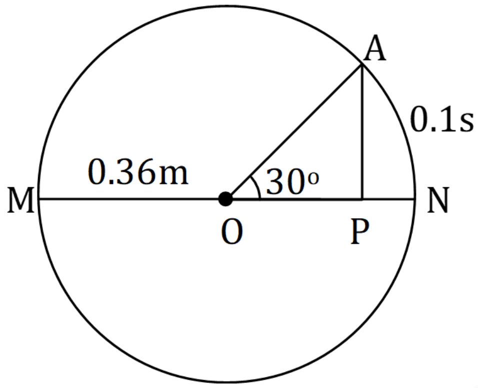
1. The point A moves with a uniform speed along the circumference of a circle of radius $0.36 \mathrm{~m}$ and cover 30° in $0.1 \mathrm{~s}$. The perpendicular projection $'P'$ from $'A'$ on the diameter MN represents the simple harmonic motion of $'P'$. The restoring force per unit mass when P touches M will be:



A. $100 \mathrm{~N}$

B. $50 \mathrm{~N}$

C. $9.87 \mathrm{~N}$

D. $0.49 \mathrm{~N}$

2. Statement I : A cyclist is moving on an unbanked road with a speed of $7 \mathrm{~kmh}^{-1}$ and takes a sharp circular turn along a path of radius of $2 \mathrm{~m}$ without reducing the speed. The static friction coefficient is 0.2. The cyclist will not slip and pass the curve.
$\left(g=10 \mathrm{~m} / \mathrm{s}^2\right)$

Statement II : If the road is banked at an angle of 45°, cyclist can cross the curve of $2 \mathrm{~m}$ radius with the speed of $15 \mathrm{~kmh}^{-1}$ without slipping.

In the light of the above statements, choose the correct answer from the options given below.

A. Both statement I and statement II are false

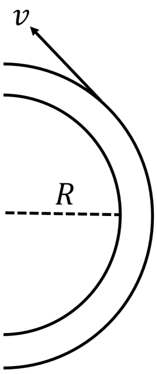
B. Both statement I and statement II are true

C. Statement I is correct and statement II is incorrect

D. Statement I is incorrect and statement II is correct

3. A modern Grand Prix racing car of mass m is travelling on a flat track in a circular arc of radius R with a speed v. If the coefficient of static friction between the tyres and the track is μ_s, then the magnitude of negative lift F_1 acting downwards on the car is -

(Assume forces on the four tyres are identical and $g =$ acceleration due to gravity)



A. $m\left(\frac{v^2}{\mu_s R} - g\right)$

B. $m\left(\frac{v^2}{\mu_s R} + g\right)$

C. $m\left(g - \frac{v^2}{\mu_s R}\right)$

D. $-m\left(g + \frac{v^2}{\mu_s R}\right)$

4. If the angular velocity of earth's spin is increased such that the bodies at the equator start floating, the duration of the day would be approximately :

($g = 10\ \mathrm{ms}^{-2}$, radius of earth, $R = 6400 \times 10^3\ \mathrm{m}, \pi = 3.14$)

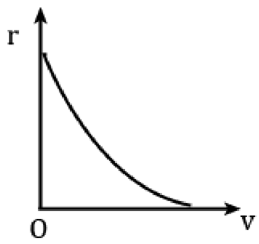
A. 60 minutes

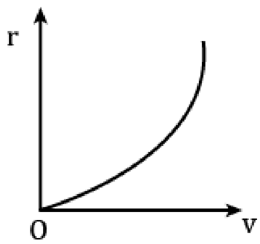
B. Does not change

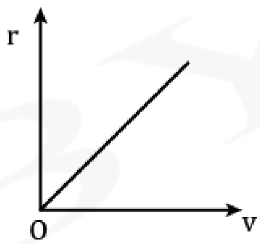
C. 84 minutes

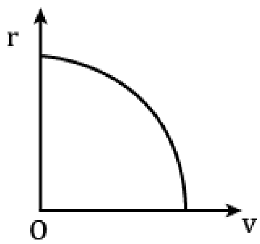
D. 1200 minutes

5. A particle of mass m moves in a circular orbit under the central potential field, $U(r) = \frac{-c}{r}$, where c is positive constant. The correct radius(r)-velocity (v) graph of the particle's motion is :

A. 

B. 

C. 

D. 

6. A spring mass system (mass m, spring constant k and natural length of spring l) rests in equilibrium, on a horizontal disc. The free end of the spring is fixed at the centre of the disc. If the disc, together with spring mass system, rotates about it's axis with an angular velocity ω, $(k >> m\omega^2)$ the relative change in the length of the spring is best given by the option:

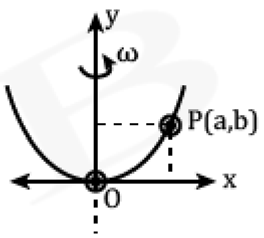
A. $\sqrt{\frac{2}{3}\left(\frac{m\omega}{k}\right)}$

B. $\frac{2m\omega^2}{k}$

C. $\frac{m\omega^2}{k}$

D. $\frac{m\omega^2}{3k}$

7. A bead of mass m stays at point $P(a, b)$ on a wire bent in the shape of a parabola $y = 4Cx^2$ and rotating with angular speed ω (see figure). The value of ω is (neglect friction)



A. $2\sqrt{2gC}$

B. $2\sqrt{gC}$

C. $\sqrt{\frac{2gC}{ab}}$

D. $\sqrt{\frac{2g}{C}}$

8. A clock has a continuously moving second's hand of $0.1 \mathrm{~m}$ length. The average accelaration of the tip of the hand (in units of ms^{-2}) is of the order of :

A. 10^{-3}

B. 10^{-4}

C. 10^{-2}

D. 10^{-1}

9. A body is projected at $t=0$ with a velocity $10 \mathrm{~ms}^{-1}$ at an angle of 60° with the horizontal. The radius of curvature of its trajectory at $t=1 \mathrm{~s}$ is R. Neglecting air resistance and taking acceleration due to gravity $g=10 \mathrm{~ms}^{-2}$, the value of R is:
$(\text{Take: } \tan 15^{\circ}=0.268 ; \cos 15^{\circ}=0.966)$

A. $10.3 \mathrm{~m}$

B. $2.8 \mathrm{~m}$

C. $2.5 \mathrm{~m}$

D. $5.1 \mathrm{~m}$

10. The normal reaction N for a vehicle of $800 \mathrm{~kg}$ mass, negotiating a turn on a 30° banked road at maximum possible speed without skidding is ______ $\times 10^{3} \mathrm{~kg}\text{-}\mathrm{m} / \mathrm{s}^{2}$.

Take $\cos 30^{\circ}=0.87$ and $\mu=0.2$

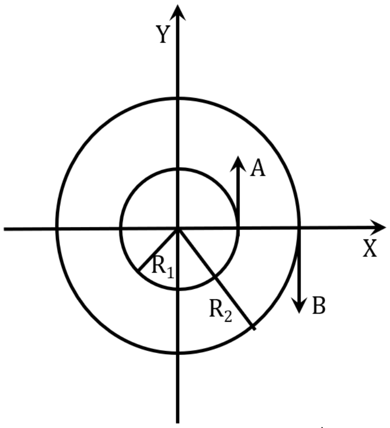
A. 10.2

B. 7.2

C. 12.4

D. 6.96

11. Two particles A and B are moving on two concentric circles of radii R_1 and R_2 with equal angular speed ω. At $t = 0$, their positions and direction of motion are shown in the figure:



The relative velocity $\overrightarrow{v_A} - \overrightarrow{v_B}$ at $t = \dfrac{\pi}{2\omega}$ is given by:

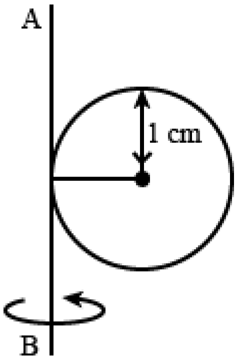
A. $\omega(R_1 + R_2)\hat{i}$

B. $-\omega(R_1 + R_2)\hat{i}$

C. $\omega(R_2 - R_1)\hat{i}$

D. $\omega(R_1 - R_2)\hat{i}$

12. A metal coin of mass $5\ \mathrm{g}$ and radius $1\ \mathrm{cm}$ is fixed to a thin stick AB of negligible mass as shown in the figure The system is initially at rest. The constant torque, that will make the system rotate about AB at 25 rotations per second in $5\ \mathrm{s}$, is close to :



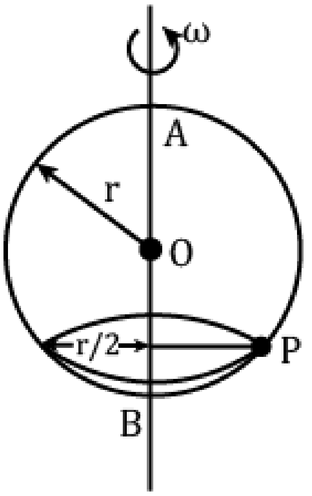
A. $4.0 \times 10^{-6}\ \mathrm{Nm}$

B. $1.6 \times 10^{-5}\ \mathrm{Nm}$

C. $7.9 \times 10^{-6}\ \mathrm{Nm}$

D. $2.0 \times 10^{-5}\ \mathrm{Nm}$

13. A smooth wire of length $2\pi r$ is bent into a circle and kept in a vertical plane. A bead can slide smoothly on the wire. When the circle is rotating with angular speed ω about the vertical diameter AB, as shown in figure, the bead is at rest with respect to the circular ring, at position P, as shown. Then the value of ω^2 is equal to :



A. $\frac{\sqrt{3g}}{2r}$

B. $\frac{2g}{(r\sqrt{3})}$

C. $\frac{(g\sqrt{3})}{r}$

D. $\frac{2g}{r}$

14. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the n^{th} power of R. If the period of rotation of the particle is T, then

A. $T \propto R^{(n+1)/2}$

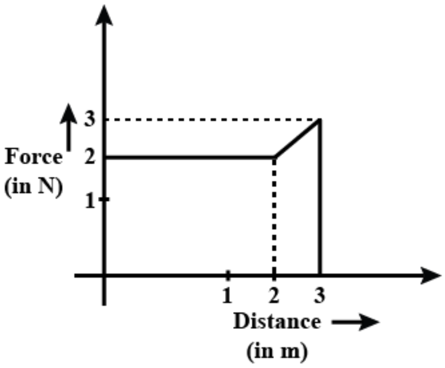
B. $T \propto R^{n/2}$

C. $T \propto R^{3/2}$ for any n

D. $T \propto R^{\frac{n}{2}+1}$

Topic : Work Power Energy

1. A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the figure. The kinetic energy of the particle after it has travelled $3\ m$ is



A. $6.5\ J$

B. $2.5\ J$

C. $4\ J$

D. $5\ J$

2. A particle is moving in a circular path of radius a under the action of an attractive potential energy $U = -\frac{k}{2r^2}$. Its total energy is

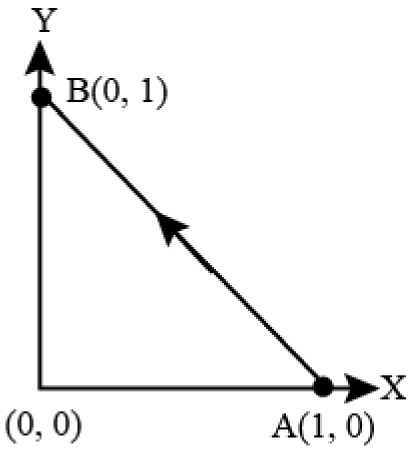
A. zero

B. $-\frac{3}{2}\frac{\mathrm{k}}{\mathrm{a}^2}$

C. $\frac{k}{4a^2}$

D. $\frac{k}{2a^2}$

3. Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force, in moving a particle, from point $A(1,0)$ to $B(0,1)$, along the line segment is: (all quantities are in SI units)



A. 2

B. $\frac{1}{2}$

C. 1

D. $\frac{3}{2}$

4. A time dependent force $F = 6t$ acts on a particle of mass $1\,kg$. If the particle starts from rest, the work done by the force during the first 1 sec will be

A. $18\,J$

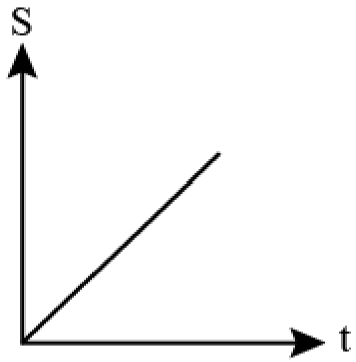
B. $22\,J$

C. $4.5\,J$

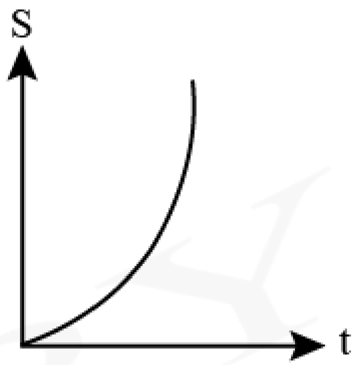
D. $9\,J$

5. A particle is moving unidirectionally on a horizontal plane under the action of a constant power supplying energy source. The displacement(S) - time (t) graph that describes the motion of the particle is (graphs are drawn schematically and are not to scale):

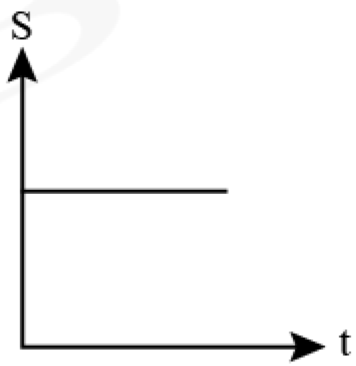
A.



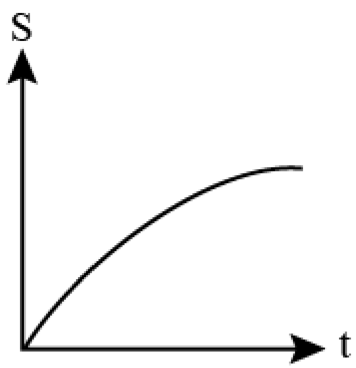
B.



C.



D.



6. A body of mass $m = 10^{-2}\ kg$ is moving in a medium and experiences a frictional force $F = -kv^2$. Its initial speed is $v_0 = 10\ ms^{-1}$. If, after $10\ s$, its energy is $\frac{1}{8}mv_0^2$, the value of k will be

A. $10^{-3}\ kg\, m^{-1}$

B. $10^{-3}\ kg\ s^{-1}$

C. $10^{-4}\ kg\, m^{-1}$

D. $10^{-1}\ kg\, m^{-1}s^{-1}$

7. A person trying to lose weight by burning fat lifts a mass of $10\ kg$ upto a height of $1\ m$, 1000 times. Assume that the potential energy lost each time he lowers the mass is dissipated. How much fat will he use up considering the work is done only when the weight is lifted up? Fat supplies $3.8 \times 10^7\ J$ of energy per kg which is converted to mechanical energy with a 20% efficiency rate. Take $g = 9.8\ ms^{-2}$.

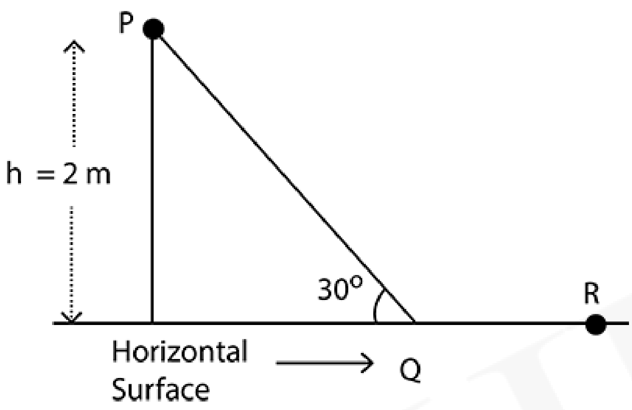
A. $2.45 \times 10^{-3}\ kg$

B. $6.45 \times 10^{-3}\ kg$

C. $9.89 \times 10^{-3}\ kg$

D. $12.89 \times 10^{-3}\ kg$

8. A point particle of mass m, moves along the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ. The particle is released, from rest, from the point P and it comes to rest at a point R. The energies, lost by the ball, over the parts, PQ and QR, of the track, are equal to each other, and no energy is lost when the particle changes direction from PQ to QR. The values of the coefficient of friction μ and the distance $x\ (=QR)$, are respectively close to



A. 0.2 and $6.5\ m$

B. 0.2 and $3.5\ m$

C. 0.29 and $3.5\ m$

D. 0.29 and $6.5\ m$

9. A $60\ HP$ electric motor lifts an elevator with a maximum total load capacity of $2000\ kg$. If the frictional force on the elevator is $4000\ N$, the speed of the elevator at full load is close to (Given $1\ HP = 746\ W$, $g = 10\ m/s^2$)

A. $1.5\ m/s$

B. $2.0\ m/s$

C. $1.7\ m/s$

D. $1.9\ m/s$

10. An elevator in a building can carry a maximum of 10 persons, with the average mass of each person being $68\ \mathrm{kg}$. The mass of the elevator itself is $920\ \mathrm{kg}$ and it moves with a constant speed of $3\ \mathrm{ms^{-1}}$. The frictional force opposing the motion is $6000\ \mathrm{N}$. If the elevator is moving up with its full capacity, the power delivered by the motor to the elevator $(g = 10\ \mathrm{ms^{-2}})$ must be at least

A. $56300\ \mathrm{W}$

B. $62360\ \mathrm{W}$

C. $48000\ \mathrm{W}$

D. $66000\ \mathrm{W}$

11. A person pushes a box on a rough horizontal platform surface. He applies a force of $200\ \mathrm{N}$ over a distance of $15\ \mathrm{m}$. Thereafter, he gets progressively tired, and his applied force reduces linearly with distance to $100\ \mathrm{N}$. The total distance through which the box has been moved, is $30\ \mathrm{m}$. What is the work done by the person, during the total movement of the box ?

A. $3280\ \mathrm{J}$

B. $2780\ \mathrm{J}$

C. $5690\ \mathrm{J}$

D. $5250\ \mathrm{J}$

12. If the potential energy between two molecules is given by $U = -\frac{A}{r^6} + \frac{B}{r^{12}}$, then at equilibrium, separation between molecules and the potential energy respectively are:

A. $\left(\frac{B}{2A}\right)^{\frac{1}{6}}, -\left(\frac{A^2}{2B}\right)$

B. $\left(\frac{B}{A}\right)^{\frac{1}{6}}, 0$

C. $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, -\left(\frac{A^2}{4B}\right)$

D. $\left(\frac{2B}{A}\right)^{\frac{1}{6}}, \left(\frac{A^2}{2B}\right)$

13. A particle moving in the xy plane experiences a velocity dependent force $\vec{F} = k(v_y\hat{i} + v_x\hat{j})$, where v_x and v_y are x and y components of its velocity $\vec{v}$. If $\vec{a}$ is the acceleration of the particle, then which of the following statements is true for the particle?

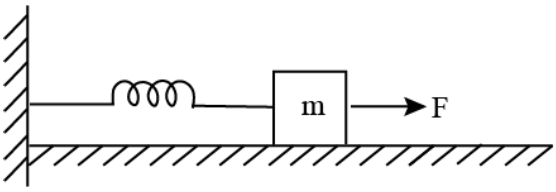
A. Quantity $\vec{v} \times \vec{a}$ is constant in time

B. $\vec{F}$ arises due to a magnetic field

C. Kinetic energy of particle is constant in time

D. Quantity $\vec{v} . \vec{a}$ is constant in time

14. A block of mass m, lying on a smooth horizontal surface, is attached to a spring (of negligible mass) of spring constant k. The other end of the spring is fixed, as shown in the figure. The block is initially at rest in its equilibrium position. If now the block is pulled with a constant force F, the maximum speed of the block is:



A. $\frac{2F}{\sqrt{mk}}$

B. $\frac{F}{\pi\sqrt{mk}}$

C. $\frac{\pi F}{\sqrt{mk}}$

D. $\frac{F}{\sqrt{mk}}$

15. A force acts on a $2\ \mathrm{kg}$ object so that its position is given as a function of time as $x = 3t^2 + 5$. What is the work done by this force in first 5 seconds ?

A. $850\ \mathrm{J}$

B. $950\ \mathrm{J}$

C. $875\ \mathrm{J}$

D. $900\ \mathrm{J}$

16. A particle which is experiencing a force, given by $\vec{F} = 3\hat{i} - 12\hat{j}$, undergoes a displacement of $\vec{d} = 4\hat{i}$. If the particle had a kinetic energy of 3 J at the beginning of the displacement, what is its kinetic energy at the end of the displacement ?

A. 9 J

B. 12 J

C. 10 J

D. 15 J

17. A body of mass 1 kg falls freely from a height of 100 m, on a platform of mass 3 kg which is mounted on a spring having spring constant $k = 1.25 \times 10^6\ \mathrm{Nm}^{-1}$. The body sticks to the platform, and the spring's maximum compression is found to be x. Given that $g = 10\ \mathrm{ms}^{-2}$, the value of x will be close to:

A. 40 cm

B. 4 cm

C. 80 cm

D. 8 cm

18. A uniform cable of mass $'M'$ and length $'L'$ is placed on a horizontal surface such that its $\left(\frac{1}{n}\right)^{th}$ part is hanging below the edge of the surface. To lift the hanging part of the cable upto the surface, the work done should be

A. $\dfrac{MgL}{2n^2}$

B. $\dfrac{MgL}{n^2}$

C. $\dfrac{2MgL}{n^2}$

D. $nMgL$

19. A wedge of mass $M = 4m$ lies on a frictionless plane. A particle of mass m approaches the wedge with speed v. There is no friction between the particle and the plane or between the particle and the wedge. The maximum height climbed by the particle on the wedge is given by-

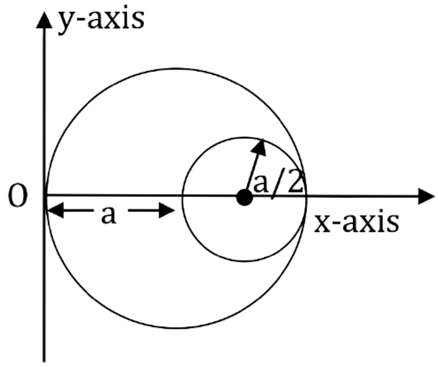
A. $\frac{v^2}{g}$

B. $\frac{2v^2}{7g}$

C. $\frac{2v^2}{5g}$

D. $\frac{v^2}{2g}$

1. A circular hole of radius $\frac{a}{2}$ is cut out of a circular disc of radius $'a'$ shown in the figure. The centroid of the remaining circular portion with respect to point $'O'$ will be :



A. $\frac{10}{11}a$

B. $\frac{2}{3}a$

C. $\frac{1}{6}a$

D. $\frac{5}{6}a$

2. Two masses A and B, each of mass M are fixed together by a massless spring. A force acts on the mass B as shown in the figure. If the mass A starts moving away from mass B with acceleration 'a', then the acceleration of mass B will be :

A. $\frac{F+Ma}{M}$

B. $\frac{F-Ma}{M}$

C. $\frac{Ma-F}{M}$

D. $\frac{MF}{F+Ma}$

3. Three point particles of mass 1 kg, 1.5 kg and 2.5 kg are placed at three corners of a right triangle of sides 4.0 cm, 3.0 cm and 5.0 cm as shown in the figure. The centre of mass of the system is at the point:

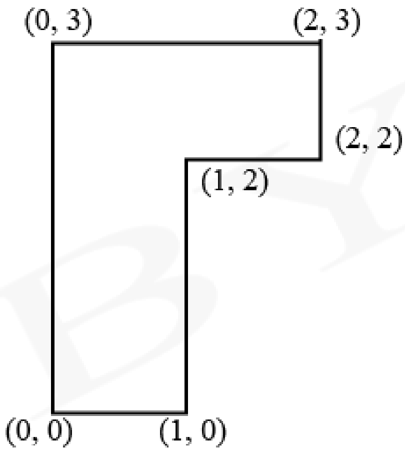
A. 0.9 cm right and 2.0 cm above 1 kg mass

B. 2.0 cm right and 0.9 cm above 1 kg mass

C. 1.5 cm right and 1.2 cm above 1 kg mass

D. 0.6 cm right and 2.0 cm above 1 kg mass

4. The coordinates of centre of mass of a uniform flag shaped lamina (thin flat plate) of mass $4\ \mathrm{kg}$. (The coordinates of the same are shown in figure) are:



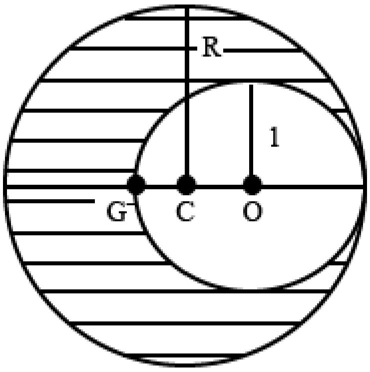
A. $1.25\ \mathrm{m}, 1.50\ \mathrm{m}$

B. $0.75\ \mathrm{m}, 1.75\ \mathrm{m}$

C. $0.75\ \mathrm{m}, 0.75\ \mathrm{m}$

D. $1\ \mathrm{m}, 1.75\ \mathrm{m}$

5. As shown in fig. when a spherical cavity $(\text{centred at } O)$ of radius 1 is cut out of a uniform sphere of radius R $(\text{centred at } C)$, the centre of mass of remaining (shaded) part of sphere is at G, i.e on the surface of the cavity. R can be determined by the equation



A. $\left(R^2+R+1\right)(2-R)=1$

B. $\left(R^2-R-1\right)(2-R)=1$

C. $\left(R^2-R+1\right)(2-R)=1$

D. $\left(R^2+R-1\right)(2-R)=1$

6. A rod of length L has non-uniform linear mass density given by $\rho(x)=a+b\left(\frac{a}{L}\right)^2$, where a and b are constants and $0 \leq x \leq L$. The value of x for the centre of mass of the rod is at:

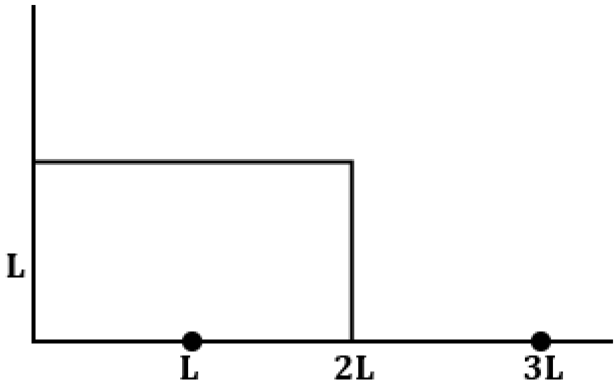
A. $\frac{3}{2}\left(\frac{a+b}{2a+b}\right)L$

B. $\frac{3}{4}\left(\frac{2a+b}{3a+b}\right)L$

C. $\frac{4}{3}\left(\frac{a+b}{2a+3b}\right)L$

D. $\frac{3}{2}\left(\frac{2a+b}{3a+b}\right)L$

7. The position vector of the centre of mass r_{cm} of an asymmetric uniform bar of negligible area of cross - section as shown in figure is:



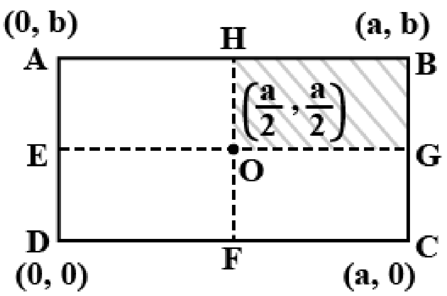
A. $\vec{r}_{\mathrm{cm}} = \frac{13}{8}L\hat{x} + \frac{5}{8}L\hat{y}$

B. $\vec{r}_{\mathrm{cm}} = \frac{5}{8}L\hat{x} + \frac{13}{8}L\hat{y}$

C. $\vec{r}_{\mathrm{cm}} = \frac{3}{8}L\hat{x} + \frac{11}{8}L\hat{y}$

D. $\vec{r}_{\mathrm{cm}} = \frac{11}{8}L\hat{x} + \frac{3}{8}L\hat{y}$

8. A uniform rectangular thin sheet ABCD of mass M has length a and breadth b, as shown in the figure. If the shaded portion HBGO is cut-off, the coordinates of the centre of mass of the remaining portion will be:



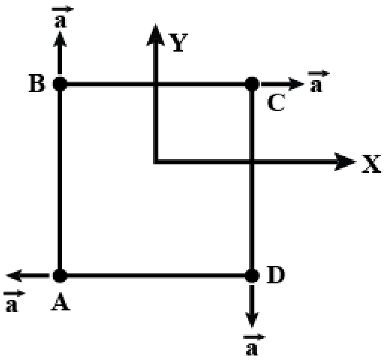
A. $\left(\frac{3a}{4}, \frac{3b}{4}\right)$

B. $\left(\frac{5a}{3}, \frac{5b}{3}\right)$

C. $\left(\frac{2a}{3}, \frac{2b}{3}\right)$

D. $\left(\frac{5a}{12}, \frac{5b}{12}\right)$

9. Four particles A, B, C and D with masses $m_A = m, m_B = 2m, m_C = 3m$ and $m_D = 4m$ are at the corners of a square. They have accelerations of equal magnitude with directions as shown. The acceleration of the centre of mass of the particles is



A. $\frac{a}{5}(\hat{i} - \hat{j})$

B. $\frac{a}{5}(\hat{i} + \hat{j})$

C. Zero

D. $a(\hat{i} + \hat{j})$

10. When a 5 V potential difference is applied across a wire of length $0.1\ m$, the drift speed of electrons is $2.5 \times 10^{-4}\ ms^{-1}$. If the electron density in the wire is $8 \times 10^{28}\ m^{-3}$, the resistivity of the material is close to:

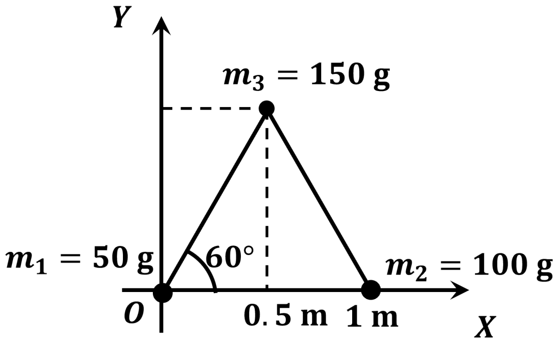
A. $1.6 \times 10^{-8}\ \Omega m$

B. $1.6 \times 10^{-7}\ \Omega m$

C. $1.6 \times 10^{-6}\ \Omega m$

D. $1.6 \times 10^{-5}\ \Omega m$

11. Three particles of masses $50\ \mathrm{g}, 100\ \mathrm{g}$ and $150\ \mathrm{g}$ are placed at the vertices of an equilateral triangle of side $1\ \mathrm{m}$ (asshown in the figure). The (x, y) coordinates of the centre of mass will be :



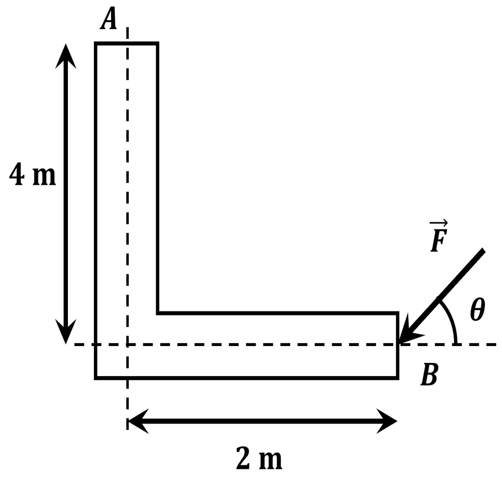
A. $\left(\frac{\sqrt{3}}{4}\mathrm{m}, \frac{5}{12}\mathrm{m}\right)$

B. $\left(\frac{7}{12}\mathrm{m}, \frac{\sqrt{3}}{8}\mathrm{m}\right)$

C. $\left(\frac{7}{12}\mathrm{m}, \frac{\sqrt{3}}{4}\mathrm{m}\right)$

D. $\left(\frac{\sqrt{3}}{8}\mathrm{m}, \frac{7}{12}\mathrm{m}\right)$

12. A force of $40 \mathrm{~N}$ acts on a point B at the end of an $L-$shaped object, as shown in the figure. The angle θ that will produce maximum moment of the force about point A is given by:



A. $\tan\theta = \frac{1}{4}$

B. $\tan\theta = 2$

C. $\tan\theta = \frac{1}{2}$

D. $\tan\theta = 4$

13. In a physical balance working on the principle of moments, when $5 \mathrm{~mg}$ weight is placed on the left pan, the beam becomes horizontal. Both the empty pans of the balance are of equal mass. Which of the following statements is correct?

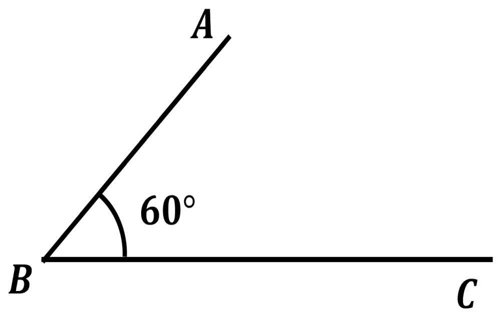
A. Left arm is longer than the right arm

B. Both the arms are of same length

C. Left arm is shorter than the right arm

D. Every object that is weighed using this balance appears lighter than its actual weight.

14. In the figure shown ABC is a uniform wire. If centre of mass of wire lies vertically below point A, then $\frac{BC}{AB}$ is close to :



A. 1.85

B. 1.5

C. 1.37

D. 3

15. A uniform thin rod AB of length L has linear mass density $\mu(x) = a + \frac{bx}{L}$, where x is measured from A. If the CM of the rod lies at a distance of $\left(\frac{7}{12}\right) L$ from A, then a and b are related as :

A. $a = 2b$

B. $2a = b$

C. $a = b$

D. $3a = 2b$

16. A thin bar of length L has a mass per unit length λ, that increases linearly with distance form one end. If its total mass is M and its mass per unit legth at the lighter end is λ_0, then the distance of the center of mass from the lighter end is:

A. $\dfrac{L}{2} - \dfrac{\lambda_0 L^2}{4M}$

B. $\dfrac{L}{3} + \dfrac{\lambda_0 L^2}{8M}$

C. $\dfrac{L}{3} + \dfrac{\lambda_0 L^2}{4M}$

D. $\dfrac{2L}{3} - \dfrac{\lambda_0 L^2}{6M}$

17. A boy of mass $20\ \mathrm{kg}$ is standing on a $80\ \mathrm{kg}$ free to move long cart. There is negligible friction between cart and ground. Initially, the boy is standing $25\ \mathrm{m}$ from a wall. If he walks $10\ \mathrm{m}$ on the cart towards the wall, then the final distance of the boy from the wall will be

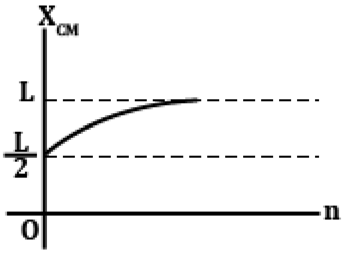
A. $15\ \mathrm{m}$

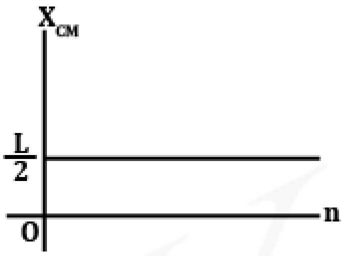
B. $12.5\ \mathrm{m}$

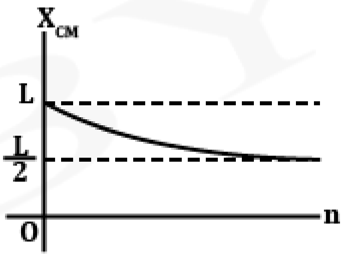
C. $15.5\ \mathrm{m}$

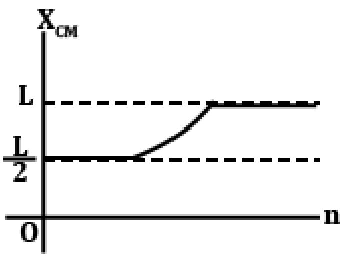
D. $17\ \mathrm{m}$

18. A thin rod of length $'L'$ is lying along the x-axis with its ends at $x=0$ and $x=L$. Its linear density $\left(\frac{\text{mass}}{\text{length}}\right)$ varies with x as $k\left(\frac{x}{L}\right)^n$, where n can be zero or any positive number. If the position x_{cm} of the center of mass of the rod is plotted against $'n'$ which of the following graphs best approximates the dependence of x_{cm} on n?

A. 

B. 

C. 

D. 

19. A circular disc of radius R is removed from a bigger circular disc of radius $2R$ such that the circumferences of the discs coincide. The center of mass of the new disc is $\frac{\alpha}{R}$ from the center of the bigger disc. The value of α is

A. $\frac{1}{4}$

B. $\frac{1}{3}$

C. $\frac{1}{2}$

D. $\frac{1}{6}$

20. Consider a two particle system with particles having masses m_1 and m_2. If the first particle is pushed towards the centre of mass through a distance d by what distance should the second particle is moved, so as to keep the centre of mass at the same position?

A. $\frac{m_2}{m_1}d$

B. $\frac{m_1}{m_1+m_2}d$

C. $\frac{m_1}{m_2}d$

D. d

21. A body A of mass M while falling vertically downwards under gravity breaks into two parts; abody B of mass $\frac{1}{3}M$ ad a body C of mass $\frac{2}{3}M$. The center of mass of bodies B and C taken together shifts compared to that of body A towards.

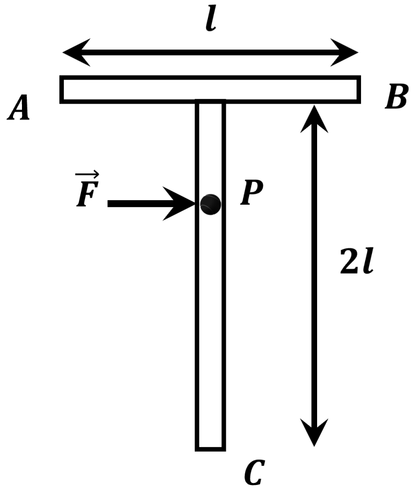
A. does not shift

B. depends on height of breaking

C. body B

D. body C

22. A $'T'$ shaped object with dimensions shown in figure, is lying on a smooth floor. A force $\vec{F}$ is applied at the point P parallel to AB, such that the object has only the translational motion without rotation. Find the location of P with respect to C.



A. $\frac{3}{2}l$

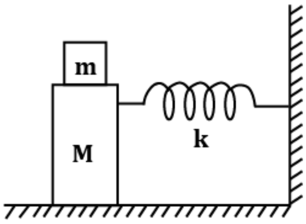
B. $\frac{2}{3}l$

C. l

D. $\frac{4}{3}l$

Topic : Collision

1. In the given figure, a mass M is attached to a horizontal spring, which is fixed on one side to a rigid support. The spring constant of the spring is k. The mass oscillates on a frictionless surface with time period T and amplitude A. When the mass is in equilibrium position, as shown in the figure, another mass m is gently fixed upon it then the new amplitude of oscillation will be :



A. $A\sqrt{\frac{M}{M+m}}$

B. $A\sqrt{\frac{M}{M-m}}$

C. $A\sqrt{\frac{M-m}{M}}$

D. $A\sqrt{\frac{M+m}{M}}$

2. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: Body P having mass M moving with speed u has head-on collision elastically with another body Q having mass m initially at rest. If $m << M$, body Q will have a maximum speed equal to $2u$ after collision.

Reason R : During elastic collision, the momentum and kinetic energy are both conserved.

In the light of the above statements, choose the most appropriate answer from the options given below:

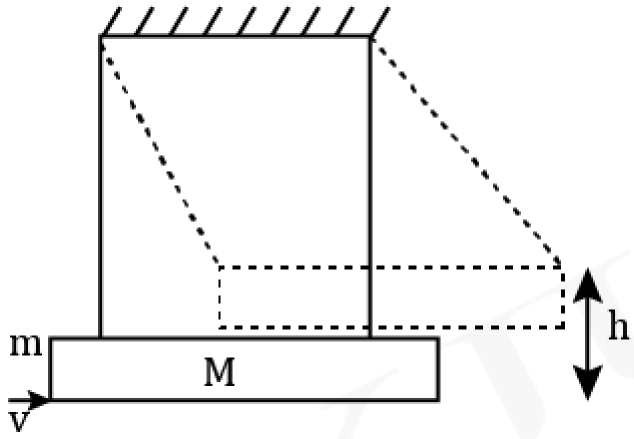
A. A is correct but R is not correct.

B. Both A and R are correct but R is NOT the correct explanation of A.

C. A is not correct but R is correct.

D. Both A and R are correct and R is the correct explanation of A.

3. A large block of wood of mass $M = 5.99 \text{ kg}$ is hanging from two long massless cords. A bullet of mass $m = 10 \text{ g}$ is fired into the block and gets embedded in it. The (block + bullet) then swing upwards, their centre of mass rising a vertical distance $h = 9.8 \text{ cm}$ before the (block + bullet) pendulum comes momentarily to rest at the end of its arc. The speed of the bullet just before collision is: (take $g = 9.8 \text{ ms}^{-2}$)



A. 831.4 m/s

B. 841.4 m/s

C. 811.4 m/s

D. 821.4 m/s

4. A rubber ball is released from a height of 5 m above the floor. It bounces back repeatedly, always rising to $\frac{81}{100}$ of the height through which it falls. Find the average speed of the ball.
(Take $g = 10 \text{ m s}^{-2}$)

A. 2.50 m s^{-1}

B. 3.50 m s^{-1}

C. 3.0 m s^{-1}

D. 2.0 m s^{-1}

5. An object of mass m_1 collides elastically with another object of mass m_2, which is at rest. After the collision, the objects move with equal speeds in opposite directions. The ratio of the masses, $m_2 : m_1$ is -

A. $2 : 1$

B. $1 : 1$

C. $1 : 2$

D. $3 : 1$

6. A bullet of $4\ \mathrm{g}$ mass is fired from a gun of mass $4\ \mathrm{kg}$. If the bullet moves with the muzzle speed of $50\ \mathrm{ms}^{-1}$, the impulse imparted to the gun and velocity of recoil of gun are :

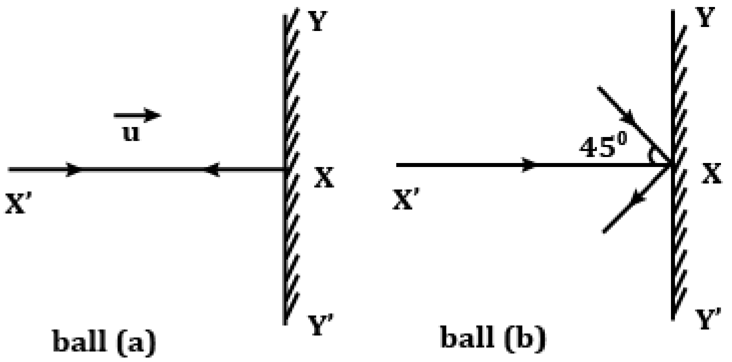
A. $0.4\ \mathrm{kg\ ms}^{-1}, 0.1\ \mathrm{ms}^{-1}$

B. $0.2\ \mathrm{kg\ ms}^{-1}, 0.05\ \mathrm{ms}^{-1}$

C. $0.2\ \mathrm{kg\ ms}^{-1}, 0.1\ \mathrm{ms}^{-1}$

D. $0.4\ \mathrm{kg\ ms}^{-1}, 0.05\ \mathrm{ms}^{-1}$

7. Two billiard balls of equal mass 30 gms strike a rigid wall with the same speed of 108 kmph (as shown) , but at different angles. If the balls get reflected with the same speed, then the ratio of the magnitude of impulses imparted to ball $'a'$ and ball $'b'$ by the wall along $'X'$ direction is :



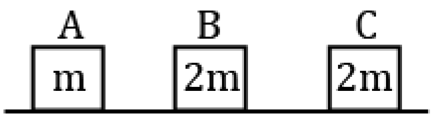
A. $1:1$

B. $\sqrt{2}:1$

C. $2:1$

D. $1:\sqrt{2}$

8. Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. The masses of A, B and C are m, $2\,m$ and $2\,m$ respectively. A moves towards B with a speed of 9 m/s and makes an elastic collision with it. Thereafter B makes a completely inelastic collision with C. All motions occur along same straight line. The final speed of C is :



A. 6 m/s

B. 9 m/s

C. 4 m/s

D. 3 m/s

9. A block moving horizontally on a smooth surface with a speed of $40 \mathrm{~m/s}$ splits into two parts with masses in the ratio of $1:2$ If the smaller part moves at $60 \mathrm{~m/s}$ in the same direction, then the fractional change in kinetic energy is

A. $\frac{1}{8}$

B. $\frac{1}{4}$

C. $\frac{1}{3}$

D. $\frac{2}{3}$

10. A particle of mass m is dropped from a height h above the ground. At the same time another particle of the same mass is thrown vertically upwards from the ground with a speed of $\sqrt{2\,gh}$. If they collide head-on completely inelastically, the time taken for the combined mass to reach the ground, in units of $\sqrt{\frac{h}{g}}$ is

A. $\sqrt{\frac{1}{2}}$

B. $\sqrt{\frac{3}{4}}$

C. $\frac{1}{2}$

D. $\sqrt{\frac{3}{2}}$

11. Two particles of equal mass m, have respective initial velocities $u\hat{i}$ and $u\left(\frac{\hat{i}+\hat{j}}{2}\right)$. They collide completely inelastically. The energy lost in the process is:

A. $\frac{1}{3}mu^2$

B. $\frac{1}{8}mu^2$

C. $\frac{3}{4}mu^2$

D. $\sqrt{\frac{2}{3}}mu^2$

12. A particle of mass m is projected with a speed of u from the ground at an angle $\theta = \frac{\pi}{3}$ w.r.t. horizontal (x-axis). When it has reached its maximum height, it collides completely inelastically with another particle of the same mass and velocity $u\hat{i}$. The horizontal distance covered by the combined mass before reaching the ground is:

A. $\frac{3\sqrt{3}}{8}\frac{u^2}{g}$

B. $\frac{3\sqrt{2}}{4}\frac{u^2}{g}$

C. $\frac{5}{8}\frac{u^2}{g}$

D. $2\sqrt{2}\frac{u^2}{g}$

13. A particle of mass m with an initial velocity $u\hat{i}$ collides elastically with a mass $3m$ at rest. It moves with a velocity $v\hat{j}$ after collision, then, v is given by :

A. $v = \sqrt{\frac{2}{3}}u$

B. $v = \frac{u}{\sqrt{3}}$

C. $v = \frac{u}{\sqrt{2}}$

D. $v = \frac{1}{\sqrt{6}}u$

14. A block of mass $1.9\ \mathrm{kg}$ is at rest at the edge of a table, of height $1\ \mathrm{m}$. A bullet of mass $0.1\ \mathrm{kg}$ collides with the block and sticks to it. If the velocity of the bullet is $20\ \mathrm{ms^{-1}}$ in the horizontal direction just before the collision then the kinetic energy, just before the combined system strikes the floor, is [Take $g = 10\ \mathrm{ms^{-2}}$]. Assume there is no rotational motion and losses of energy after the collision is negligible.

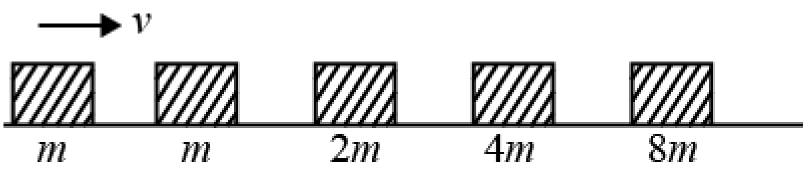
A. $20\ \mathrm{J}$

B. $21\ \mathrm{J}$

C. $19\ \mathrm{J}$

D. $23\ \mathrm{J}$

15. Blocks of masses $m,\ 2m,\ 4m$ and $8m$ are arranged in a line on a frictionless floor. Another block of mass m, moving with speed v along the same line (as shown) collides with mass m in a perfectly inelastic manner. All the subsequent collisions are also perfectly inelastic. By the time the last block of mass $8m$ starts moving, the total energy loss is $p\%$ of the original energy. The value of p is close to-



A. 77

B. 94

C. 37

D. 87

16. Particle A of mass m_1 moving with velocity $(\sqrt{3}\hat{i}+\hat{j})\ \mathrm{ms}^{-1}$ collides with another partice B of mass m_2 which is at rest initially. Let $\overrightarrow{V_1}$ and $\overrightarrow{V_2}$ be the velocities of particles A and B after collision respectively. If $m_1=2m_2$ and after collision $\overrightarrow{V_1}=(\hat{i}+\sqrt{3}\hat{j})\mathrm{ms}^{-1}$, the angle between $\overrightarrow{V_1}$ and $\overrightarrow{V_2}$ is :

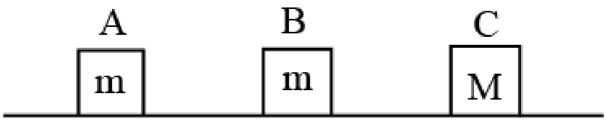
A. 15°

B. 60°

C. -45°

D. 105°

17. Three block A, B and C are lying on a smooth horizontal surface, as shown in the figure. A and B have equal masses, m while C has mass M. Block A is given an initial speed v towards B due to which it collides with B perfectly inelastically. The combined mass collides with C, also perfectly inelastically $\frac{5^{th}}{6}$ of the initial kinetic energy is lost in the whole process. What is the value of $\frac{M}{m}$?



A. 5

B. 2

C. 4

D. 3

18. A piece of wood of mass $0.03\ \mathrm{kg}$ is dropped from the top of a $100\ \mathrm{m}$ height building. At the same time, a bullet of mass $0.02\ \mathrm{kg}$ is fired vertically upward, with a velocity $100\ \mathrm{ms^{-1}}$, from the ground. The bullet gets embedded in the wood. Then the maximum height to which the combined system reaches above the top of the building before falling below is: $(g = 10\ \mathrm{ms^{-2}})$

A. $20\ \mathrm{m}$

B. $30\ \mathrm{m}$

C. $40\ \mathrm{m}$

D. $10\ \mathrm{m}$

19. An alpha-particle of mass m suffers $1-$dimensional elastic collision with a nucleus at rest of unknown mass. It is scattered directly backwards losing, 64% of its initial kinetic energy. The mass of the nucleus is:

A. $2m$

B. $3.5\ m$

C. $1.5\ m$

D. $4\ m$

20. A body of mass m_1 moving with an unknown velocity of $v_1\hat{i}$, undergoes a collinear collision with a body of mass m_2 moving with a velocity $v_2\hat{i}$. After collision, m_1 and m_2 move with velocities of $v_3\hat{i}$ and $v_4\hat{i}$, respectively.
If $m_2 = 0.5\ \mathrm{m}_1$ and $v_3 = 0.5 v_1$ then v_1 is equal to,

A. $v_4 - \frac{v_2}{2}$

B. $v_4 - v_2$

C. $v_4 - \frac{v_2}{4}$

D. $v_4 + v_2$

21. A body of mass $2\ \mathrm{kg}$ makes an elastic collision with a second body at rest and continues to move in the original direction but with one fourth of its original speed. What is the mass of the second body ?

A. $1\ \mathrm{kg}$

B. $1.5\ \mathrm{kg}$

C. $1.8\ \mathrm{kg}$

D. $1.2\ \mathrm{kg}$

22. A particle of mass m is moving with speed $2v$ and collides with a mass $2m$ moving with speed v in the same direction. After collision, the first mass is stopped completely while the second one splits into two particles each of mass m, which move at angle 45° with respect to the original direction. The speed of each of the moving particle will be-

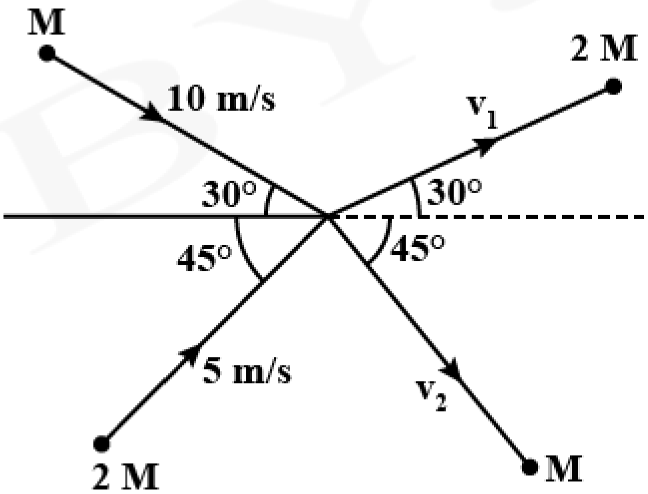
A. $\sqrt{2}v$

B. $2\sqrt{2}v$

C. $\frac{v}{2\sqrt{2}}$

D. $\frac{v}{\sqrt{2}}$

23. Two particles, of masses M and $2M$, moving, as shown, with speeds of $10\ \mathrm{m/s}$ and $5\ \mathrm{m/s}$, collide elastically at the origin. After the collision, they move along the indicated directions with speeds v_1 and v_2, respectively. The values of v_1 and v_2 are nearly



A. $6.5\ \mathrm{m/s}$ and $6.3\ \mathrm{m/s}$

B. $3.2\ \mathrm{m/s}$ and $6.3\ \mathrm{m/s}$

C. $6.5\ \mathrm{m/s}$ and $3.2\ \mathrm{m/s}$

D. $3.2\ \mathrm{m/s}$ and $12.6\ \mathrm{m/s}$

24. A particle of mass m moving in the x direction with speed $2v$ is hit by another particle of mass $2m$ moving in the y direction with speed v. If the collision is perfectly inelastic, the percentage loss in the energy during the collision is close to

A. 50%

B. 56%

C. 62%

D. 44%

25. A satellite of mass M is in a circular orbit of radius R about the centre of the earth. A meteorite of the same mass falling towards the earth, collides with the satellite completely inelastically. The speeds of the satellite and the meteorite are the same, just before the collision. The subsequent motion of the combined body will be

A. such that it escape to infinity

B. In an elliptical orbit

C. in the same circular orbit of radius R

D. in a circular orbit of a different radius

26. A simple pendulum, made of a string of length l and a bob of mass m, is released from a small angle θ_0. It strikes a block of mass M kept on a horizontal surface at its lowest point of oscillations, elastically. It bounces back and goes up to an angle θ_1. The M is given by :

A. $\frac{m}{2}\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$

B. $m\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$

C. $m\left(\frac{\theta_0+\theta_1}{\theta_0-\theta_1}\right)$

D. $\frac{m}{2}\left(\frac{\theta_0-\theta_1}{\theta_0+\theta_1}\right)$