1. Choose the correct statement (s) from the following ;

(i) In an elastic collision of two bodies, the momentum and energy of each body is conserved.

(ii) The work done by a force on a body in nature, over a closed loop is always zero.

(iii) In an inelastic collision of two bodies, the final kinetic energy is less than the initial kinetic energy of the system.

(a) (i) (b) (ii)

(c) (iii) (d) all

MSLIVE

2. A massive ball moving with speed v collides head on with a tiny ball having mass very much smaller than the mass of the first ball. If the collision is completely elastic, then the speed of the second ball after the collision approximately equal to ;

(a) v (b) $2\,v$

(c) $\frac{v}{2}$ (d) ∞

MSLIVE

3. Two particles having position vectors $\vec{r}_1 = (3\,\vec{i} + 5\,\vec{j})$ meter and $\vec{r}_2 = (-5\,\vec{i} - 3\,\vec{j})$ meter are moving with velocities $\vec{v}_1 = (4\,\vec{i} + 3\,\vec{j})$ m/s and $\vec{v}_2 = (a\,\vec{i} + 7\,\vec{j})$ m/s. If they collide after 2 second, the value of a ;

(a) 2 (b) 4

(c) 6 (d) 8

MSLIVE

4. A ball '*A*' of mass 1 kg, moving with speed of 12 m/s, collides obliquely and elastically with another ball *B* which was initially at rest. Ball *A* then moves off at right angles to its direction with a speed of 5 m/s. The momentum of ball *B* after collision is ;

(a) 5 kg m/s
(b) 11 kg m/s
(c) 13 kg m/s
(d) 17 kg m/s

MSLIVE

5. A particle of mass 4 m which is at rest explodes into three fragments. Two of fragments, each of mass m are found to move with a speed v each in mutually perpendicular directions. The total energy released in the process is ;

(a) $\frac{1}{2} mv^2$ (b) mv^2

(c) $\frac{3}{2} mv^2$ (d) $\frac{5}{2} mv^2$

MSLIVE

6. If the masses of two balls be as 3 : 2 and their respective velocities before impact be as 2 : 3 and in opposite directions, and the coefficient of restitution is 2/3, find with what velocity will each ball move back with respect to the original velocity.

(a) 1/3 times the original velocity

(b) 2/3 times the original velocity

(c) 3/1 times the original velocity

(d) 3/2 times the original velocity

MSLIVE

7. A particle of mass m moving with a velocity u makes an elastic one dimensional collision with a stationary particle of mass m establishing a contact with if for extremely small time T. Their force of contact increases form zero to F_0 linearly in time $T/4$, remains constant for a further time $T/2$ and decreases linearly from F_0 to zero in further time $T/4$ as shown. The magnitude possessed by F_0 is

(a) $\frac{mu}{T}$

(b) $\frac{2mu}{T}$

(c) $\frac{4mu}{3T}$

(d) $\frac{3mu}{4T}$

MSLIVE

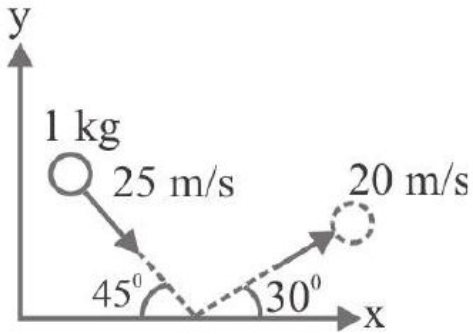
8. A ball of mass 1 kg bounces against the ground as shown in the figure. The approaching velocity is 25 m/s and the velocity after hitting the ground is 20 m/s. The impulse exerted on the ball is :

(a) 7.8 N - s

(b) 27.68 N - s

(c) 31 N - s

(d) 62 N - s



MSLIVE

9. An intense stream of water of cross–sectional area A strikes a wall at an angle θ with the normal to the wall and returns back elastically. If the density of water is ρ and its velocity is v, then the force exerted in the wall will be

(a) $2Av^2\rho \cos\theta$ (b) $2Av^2\rho \cos\theta$

(c) $2Av^2\rho$ (d) $2Av\rho$

MSLIVE

10. A body of mass $m_1 + m_2$ is split into two parts of masses m_1 and m_2 by an internal explosion which generates a kinetic energy E. If after explosion the parts move in the same line as before, then their relative speed is

(a) $\sqrt{\frac{E(m_1+m_2)}{m_1+m_2}}$

(b) $\sqrt{\frac{2E(m_1+m_2)}{m_1 m_2}}$

(c) $\sqrt{\frac{E(m_1+m_2)}{m_1+m_2}}$

(d) $\sqrt{\frac{E(m_1+m_2)}{2m_1 \times m_2}}$

MSLIVE

11. A ball is dropped from a height h. It the coefficient of restitution be e, then to what height will it rise after jumping twice from the ground

(a) $eh/2$ (b) $3eh$

(c) eh (d) e^4h

MSLIVE

12. A body falling from a height of 10m rebounds from hard floor. If it loses 20% energy in the impact, then coefficient restitution is

(a) 0.89 (b) 0.56

(c) 0.23 (d) 0.18

MSLIVE

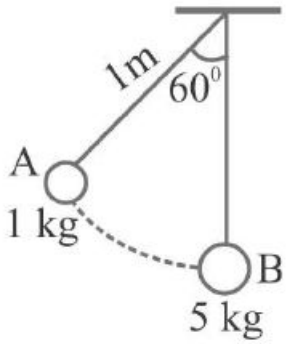
13. In figure, if the coefficient of restitution is 0.8, what is the maximum angle from the vertical that body B will reach after the first impact :

(a) $30°$

(b) $\cos^{-1}(0.45)$

(c) $\cos^{-1}(0.9995)$

(d) none



MSLIVE

14. A ball is projected from a point on a smooth horizontal plane with a velocity u at an angle θ with the horizontal and continuous to rebound. If the coefficient of restitution is e, then range after first rebound is

(a) $\dfrac{u^2 \sin 2\theta}{g}$

(b) $\dfrac{eu^2 \sin 2\theta}{g}$

(c) $\dfrac{eu^2 \sin 2\theta}{2g}$

(d) none of these

MSLIVE

15. Block A of mass m is hanging from a vertical spring of force constant k. Another identical block B strikes the block A with velocity v and sticks to it. The value of v for which the spring just attains natural length is

(a) $\sqrt{\frac{6m}{k}}g$ (b) $\sqrt{\frac{8m}{k}}g$

(c) $\sqrt{\frac{24m}{k}}g$ (d) $\sqrt{\frac{12m}{k}}g$

MSLIVE

16. A particle of mass $2m$ is projected at an angle of $45°$ with horizontal with a velocity of $20\sqrt{2}$ m/s. After 1 second explosion takes place and the particle is broken into two equal pieces. As a result of explosion one part comes to rest. The maximum height from the ground attained by the other part is $(g = 10\ m/s^2)$

(a) 50 m

(b) 25 m

(c) 40 m

(d) 35 m

MSLIVE

17 A neutron of mass m collides elastically with a nucleus of mass M, which is initially at rest. If the neutron's initial kinetic energy is k_0, the maximum kinetic energy that it can lose during the collision is ;

(a) k_0

(b) $\frac{k_0}{2}$

(c) $\frac{m M k_0}{(M+m)^2}$

(d) $\frac{4m M k_0}{(M+m)^2}$

MSLIVE

18 A ball A, moving with kinetic energy K, makes a head on elastic collision with a stationary ball with mass n times that of A. The maximum potential energy stored in the system during the collision is

(a) K/n

(b) $\dfrac{(n-1)K}{n}$

(c) $\dfrac{(n+1)K}{n}$

(d) $\dfrac{nK}{(n+1)}$

MSLIVE

19 Two identical mass M moving with velocity u_1 and u_2 collide perfectly inelastically. The loss in energy is

(a) $\frac{M}{2}(u_2 - u_1)^2$

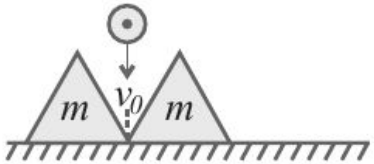
(b) $\frac{M}{2}(u_1 - u_2)^2$

(c) $\frac{M}{4}(u_1 - u_2)^2$

(d) $\frac{M}{8}(u_2 - u_1)^2$

MSLIVE

20. Figure shows a smooth spherical ball of mass m striking two identical equilateral triangular wedges, each of mass m. The velocity of ball at the instant of impact is v_0. If e is the coefficient of restitution, then velocity of either wedge after impact is



(a) $\frac{\sqrt{3}}{5}(1+e)v_0$

(b) $\frac{5}{\sqrt{3}}(1+e)v_0$

(c) $\sqrt{3}(1+e)v_0$

(d) $\frac{ev_0}{3}$

MSLIVE

21. Two bodies of mass 1 kg and 3 kg have position vectors $\hat{i}+2\hat{j}+\hat{k}$ and $-3\hat{i}-2\hat{j}+\hat{k}$, respectively. The centre of mass of this system has a position vector

(a) $-2\hat{i}+2\hat{k}$

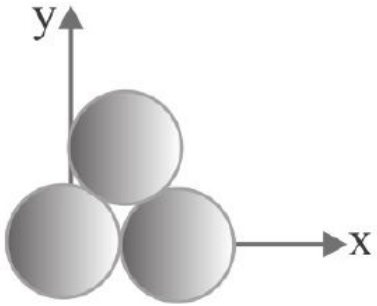
(b) $-2\hat{i}-\hat{j}+\hat{k}$

(c) $2\hat{i}-\hat{j}+\hat{k}$

(d) $-\hat{i}+\hat{j}+\hat{k}$

MSLIVE

22. Three identical spheres each of radius R are placed touching each other on a horizontal table as shown in figure. The co-ordinates of centre of mass are ;



(a) (R, R)

(b) $(0, 0)$

(c) $\left(\frac{R}{2}, \frac{R}{2}\right)$

(d) $\left(R, \frac{R}{\sqrt{3}}\right)$

MSLIVE

23. The mass per unit length of a non - uniform rod of length L varies as $m = \lambda x$ where λ is constant. The centre of mass of the rod will be at ;

(a) $\frac{2}{3} L$

(b) $\frac{3}{2} L$

(c) $\frac{1}{2} L$

(d) $\frac{4}{3} L$

MSLIVE

24. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and are placed on a frictionless horizontal surface. An impulse gives a speed of 14 m/s to the heavier block in the direction of the lighter block. Then, the velocity of the centre of mass is :

(a) $30\ ms^{-1}$

(b) $20\ ms^{-1}$

(c) $10\ ms^{-1}$

(d) $5\ ms^{-1}$

MSLIVE

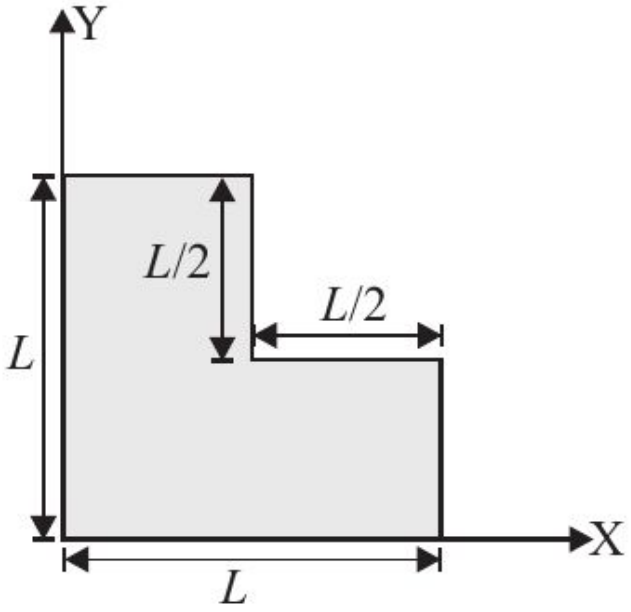
25. The centre of mass coordinates of a block of shape shown in the figure is

(a) $\left(\frac{L}{2}, \frac{L}{2}\right)$

(b) $\left(\frac{5}{12}L, \frac{5}{12}L\right)$

(c) $\left(\frac{2}{3}L, \frac{2}{3}L\right)$

(d) $\left(\frac{L}{4}, \frac{L}{4}\right)$



MSLIVE

26 One end of a thin rod of length L and mass M_1 is riveted to the centre of a circular uniform disc of radius R and mass M_2, such that they are coplanar. The centre of mass of system relative to centre of the disc is:

(a) $\frac{(M_1+M_2)L}{2M_1}$

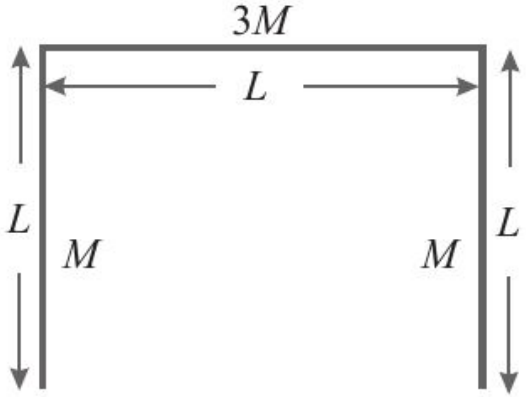
(b) $\frac{M_1L}{(M_1+M_2)}$

(c) $\frac{M_1L}{2(M_1+M_2)}$

(d) $\frac{M_1L+M_2R}{M_1+M_2}$

MSLIVE

27 Three thin rods, each of length L, are arranged in an inverted U, as shown in figure. The two rods on the arms of the U each have mass M; the third rod has mass $3M$. The centre of mass of the system from upper rod is



(a) $\frac{L}{3}$

(b) $\frac{L}{2}$

(c) $\frac{L}{5}$

(d) $\frac{2L}{3}$

MSLIVE

28 A child is sitting at one end of a long trolley moving with a uniform speed v on a smooth horizontal track. If the child starts running towards the other end of the trolley with a speed u, the speed of the centre of mass of the system will;

(a) $u + v$

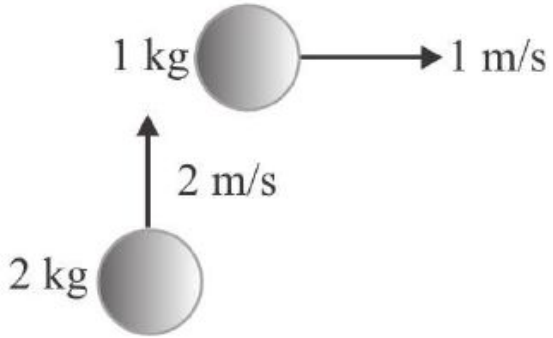
(b) $v - u$

(c) v

(d) none

MSLIVE

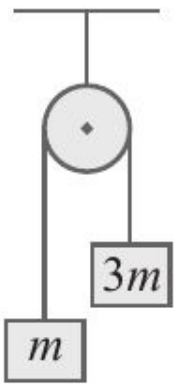
29 Two bodies of masses 1 kg and 2 kg are moving in two perpendicular direction with velocities 1 m/s and 2 m/s as shown in figure. The velocity of the centre of mass (in magnitude) of the system will be ;



(a) 3 m/s
(b) 1.67 m/s
(c) 1.5 m/s
(d) 1.37 m/s

MSLIVE

30. Two masses 3 m and m are suspended from a light frictionless pulley with the help of a massless string. If system is set free the acceleration of centre of mass will be:



(a) g

(b) $\frac{g}{2}$

(c) $\frac{g}{4}$

(d) none of these

MSLIVE

31. Particles of masses m, $2m$, $3m$, ... nm grams are placed on the same line at distances l, $2l$, $3l$, ... nl cm from a fixed point. The distance of centre of mass of the particles from the fixed point in centimetres is

(a) $\frac{(2n+1)l}{3}$

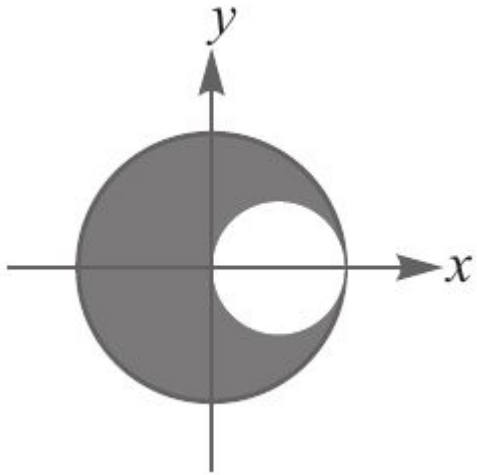
(b) $\frac{1}{n+1}$

(c) $\frac{n(n^2+1)l}{2}$

(d) $\frac{2l}{n(n^2+1)}$

MSLIVE

32. A hole of radius $\frac{r}{2}$ is cut in a disc of radius having mass m. The centre of mass system will be:



(a) at the centre

(b) at distance $\frac{r}{3}$ from centre away from the hole

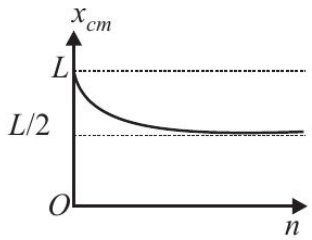
(c) at distance $\frac{r}{4}$ from centre away from the hole

(d) at distance $\frac{r}{6}$ from centre away from the hole along the common diameter.

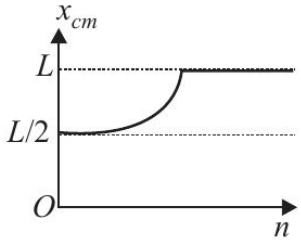
MSLIVE

33. A thin rod of length 'L' is lying along the x-axis with its ends at $x = 0$ and $x = L$. Its linear density (mass/length) 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 centre of mass of the rod is plotted against 'n', which of the following graphs best approximates the dependence of x_{cm} on n

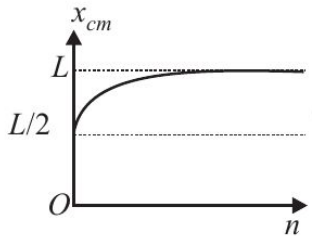
(a)



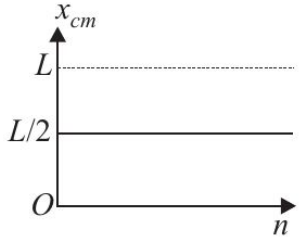
(b)



(c)

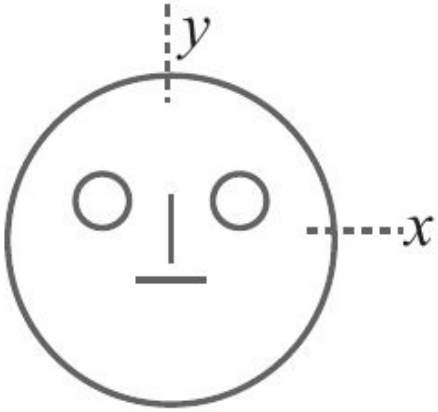


(d)



MSLIVE

34. Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is 6 m. The coordinates of the centres of the different parts are: outer circle (0, 0), left inner circle (–a, a), right inner circle (a, a) vertical line (0, 0) and horizontal line (0, –a). The y-coordinate of the centre of mass of the ink in this drawing is



(a) $\frac{a}{10}$

(b) $\frac{a}{8}$

(c) $\frac{a}{12}$

(d) $\frac{a}{3}$

MSLIVE

35. Consider a particle of two particles having masses m_1 and m_2. It the particle of mass m_1 is pushed towards the centre of mass of particles through a distance d, by what distance would be particle of mass m_2 move so as to keep the centre of mass of particles at the original position

(a) $\frac{m_1}{m_1+m_2}d$

(b) $\frac{m_1}{m_2}d$

(c) d

(d) $\frac{m_2}{m_1}d$

MSLIVE

36. Centre of mass of 3 particles 10 kg , 20 kg and 30 kg is at (0, 0,0). Where should a particle of mass 40 kg be placed so that the combination centre of mass will be at (3,3,3)

(a) (0, 0, 0)
(b) (7.5, 7.5, 7.5)
(c) (1, 2, 3)
(d) (4, 4, 4)

MSLIVE

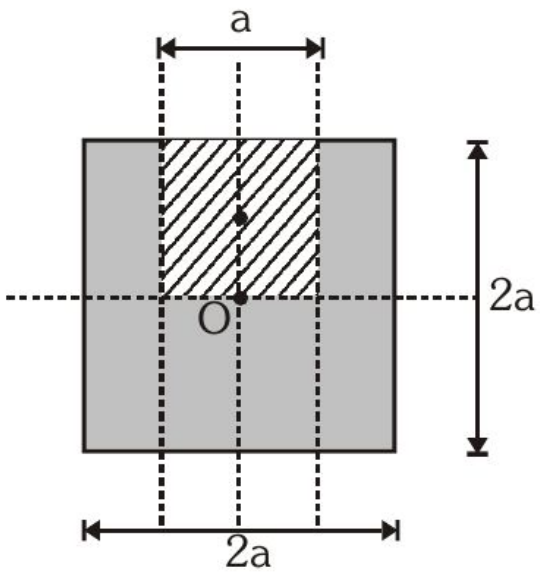
37. A uniforme sheet is shown below if the shaded area is removed find new position of centre of mass.

(1) $+\frac{a}{6}$

(2) $-\frac{a}{6}$

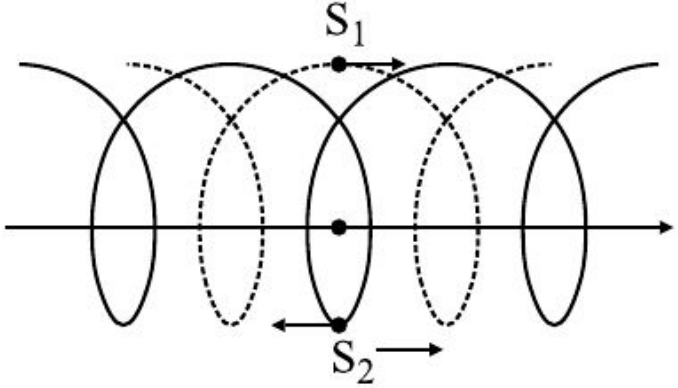
(3) $+\frac{a}{3}$

(4) $-\frac{a}{3}$



MSLIVE

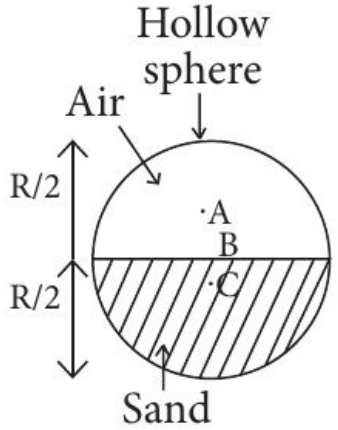
38. The motion of binary stars, S_1, and S_2 is the combination of ___X___ and ___Y___ Here, X and Y refer to



(a) motion of the CM and motion about the CM
(b) motion about the CM and motion of one star
(c) position of the CM and motion of the CM
(d) motion about CM and position of one star

MSLIVE

39. Which of the following points is the likely position of the centre of mass of the system shown in figure?

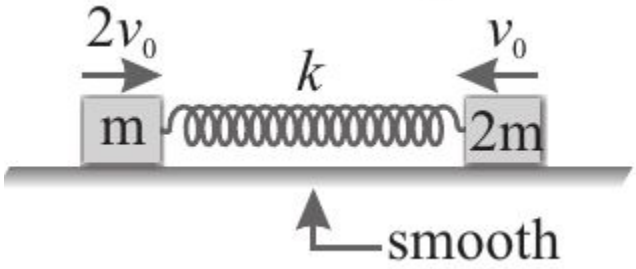


(a) A (b) B

(c) C (d) D

MSLIVE

40. Two blocks A and B of masses m and $2m$ respectively, attached at opposite ends of a spring of force constant k, placed on smooth horizontal surface. Spring is initially at its natural length ℓ. A is given a velocity $2v_0$ and B given velocity v_0 as shown. The maximum separation between 2 m and centre of mass of the system will be:



(a) $\frac{\ell}{3}+\sqrt{\frac{8mv_0^2}{k}}$

(b) $\frac{2\ell}{3}+\sqrt{\frac{2mv_0^2}{3k}}$

(c) $\frac{\ell}{3}+\sqrt{\frac{2mv_0^2}{3k}}$

(d) none of these

MSLIVE

ANSWER KEY

1. c	11. d	21.b	31.a
2. b	12. a	22.d	32.d
3. d	13. c	23.a	33.c
4. c	14. b	24.c	34.a
5. c	15. a	25.b	35.b
6. b	16. b	26.c	36.b
7. c	17. d	27.c	37.2
8. b	18. d	28.c	38.a
9. a	19. c	29.d	39.c
10. b	20. a	30.c	40.c

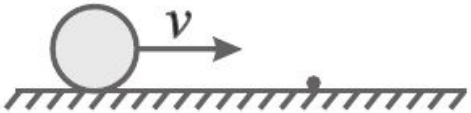
MSLIVE

1. In an inelastic collision, some part of KE will convert into heat energy.

MSLIVE

2.

$$Mv + 0 = Mv_1 + mv_2$$



$$\frac{1}{2}Mv^2 + 0 = \frac{1}{2}Mv_1^2 + \frac{1}{2}mv_2^2$$

Simplifying for m << M, we get $v_z \simeq 2v$.

MSLIVE

3. For collision,

$$\vec{r}_1 + \vec{v}_1 t = \vec{r}_2 + \vec{v}_2 t$$

$$\text{or } (3\hat{i} + 5\hat{j}) + (4\hat{i} + 3\hat{j}) \times 2 = (-5\hat{i} - 3\hat{j}) + (a\hat{i} + 7\hat{j}) \times 2$$

$$\therefore \qquad a = 8$$

MSLIVE

4.

$$\vec{P} = \vec{P}_1 + \vec{P}_2$$

$$\therefore \quad \vec{P}_2 = \vec{P} - \vec{P}_1$$

$$\text{or} \quad P_2 = \sqrt{P^2 + P_1^2} = \sqrt{12^2 + 5^2}$$

$$= 13 \text{ kgm/s.}$$

MSLIVE

5. $\vec{P}_1 + \vec{P}_2 + \vec{P}_3 = 0,$

and so $\vec{P}_3 = -(\vec{P}_1 + \vec{P}_2)$

or $(2m)\, v_3 = \sqrt{(mv)^2 + (mv)^2}$

$$\therefore \quad v_3 = \frac{v}{\sqrt{2}}.$$

Total energy released in the process

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)\left(\frac{v}{\sqrt{2}}\right)^2$$

$$= \frac{3}{2}mv^2.$$

MSLIVE

6.

$$3 \times 2 - 2 \times 3 = 3v_1 + 2v_2$$

and

$$\frac{2}{3} = -\frac{[v_2 - v_1]}{[3-(-2)]}$$

After simplifying, we get

$$v_1 = -4/3,\ v_2 = 2$$

MSLIVE

7.

$$\frac{F_0(T+\frac{T}{2})}{2} = m\,(0-u)$$

$$\therefore \qquad F_0 = \frac{4mu}{3T}.$$

MSLIVE

8.

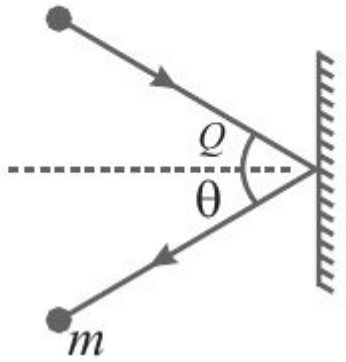
$$J = m(v_f - v_i)_y = 1\ (25 \sin 45° + 20 \sin 30°)$$
$$= 27.67 \text{ N-s}$$

MSLIVE

9.

$$F = \rho AQ = \rho AV^2$$

$$\therefore \quad F_{\text{wall}} = 2F \cos\theta = 2\rho Av^2 \cos\theta.$$



MSLIVE

10.

$$0 = m_1 v_1 - m_2 v_2$$

and $\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = E$

After simplifying above equations, we get

$$v_1 + v_2 = \sqrt{\frac{2E(m_1 + m_2)}{m_1 m_2}}$$

MSLIVE

11. $h^{n} = e^{4}h.$

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12

$$h = 10 \text{ m},$$

$$\therefore \quad u_1 = \sqrt{2g \times 10}$$

$$h_1 = 0.8\, h = 8 \text{ m},$$

$$\therefore \quad v_1 = \sqrt{2g \times 8}$$

Now,
$$e = -\left[\frac{v_2 - v_1}{u_2 - u_1}\right]$$

$$= -\left[\frac{0 - (-\sqrt{2g \times 8})}{0 - \sqrt{2g \times 10}}\right] = 0.89$$

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13. The velocity of body A, before collision

$$u = \sqrt{2g\,y} = \sqrt{2g(1-1\cos 60°)} = 3.13\ m/s.$$

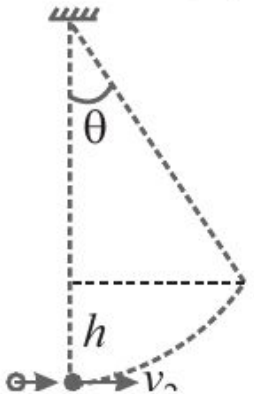
Now $1 \times 3.13 + 5 \times 0 = v_1 + 5v_2$ ...(i)

and $$0.8 = -\left[\frac{v_2 - v_1}{0 - 3.13}\right]$$ ...(ii)

After solving, we get $h = 0.0005\ m$

Now $$\cos\theta = \frac{h}{L} = \left(\frac{1-0.0005}{1}\right)$$

$$= 0.995\ m.$$



MSLIVE

14. Range, $$R = \frac{2u_x u_y}{g} = \frac{2(u\cos\theta)\ (eu\sin\theta)}{2}$$

$$= \frac{eu^2 \sin 2\theta}{g}$$

MSLIVE

15. (a) The initial extension of the spring

$$y_0 = \frac{mg}{k} \qquad \ldots \text{(i)}$$

The velocity of combined block after collision

$$mv = (m + m)\, v$$

$$\therefore \qquad v' = \frac{v}{2}$$

Now from conservation of mechanical energy, we have

$$\frac{1}{2}(2m)\left(\frac{v}{2}\right)^2 + \frac{1}{2}ky_0^2 = 2m\, gy_0 \qquad \ldots\text{(ii)}$$

After solving above equations, we get

$$v = \sqrt{\frac{6m}{k}}g$$

MSLIVE

16. After 1 second,

$v_y = u_y - gt = 20\sqrt{2} \sin 45° - 10 \times 1 = 10$ m/s.

Now $2m \times 10 = m \times 0 + mv$

$\therefore \quad v = 20$ m/s.

Height attained in addition to previous height

$$h = \frac{10^2}{2g} = 5 \text{ m.}$$

Previous height,

$$h_0 = \frac{U_y^2}{2g} = \frac{(20\sqrt{2} \sin 45°)^2}{2g} = 20 \ m.$$

Thus, $h_0 + h = 20 + 5 = 25$ m.

MSLIVE

17.

$$K_0 = \frac{1}{2}mu^2$$

$$mu + 0 = mv_1 + mv_2$$

and $$k_0 + 0 = \frac{1}{2}mv_1^2 + \frac{1}{2}Mv_2^2$$

After simplifying above equations, we get

$$\frac{1}{2}Mv_2^2 = \frac{4mMk_0}{(M+m)^2}$$

MSLIVE

18. Given, $K = \frac{1}{2}mv^2$

If v' is the velocity of the balls during collision, then

$mv + 0 = (m + nm)v'$

$$v' = \left(\frac{v}{n+1}\right)$$

The maximum potential energy stored during collision

$$= \frac{1}{2}mv^2 - \frac{1}{2}(m + nm)v'^2$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}(n+1)\frac{mv^2}{(n+1)^2}$$

$$= K - \frac{K}{n+1}$$

$$= \frac{nK}{n+1}$$

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19. Loss in KE in inelastic collision is given by

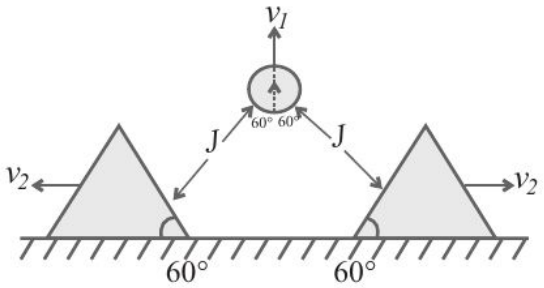
$$\Delta K = \frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)(u_1 - u_2)^2$$

$$= \frac{1}{2}\left(\frac{MM}{M + M}\right)(u_2 - u_1)^2$$

$$= \frac{M}{4}(u_2 - u_1)^2$$

MSLIVE

20. If v_1 and v_2 are the velocity of ball and the wedge after collision, then



For ball:

$$2J\cos 60° = mv_1 - (-mv_0)$$

or $$J = mv_1 + mv_0$$

And $J \sin 60° = mv_2 - 0$

From above equations, we get

$$\frac{2v_2}{\sqrt{3}} = v_1 + v_0 \qquad \text{...(i)}$$

Also $$e = \frac{[v_1 \cos 60° - (-v_2 \cos 30°)]}{(v_0 \cos 60° - 0)}$$

$$= \frac{v_1 + \sqrt{3}v_2}{v_0} \qquad \text{...(ii)}$$

After simplifying above equations, we get

$$v_2 = \frac{\sqrt{3}}{5}(1+e)v_0 .$$

MSLIVE

21.

$$\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$$

$$= \frac{1\times(\hat{i} + 2\hat{j} + \hat{k}) + 3(-3\hat{i} - 2\hat{j} + \hat{k})}{1+3}$$

$$= -2\hat{i} - \hat{j} + \hat{k}\ .$$

MSLIVE

22. Coordinates of spheres are : $(0, 0)$, $(2R, 0)$ and $(R, \sqrt{3}R)$

$$X_{cm} = \frac{m \times 0 + m \times 2R + m \times R}{m + m + m} = R$$

and $$Y_{cm} = \frac{m \times 0 + m \times 0 + m\sqrt{3}R}{m + m + m} = \frac{R}{\sqrt{3}}.$$

MSLIVE

23.

$$X_{\text{cm}} = \int_0^L \frac{(dm)x}{\int_0^L (dm)} = \frac{\int_0^L (\lambda x dx)x}{\int_0^L (\lambda x dx)} = \frac{2L}{3}$$

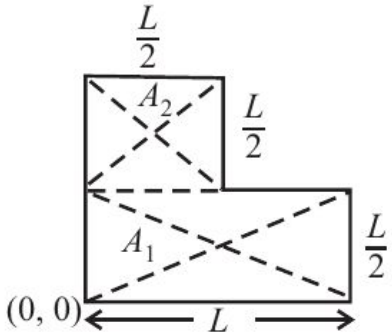
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24.

$$v_{cm} = \frac{10\times 14 + 4\times 0}{10+4} = 10\ m/s.$$

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25.



$A_1 = L \times \frac{L}{2} = \frac{L^2}{2}$ and its centroid $\left(\frac{L}{2}, \frac{L}{4}\right)$

$A_2 = \frac{L}{2} \times \frac{L}{2} = \frac{L^2}{4}$, its centroid $\left(\frac{L}{4}, \frac{3L}{4}\right)$

$$\therefore \ \bar{x} = \frac{A_1 x_1 + A_2 x_2}{A_1 + A_2}$$

$$= \frac{\frac{L^2}{2} \times \frac{L}{2} + \frac{L^2}{4} \times \frac{L}{4}}{\left(\frac{L^2}{2} + \frac{L^2}{4}\right)} = \frac{5L}{12}$$

Similarly $\bar{y} = \frac{5L}{12}$

MSLIVE

26.

$$x_{cm} = \frac{M_2 \times 0 + M_1 L/2}{M_1 + M_2} = \frac{M_1 L}{2(M_1 + M_2)}$$

MSLIVE

27.

$$y_{\text{cm}} = \frac{M \times \frac{L}{2} + 3M \times 0 + M \times \frac{L}{2}}{M + 3M + M} = \frac{L}{5}.$$

MSLIVE

28. Child is the internal part of the system, so velocity of centre of mass will not change due to his movement.

MSLIVE

29.

$$v = \frac{\sqrt{P_1^2 + P_2^2}}{m_1 + m_2} = \frac{\sqrt{(1\times 1)^2 + (2\times 2)^2}}{1+2} = 1.37\ m/s.$$

MSLIVE

30.

$$a = \frac{(3m - m)g}{3m + m} = \frac{g}{2}$$

$$a_{cm} = \frac{3m \times g/2 + m(-g/2)}{3m + m} = \frac{g}{4}\ \mathrm{m/s^2}$$

MSLIVE

31.

$$x_{cm} = \frac{m\times\ell + 2m\times 2\ell + 3m\times 3\ell + \ldots + nm\times n\ell}{m + 2m + 3m + .. + nm}$$

$$= \frac{(1+4+9+..+n^2)\ell}{1+2+..+n}$$

$$= \frac{\ell n(n+1)(2n+1)/6}{n(n+1)/2}$$

$$= \frac{(2n+1)\ell}{3}$$

MSLIVE

32.

(d) Mass of removed disc, $m' = \frac{m}{\pi r^2} \times \pi \left(\frac{r}{2}\right)^2 = \frac{m}{4}$

Thus, $x_{cm} = \frac{m \times 0 - \frac{m}{4}\left(\frac{r}{2}\right)}{\left(m - \frac{m}{4}\right)} = \frac{r}{6}$

MSLIVE

33.

$$x_{cm} = \frac{\int_0^L x\,dm}{\int_0^L dm} = \frac{\int_0^L xK\left(\frac{x}{L}\right)^n dx}{\int_0^L K\left(\frac{x^n}{L^n}\right)dx}$$

$$= \frac{\int_0^L x^{n+1}dx}{\int_0^L x^n dx} = \left|\frac{x^{(n+2)/(n+2)}}{x^{(n+1)/(n+1)}}\right|_0^L$$

$$= \frac{L(1+n)}{(2+n)} = \frac{Ln\left(1+\frac{1}{n}\right)}{n\left(1+\frac{2}{n}\right)} = \frac{L\left(1+\frac{1}{n}\right)}{\left(1+\frac{2}{n}\right)}$$

For n = 0, $x_{cm} = \frac{L}{2}$

and $n = \infty$, $x_{cm} = L$

Clearly option (c) is correct.

MSLIVE

34.

$$y_{cm} = \frac{6m \times 0 + m \times a + m \times a + m \times 0 + m(-a)}{6m + m + m + m + m} = \frac{a}{10}$$

MSLIVE

35.

$$m_1 d - m_2 x_2 = 0$$

$$\therefore \quad x_2 = \frac{m_1 d}{m_2}$$

MSLIVE

36.

$$3\hat{i}+3\hat{j}+3\hat{k} = \frac{(10+20+30)\times 0+40\times \vec{r}_2}{(10+20+30+40)}$$

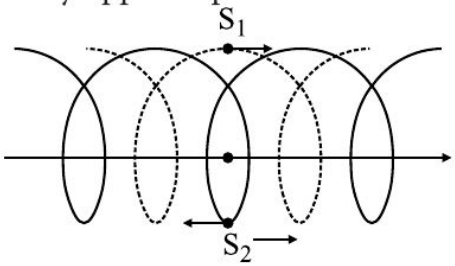
$$\therefore \quad \vec{r}_2 = 7.5\hat{i}+7.5\hat{j}+7.5\hat{k}.$$

MSLIVE

37. $$Y_{CM} = \frac{4m \times 0 - m\ a/2}{4m - m} = -\frac{ma}{2(3m)} = -\frac{a}{6}$$

MSLIVE

38. When no external force acts on the binary star, its CM will move like a free particle [see figure below]. From the CM frame, the two stars will seem to move in a circle about the CM with diametrically opposite positions.



(i) Trajectories of two stars S_1 (dotted line) and S_2 (solid line) forming a binary system with their centre of mass C in uniform motion.

(ii) The same binary system, with the centre of mass, C at rest. So, to understand the motion of a complicated system, we can separate the motion of the system into two parts. So, the combination of the motion of the CM and motion about the CM could be described the motion of the system.

MSLIVE

39. The position of centre of mass of the system in this problem is closer to heavier mass or masses or it depends upon distribution of mass. So it is likely to be at *C*. In the above diagram, lower part of the sphere containing sand is heavier than upper part containing air. Hence CM of the system lies below the horizontal diameter.

MSLIVE

40. Initial position of centre of mass from $2m$

$$x_0 = \frac{\times \ell}{m \quad 2m} \quad \frac{\ell}{3}.$$

Now $\frac{1}{2}k(x_1 + x_2)^2 = \frac{1}{2}m(2v_0)^2 + \frac{1}{2}(2m)v_0^2$

and $mx_1 = (2m)x_2$

After solving above equations, we get

$$x_2 = \sqrt{\frac{2mv_0^2}{3k}}.$$

Thus maximum separation between centre of mass and $2m$ (it happens when m moves away from centre of mass) $= x_0 + x_2$.

MSLIVE