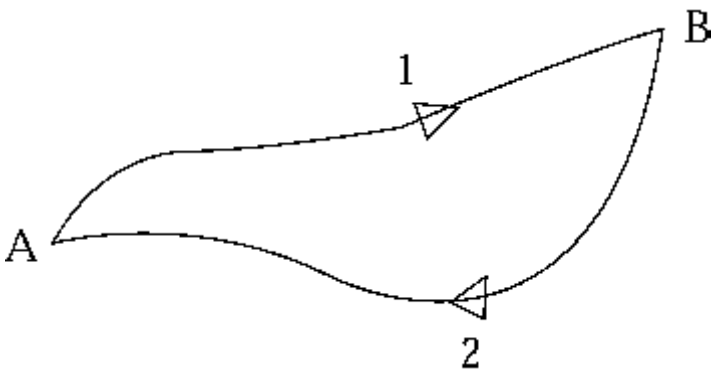
B) The work done by a conservative force on an object along path A→B is negative that of path B→A.
C) The force due to gravity is an example of a conservative force.
D) Friction is an example of a conservative force.
E) The work done by friction on an object depends on the path taken.

217. Which of the following are units of energy?
A) MeV
B) MeV·c^2
C) c^2/MeV
D) 1/MeV
E) MeV/c^2

218. A body falls through the atmosphere (consider air resistance) gaining 20 J of kinetic energy. How much gravitational potential energy did it lose?
A) 20 J
B) more than 20 J
C) less than 20 J
D) It is impossible to tell without knowing the mass of the body.
E) It is impossible to tell without knowing how far the body falls.

219. A woman on a bicycle traveling at 10 m/s on a horizontal road stops pedaling as she starts up a hill inclined at 3.0º to the horizontal. If friction forces are ignored, how far up the hill does she travel before stopping?
A) 5.1 m
B) 30 m
C) 97 m
D) 10 m
E) The answer depends on the mass of the woman.

220.



Consider a motion in which a particle goes from A → B along path 1 and from B back to A along path 2, as shown.

W(AB, 1) = work in going from A → B along path 1.
W(BA, 2) = work in going from B → A along path 2.

If only conservative forces are acting, then
A) W(AB, 1) > W(BA, 2)
B) W(AB, 1) < W(BA, 2)
C) W(AB, 1) + W(BA, 2) > 0
D) W(AB, 1) + W(BA, 2) < 0
E) W(AB, 1) + W(BA, 2) = 0

221. A Saturn V rocket with an initial mass m_0 of 3×10^6 kg has a payload that accounts for 27% of this mass, a burn rate of 15×10^3 kg/s, and a thrust F_{th} of 35×10^6 N. The acceleration at lift-off is
A) 1.86 m/s^2
B) 2.89 m/s^2
C) 3.46 m/s^2
D) 3.51 m/s^2
E) 3.67 m/s^2

222. A particle of mass m moving at 5.0 m/s in the positive x direction makes a glancing elastic collision with a particle of mass $2m$ that is at rest before the collision. After the collision, m moves off at an angle of 45º to the x axis and $2m$ moves off at 60º to the x axis. The speed of m after the collision is
A) 4.5 m/s
B) 2.5 m/s
C) 3.3 m/s
D) 1.8 m/s
E) 1.1 m/s

223. An automobile of mass 1300 kg has an initial velocity of 7.20 m/s toward the north and a final velocity of 6.50 m/s toward the west. The magnitude and direction of the change in momentum of the car are
A) 1.26×10^4 kg · m/s at 48º S of E
B) 1.26×10^4 kg · m/s at 48º S of W
C) 1.26×10^4 kg · m/s at 48º N of W
D) 1.78×10^4 kg · m/s at 48º N of W
E) 910 kg · m/s at 48º S of E

224. If a body moves in such a way that its linear momentum is constant, then
A) its kinetic energy is zero.
B) the sum of all the forces acting on it must be zero.
C) its acceleration is greater than zero and is constant.
D) its center of mass remains at rest.
E) the sum of all the forces acting on the body is constant and nonzero.

225. Glider A, traveling at 10 m/s on an air track, collides elastically with glider B traveling at 8.0 m/s in the same direction. The gliders are of equal mass. The final speed of glider B is
A) 8.4 m/s
B) 10 m/s
C) 8.0 m/s
D) 4.0 m/s
E) 12 m/s

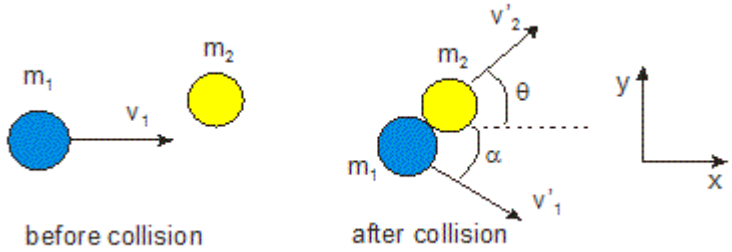
226. A particle of mass $2m$ is moving to the right in projectile motion. At the top of its trajectory, an explosion breaks the particle into two equal parts. After the explosion, one part falls straight down with no horizontal motion. What is the direction of the motion of the other part just after the explosion?
A) up and to the left
B) stops moving
C) up and to the right
D) straight up

E) down and to the right

227. A bullet (mass = m) is fired at speed V into a block of mass M (with $M>m$) which is hanging vertically from a light string of length L. The bullet stops in the block. If the recoiling block + bullet system reaches a height of $2/3L$, then the initial speed of the bullet is given by
A) $M \times (1gL/3)^{1/2}/m$
B) $M \times (2gL/3)^{1/2}/m$
C) $M \times (3gL/4)^{1/2}/m$
D) $m \times (4gL/3)^{1/2}/M$
E) $M \times (4gL/3)^{1/2}/m$

Use the following to answer question 68:

A puck of m_1 and moving with velocity v_1 collides elastically with a second puck of mass m_2, which is initially at rest. After the collision, m_1 moves with velocity v_1' at an angle α below the x axis and m_2 moves with velocity v_2' at an angle θ above the x axis.



228. The conservation of momentum along the x direction can be written as
A) $m_1 v_1 = m_1 v_1' \cos\alpha + m_2 v_2' \cos\theta$
B) $0 = m_1 v_1' \cos\alpha + m_2 v_2' \cos\theta$
C) $m_1 v_1 = m_1 v_1' \sin\alpha + m_2 v_2' \sin\theta$
D) $0 = m_1 v_1' \sin\alpha + m_2 v_2' \sin\theta$
E) none of the above

229. Two equal masses travel in opposite directions with equal speed. If they collide in a perfectly elastic collision, then, just after the collision, their velocities will be
A) zero.
B) equal to their original velocities.
C) equal in magnitude but opposite in direction to their original velocities.
D) less in magnitude and in the same direction as their original velocities.
E) less in magnitude and opposite in direction to their original velocities.

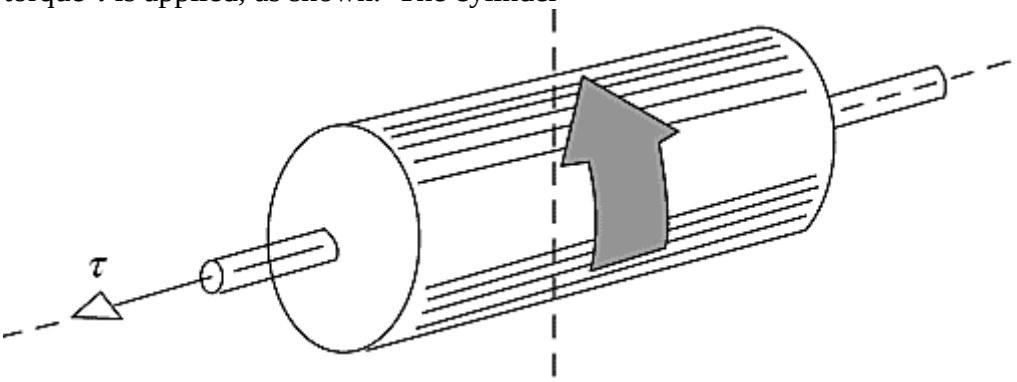
230. A projectile with a mass $6M$ is fired at a speed of 400 m/s at an angle of 60º above the horizontal. At the highest point of its trajectory, the projectile is broken into two equal pieces by an internal explosion. Just after the explosion, one of the two pieces is known to be traveling vertically downward at a speed of 300 m/s. The magnitude of the velocity of the other half of the projectile is
A) 500 m/s
B) 1.50 km/s
C) 400 m/s
D) 710 m/s
E) 123 m/s

231. If the sum of the external torques acting on an isolated system of particles is zero, it must be true that
A) the system can have no kinetic energy.
B) the angular momentum of the system does not change.
C) the system can have no angular velocity.
D) the system can have no linear velocity.
E) the angular momentum of the system must be continually decreasing.

232. If the sum of the external torques on a system is zero, there is
A) a change in the system's moment of inertia.
B) no change in the system's moment of inertia.
C) a change in the system's angular momentum.
D) no change in the system's angular momentum.
E) a precessional angular velocity.

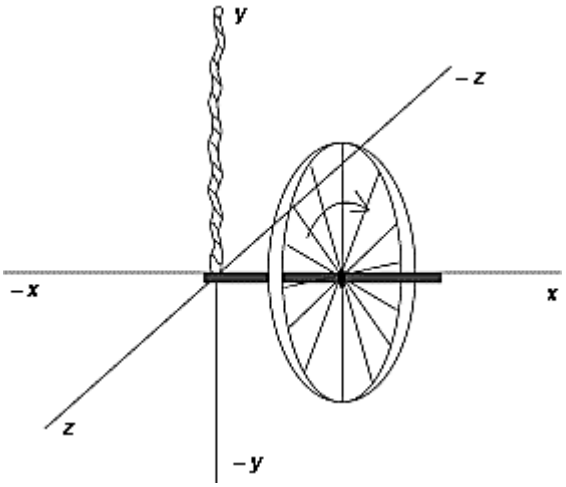
233. The angular momentum of a rotating object is initially $\vec{L}_i = 2\hat{i} + 4\hat{j}$ and 2s later it is $\vec{L}_f = 3\hat{i} + 8\hat{j}$. The units are in kg·m^2/s. The torque that produces the change in angular momentum is
A) $-0.5\,N\cdot m\,\hat{i} - 2\,N\cdot m\,\hat{j}$
B) $0.5\,N\cdot m\,\hat{i} + 2\,N\cdot m\,\hat{j}$
C) $-1N\cdot m\,\hat{i} - 4\,N\cdot m\,\hat{j}$
D) $1N\cdot m\,\hat{i} + 4\,N\cdot m\,\hat{j}$
E) none of the above

234. A solid cylinder is spinning counterclockwise about a longitudinal axis when a net torque τ is applied, as shown. The cylinder



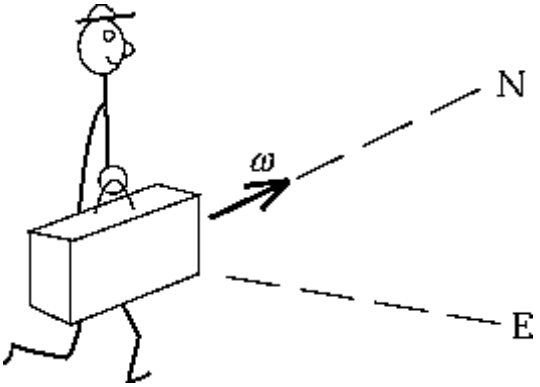
A) speeds up.
B) slows down.
C) precesses about a vertical axis.
D) precesses about a horizontal axis.
E) does none of these.

235. A spinning bicycle wheel is supported as shown by a line fastened to one end of its axle. The resultant torque acting on the wheel lies along which of the following axes?



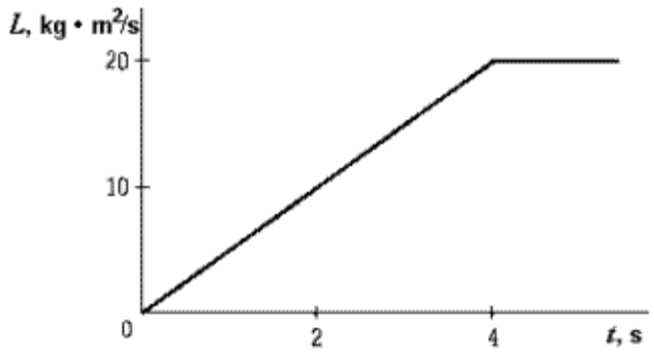
A) x
B) y
C) $-y$
D) z
E) $-z$

236. A man is walking north carrying a suitcase that contains a spinning gyroscope mounted on an axle attached to the front and back of the case. The angular velocity of the gyroscope points north. The man now begins to turn to walk east. As a result, the front end of the suitcase



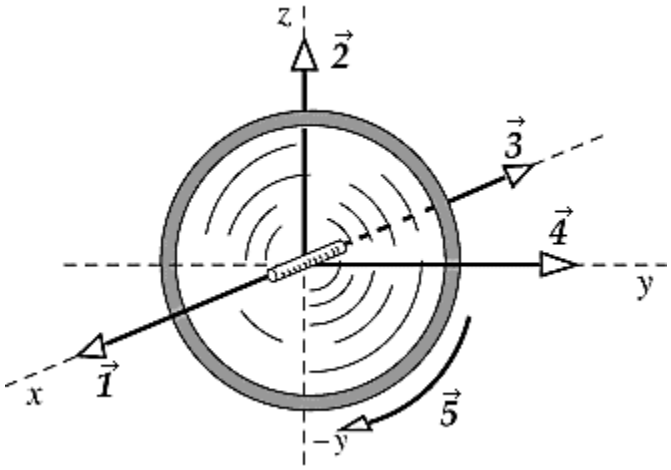
A) resists his attempt to turn and tries to remain pointed north.
B) fights his attempt to turn and pulls to the west.
C) rises upward.
D) dips downward.
E) does nothing whatever unusual.

237. The angular momentum of a body about a particular axis as a function of time is shown in the graph. The external torque acting on the body along this axis at $t = 2$ s is



A) 0
B) 5 N · m
C) 10 N · m
D) 20 N · m
E) 40 N · m

238. A wheel is rotating clockwise on a fixed axis perpendicular to the page (x). A torque that causes the wheel to slow down is best represented by the vector

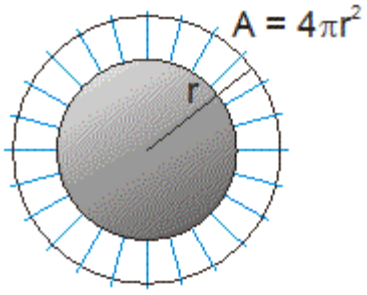


A) $\vec{1}$
B) $\vec{2}$
C) $\vec{3}$
D) $\vec{4}$
E) $\vec{5}$

239. A disc-shaped grindstone of mass 3.0 kg and radius 8.0 cm is spinning at 600 rev/min. After the power is shut off, a man continues to sharpen his axe by holding it against the grindstone until it stops 10 s later. What was the stone's initial kinetic energy when the power was turned off?
A) 19 J
B) 3.8×10^{-3} J
C) 4.8×10^{-5} J
D) 1.9×10^{-3} J
E) 2.4×10^{-2} J

240. If the angular momentum of a system is constant, which of the following statements must be true?
A) No torque acts on any part of the system.
B) A constant torque acts on each part of the system.
C) Zero net torque acts on each part of the system.
D) A constant external torque acts on the system.
E) Zero net torque acts on the system.

241. Earth's gravitational field is given by $\vec{g} = -\dfrac{GM_E}{r^2}\hat{r}$. The total flux (field times area) for a spherical surface area A that encloses all the field lines is



A) $-4\pi GM_E$

B) $-GM_E$
C) $-GM_E/4\pi$
D) $-2\pi GM_E$
E) $-4GM_E$

242. What is the escape speed from the sun, beginning (from rest relative to the sun) at the orbit of Earth, $R = 1.50 \times 10^8$ km. (Given: $G = 6.67 \times 10^{-11}$ N · m^2/kg^2; mass of the sun = 2.0×10^{30} kg.)
A) 3.0×10^4 m/s
B) 2.1×10^4 m/s
C) 1.3×10^6 m/s
D) 9.4×10^5 m/s
E) 4.2×10^4 m/s

243. A satellite of 1000 kg is in a circular orbit at a height of R_E above the surface of Earth. Calculate the minimum energy required to put such a satellite into this orbit. ($R_E = 6.38 \times 10^6$ m, $M_E = 5.98 \times 10^{24}$ kg, $G = 6.67 \times 10^{-11}$ N·m^2/kg^2)
A) 3.13×10^{10} J
B) 8.34×10^{10} J
C) 4.69×10^{10} J
D) 6.25×10^{10} J
E) 1.56×10^{10} J

244. A planet is made of two distinct materials. From the core to R/2, the density of the material is 4000 kg/m^3, and from R/2 to R the density is 3000 kg/m^3. What is the gravity at the surface of the planet if R = 5000 km?
A) 0.699 m/s^2
B) 3.66 m/s^2
C) 4.19 m/s^2
D) 4.38 m/s^2
E) 4.99 m/s^2

245. If the mass of a planet is doubled with no increase in its size, the escape speed for that planet is
A) increased by a factor of 1.4.
B) increased by a factor of 2.
C) not changed.
D) reduced by a factor of 1.4.
E) reduced by a factor of 2.

246. An object whose mass is 4 kg experiences a gravitational force of $20\ \text{N}\hat{i}$ at some point P. The gravitational field at this point is
A) $5\ \text{m/s}^2\ \hat{i}$
B) $4\ \text{m/s}^2\ \hat{i}$
C) $-5\ \text{m/s}^2\ \hat{i}$
D) $20\ \text{n/kg}\ \hat{i}$
E) $80\ \text{N/kg}\ \hat{i}$

247. If the mass of Earth is 6×10^{24} kg, the mass of the moon 7×10^{22} kg, the radius of the moon's orbit 4×10^8 m, and the value of the gravitational constant 6×10^{-11} N · m^2/kg^2,

the force between Earth and the moon is approximately

A) 5×10^4 N
B) 2×10^{20} N
C) 3×10^{50} N
D) 7×10^{30} N
E) 3×10^{28} N

248. Halley's comet returns to the vicinity of the sun (and Earth) about once every 76 years. Its last appearance was in 1986. What is the average distance from Halley's comet to the sun, given that the average distance from Earth to the sun is 1.50×10^{11}m?

A) 6.4×10^{11} m
B) 1.8×10^{12} m
C) 2.7×10^{12} m
D) 1.1×10^{13} m
E) 9.9×10^{13} m

249. Two satellites of the same mass are placed in orbits around Earth. Satellite One is at an altitude of $1R_E$ and Satellite Two at an altitude of $2R_E$ where R_E = 6370 km is the radius of Earth. What is the ratio of the potential energy of Satellite One to Satellite Two?

A) $\frac{1}{2}$
B) 2/3
C) 3/2
D) $\frac{1}{4}$
E) 2

250. Two satellites, one in geosynchronous orbit (T = 24 hrs) and one with a period of 12 hrs, are orbiting Earth. How many times larger than the radius of Earth is the distance between the orbits of the two satellites. (Mass(Earth) = 5.98×10^{24} kg, $G = 6.67 \times 10^{-11}$ N·m^2, g = 9.81 m/s^2, radius(Earth) = 6.38×10^6 m)

A) 0.51
B) 2.0
C) 6.6
D) 5.7
E) none of the above

GOOD LUCK
and
BEST REGARDS