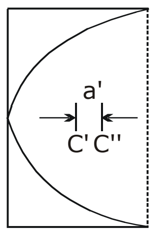
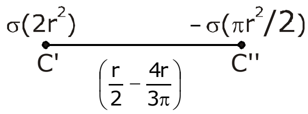
# COM

## EXERCISE – I | SINGLE CORRECT

**1. D**



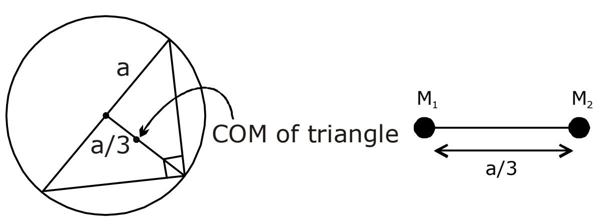

$$a' = \frac{(\sigma 2r^2)\left(\frac{r}{2} - \frac{4r}{3\pi}\right)}{\sigma 2r^2 - \frac{\sigma\pi r^2}{2}}$$

$$a' = \frac{2(3\pi r - 8r)}{3\pi(4-\pi)}$$

Required Ans = $a' + \frac{4r}{3\pi}$

$$= \frac{2(3\pi r - 8r)}{3\pi(4-\pi)} + \frac{4r}{3\pi} = \frac{2r}{3(4-\pi)}$$

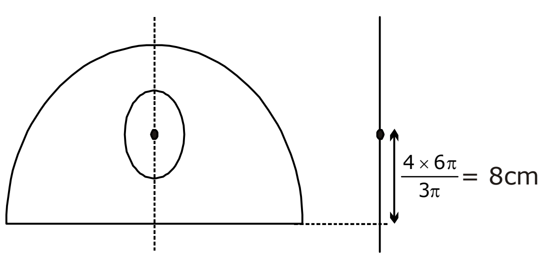
**2. C**




$$r_1 = \frac{M_2\ell}{M_1 + M_2} = \frac{-\sigma a^2}{\sigma\pi a^2 - \sigma a^2} \times \frac{a}{3}$$

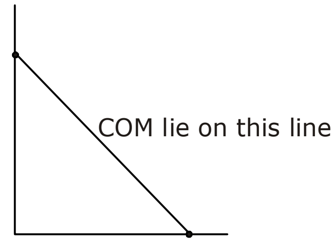
$$= \frac{a^2 \times a}{3a^2(\pi - 1)} = \frac{a}{3(\pi-1)}$$

**3. B**

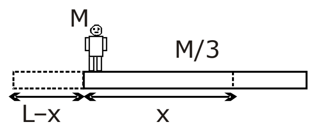



Center of mass coincides

**4. D**

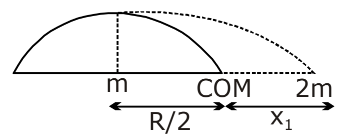



**5. B**




$$\frac{M}{3}(L - x) = M - x \Rightarrow \quad x = \frac{L}{4}$$

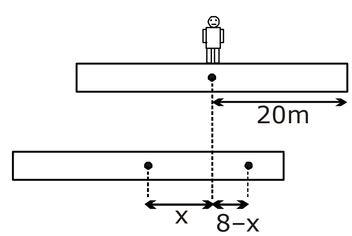
**6. C**




$$\frac{m.R}{2} = 2mx_1 \Rightarrow x_1 = \frac{R}{4}$$

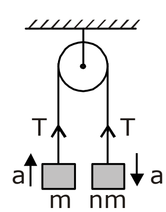
$$\therefore \text{ Distance} = R + \frac{R}{4} = \frac{5R}{4}$$

**7. C**




80 (8 – x) = 200x
640 – 80x = 200x
x = 2.3 m
Now, Required distance
= 20 – (8 – x)
= 20 – (8 – 2.3) = 20 – 5.7
= 14.3 m

**8. [C]**




nmg – T = nma

T – mg = ma

After solving

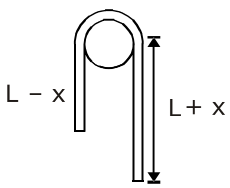
$a = \frac{(n-1)g}{n+1}$

$a_{COM} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2}{m_1 + m_2}$

$= \frac{ma - nma}{(n+1)m} = \frac{a - na}{n+1}$

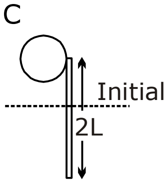
$= \left(\frac{n-1}{n+1}\right)^2 g$

**9.** A




$a = \frac{2x}{2L} g = \frac{x}{L} g$

**10.** C




$mg\,\frac{\ell}{2} = \frac{1}{2}mv^2 \Rightarrow u = \sqrt{g\ell}$

**11.** B

When internal force acts.

Net force is zero.

$\therefore F = \frac{dP}{dt}$ Momentum conserved.

Internal force will not change the linear momentum.

But due to force, K.E. increases.

**12.** D

Speed constant K.E. → Constant

Gravitational potential energy change.

$\because$ Momentum = $m\vec{v}$

$\because$ Direction of v changes

$\therefore$ Momentum changes

**13.** D

$\frac{P^2}{2m} = K.E.$

$\ln \frac{P^2}{2m} = \ln K.E.$

2ln P – ln (2m) = ln K.E.

Straight line with intercept.

**14.** D

$a_{com} = \frac{m_1(-g) + m_2(g)}{m_1 + m_2} = -g$

**15.** C

$C_1$ will move but $C_2$ will be stationary with respect to the ground.

**16.** (a) [B] (b) [C]

(a) It could be non-zero, but it must be constant.

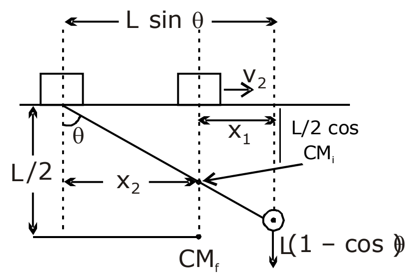
(b) It could be non-zero and it might not be constant.

**17.** (a) [C] (b) [B]

$Mv_0 = (Nm + M)v'$

$v' = \frac{Mv_0}{(Nm + M)}$

**18.** A




$mx_1 = mx_2$ [$\because F_x = 0$]

$x_1 = x_2$

Now $x_1 + x_2 = L \sin\theta$

$\Rightarrow CM_f = \frac{L\sin\theta}{2}$

**19.** D

$V_{CMx} = 0$ and $F_x = 0$

$mv_1 = mv_2 \Rightarrow v_1 = v_2 = v(\text{let})$

Now E.C.

$mg\ell\,(1 - \cos\theta) = 2\left[\frac{1}{2}mv^2\right]$

$v^2 = g\ell\,(1 - \cos\theta)$

Distance from centre of mass = R = $\frac{\ell}{2}$

So $T = \frac{mv^2}{R} = \frac{mg\ell(1-\cos\theta)}{\ell/2}$

T = 2mg (1 – cos θ)

**20.** A

$v_{max} = V = [g\ell(1-\cos\theta)]^{1/2}$

**21.** B

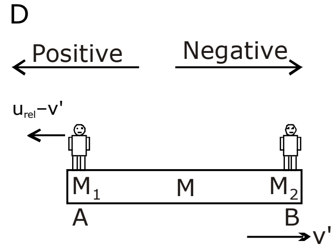
Only in vertical direction

[$\because f_x = 0$ always]

So displacement = $\frac{L}{2} - \frac{L}{2}\cos\theta$

$= \frac{L}{2}[1 - \cos\theta]$

**22.** D



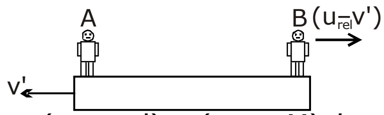
By momentum conservation

$O = m_1 (u_{rel} - v') - (m_2v' + Mv')$

$m_1(u_{rel} - v') = m_1v' + Mv'$

$$v' = \frac{m_1u_{rel}}{m_1 + m_2 + M}$$

**23.** D




$m_2(u_{rel} - v') = (m_1 + M)v'$

$m_2\, u_{rel} - m_2v' = m_1v' + Mv'$

$v'(m_1 + M + m_2) = m_2\, u_{rel}$

$$v' = \frac{m_2u_{rel}}{m_1 + M + m_2}$$

**24.** A

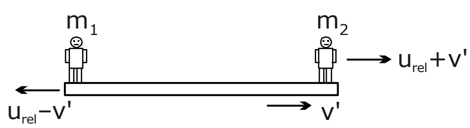
$\vec{F}_{net} = 0 \quad \vec{V}_{com} = 0$

$\therefore$ COM is at rest.


$-m_1u + m_2u + Mv = 0$

$$v' = \frac{(m_1 - m_2)}{M}u$$

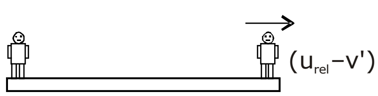
**25.** [A]




$m_2(U_{rel} + v') + Mv' = m_1(u_{rel} - v')$

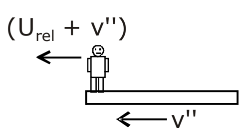
$$v' = \frac{|\, m_1 - m_2 \,|\, U_{rel}}{m_1 + m_2 + M}$$

**26.** D



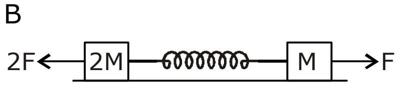

$m(u - v') = (M + m)v'$

$$v' = \frac{mu_{rel}}{(M + 2m)}$$



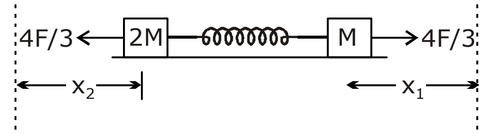

$$m(u_{rel} + v'') + Mv'' = \frac{(M + m)mu_{rel}}{(M + 2m)}$$

**27.** B




$$a_{COM} = \frac{F}{3M}$$

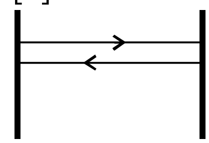
w.r. to COM




$$\frac{4F}{3}x_1 + \frac{4F}{3}x_2 = \frac{1}{2}k\,(x_1 + x_2)^2$$

$$\frac{8F}{3K} = (x_1 + x_2)$$

**28.** [B]



Time between two collisions = $\frac{2d}{v_0}$

So no. of collision/sec = $\frac{v_0}{2d}$

Impulse in one collision = $v_0 - (-mv_0)$
$= 2mv_0$

$$F = 2mv_0 \times \frac{v_0}{2d} = \frac{mv_0^2}{d}$$

**29.** B

(i) From M.C. $mv = 2mv'$
 $v' = v/2$

(ii) from M.C. $mv = 2mv'$
 $v' = v/2$

(iii) Impulse = $mv = 3mv'$

$$v' = \frac{v}{3}$$

**30.** B

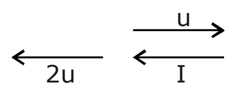
$-I = -m2v - mv$

$I = 3mv$

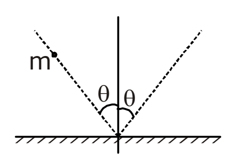
$$W.D. = \frac{1}{2}m(2v)^2 - \frac{1}{2}mv^2$$

$$= \frac{1}{2}m^3u^2$$

$$W.D. = \frac{Iu}{2}$$




**31.** B




$\Delta P = 2mv \cos\theta$

$F_{avg}$ unit volume

$= (2mv \cos\theta)\,(nv) = 2mnv^2 \cos\theta$

$$\text{Pressure} = \frac{F_\perp}{\text{area}} = 2mnv^2 \cos\theta \cos\theta$$

**32.** C

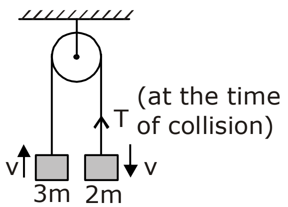
$\int F.dt = \Delta P$

Given $\int F.dt = J$

Now

$\int \vec{F}.2dt = J' \Rightarrow J' = 2J$

**33.** D

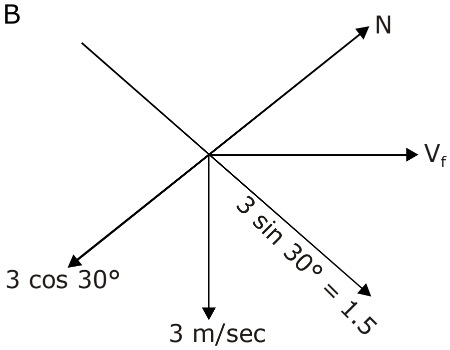



So, $-T\Delta t = 2mv - mu$ (for bullet)
$I = T\Delta t = 3mv$ (for mass 3m)
$3mv = 2mv - mu$
$v = u/5$

$\Rightarrow I = \frac{3mu}{5}$

**34.** B
If e = 1 then angle = 45°
If 0 < e < 1 then angle is less than 45° with the horizontal.

**35.** B




$V_f \cos 30° = 1.5$

$v_f = \sqrt{3}\ m/s$

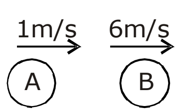
**36.** D

$0.25 \times 0.45 \times 10 = 1 + \frac{1}{2}(0.25)v^2$

v = 1 m/s
Ball B is heavy

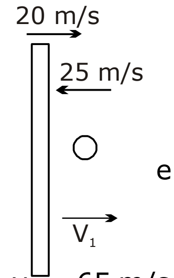
**37.** B
From momentum conservation
$1 \times 21 - 2 \times 4 = 1 \times 1 + 2 \times v'$

v' = 6 m/sec.




$e = \frac{1}{5} = = 0.2$

**38.** A



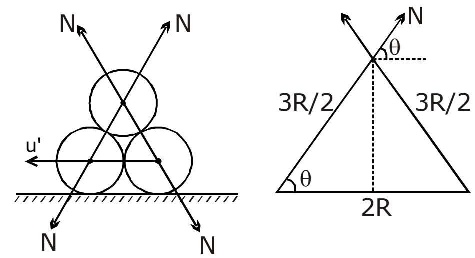

$e = \frac{V_1 - 20}{45}$

$v_1 = 65$ m/s

**39.** C
$\because e = 1$
So $\Delta K = 0$

$\Rightarrow k_f = k_i = \frac{1}{2} m \left(u_1^2 + u_2^2\right)$

**40.** C




$\int 2N\sin\theta\,.dt = mv_0$ ..........(i)

$\int N\cos\theta\,.\,dt = mv_0$

$\int N.dt = \frac{mv_0}{2\sqrt{5}}\,.\,3$

$\sin\theta = \frac{\sqrt{(3/2)R^2 - R^2}}{3/2R}$

$\sin\theta = \frac{\sqrt{5}}{3}$ ; $\cos\theta = \frac{2}{3}$

$\frac{mv_0 3}{2\sqrt{5}}\,\frac{2}{3} = mv' \Rightarrow v' = \frac{v_0}{\sqrt{5}}$

**41.** C

$\int 2N\sin\theta dt = \frac{mv_0}{2}$

$\int N.\cos\theta dt = mv'$

$\int 2N\sin\theta dt = \frac{mv_0}{2}$

$\int N\cos\theta dt = mv'$

$\int 2N \times \frac{\sqrt{5}}{3} dt = \frac{mv_0}{2}$

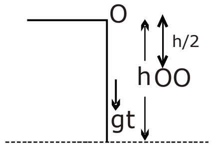
$\int \frac{2N}{3} dt = mv'$

On dividing

$$\frac{2N \times \sqrt{5}}{3} \times \frac{3}{2N} = \frac{v_0}{2v'}$$

$$v' = \frac{v_0}{2\sqrt{5}}$$

**42.** D




$$t = \sqrt{\frac{h}{g}}$$

$$\frac{h}{2} = v\sqrt{\frac{h}{g}} - \frac{1}{2}g\left(\sqrt{\frac{h}{g}}\right)^2$$

$$h = v\sqrt{\frac{h}{g}}, \quad v = \sqrt{hg}$$

$$v_f = \sqrt{hg} - g\sqrt{\frac{h}{g}}$$

$v_f = 0$

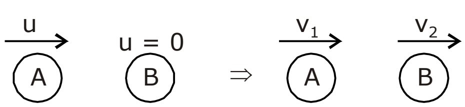
Now $\quad mg.t = 3mv'$

$gt/3 = v'$

$$\Rightarrow \frac{1}{2}3m\,(gt/3)^2 + 3mg\,\frac{h}{2} = \frac{1}{2}3m.v_1^2$$

$$v_1 = \frac{\sqrt{10gh}}{3}$$

**43.** A




$$c = \frac{v_2 - v_1}{u} \Rightarrow cu = v_2 - v_1 \text{ ....... (1)}$$

Now $\quad mu = mv_1 + mv_2$

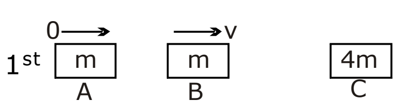
$u = v1 + v2 \quad$ ....... (2)

from (1) and (2) $\dfrac{v_1}{v_2} = \dfrac{1-e}{1+e}$

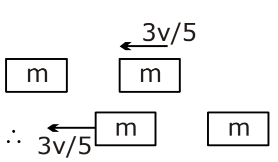
**44.** D

Infinite

**45.** A

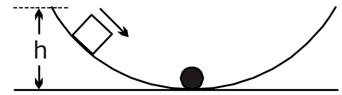



$2^{nd} \qquad v = \dfrac{mv + 4m(0-v)}{5m} = \dfrac{3m}{5}$




**46.** A

$$mgh = \frac{1}{2}mv^2$$




$v = \sqrt{2gh}$

By momentum conservation

$m\sqrt{2gh} + 0 = 2mv'$

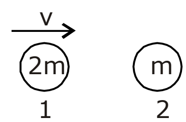
$$v' = \frac{\sqrt{2gh}}{2}$$

By energy conservation

$$\frac{1}{2}(2m)v'^2 = 2mgh', \quad m\,\frac{(2gh)}{4} = 2mgh'$$

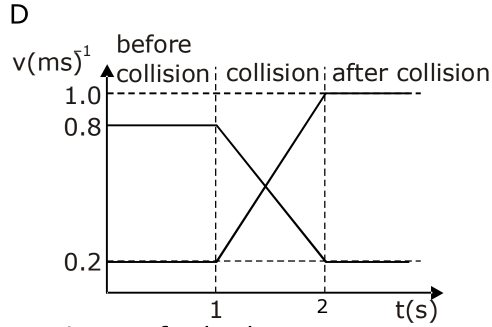
$$h' = \frac{h}{4}$$

**47.** B




$$\frac{v}{3} = \frac{2mv + em(0-v)}{3m} \qquad e = 1$$

**48.** D




(i) $\because$ v is +ve for both.

(ii) Yes (when maximum compression)

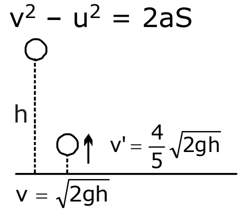
(iii) $\because$ S have greater velocity after collision then R have before collision and K.E. of S will be less then initial K.E. of R

$$\frac{1}{2}m_sV_s^2 < \frac{1}{2}m_R\,(V_R)^2$$

but $V_S > V_R$ So $m_s < m_R$

**49.** C

$v^2 - u^2 = 2aS$




$$0 - \left(\frac{4}{5}\sqrt{2gh}\right)^2 = 2x - g \times h$$

$$\frac{16}{25} \times 2gh = 2gh$$

$$h' = \frac{16}{25}h$$

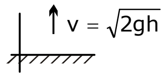
or $h' = e^2h = \frac{16}{25}h$ [e = 4/5]

**50.** A

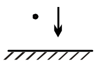
$\cdot\downarrow\ \sqrt{2gh}$

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

$v = 2\sqrt{gh}$ $\therefore$ $e = \frac{1}{\sqrt{2}}$,




**51.** C



$\sqrt{2\times10\times5}$ = 10 m/sec.

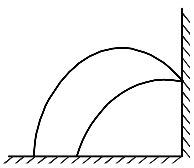
$$\therefore \frac{10}{10} + \frac{2\times e\times 10}{10} + \frac{2\times e^2\times 10}{10} + ....$$

$1 + 2\,[e + e^2 + ....]$

$$1 + \frac{2e}{1-e} = 3 \text{ sec.}$$

**52.** B

$$\frac{2v\cos\theta}{g}$$



**53.** D

$$F_{thurst} = V_{rel.}\frac{dm}{dt}$$

$$\frac{dm}{dt} = (10 \times (10^{-2})^3 \times 10^3) = 0.1 \text{ kg/sec.}$$

$$AV_{rel} = \frac{\text{Volume}}{\text{sec.}} = 10 \times (10^{-2})^3$$

$$= \frac{10^{-5}}{\pi\left(\frac{1\times10^{-3}}{2}\right)^2} = \frac{20}{\pi}$$

$$F_{thrust} = \frac{20}{\pi}\times 0.1 = 0.127 \text{ N}$$

**54.** C

$5 \times 10^3 \times 1.2 = 6 \times 10^3 \times v$

v = 1 m/sec.

**55.** D

$$F_{thurst} = V_{rel}\ .\ \frac{dm}{dt}$$

$$210 = 300\ .\ \frac{dm}{dt}$$

$$\frac{dm}{dt} = 0.7 \text{ kg/sec.}$$

**56.** C

$$F_t = V_r\frac{dm}{dt}$$

$$V_r\frac{dm}{dt} - mg = m + a$$

$$980 \times \frac{dm}{dt} - 4000 \times 9.8 = 4000 + 196$$

$$\frac{dm}{dt} = 120 \text{ kg/sec.}$$

**57.** D

P = mv

$$\frac{dP}{dt} = m\frac{dv}{dt} + v\frac{dm}{dt}$$

$$F_{net} = (m_0\lambda t)\frac{dv}{dt} + \lambda v$$