Single Correct Answer Type

1 **(a)**

$F = \frac{mv^2}{r}$. If m and v are constants then $F \propto \frac{1}{r}$

$\therefore \frac{F_1}{F_2} = \left(\frac{r_2}{r_1}\right)$

2 **(d)**

It spends negligible time on earth *ie*, it performs projectile motion

Here maximum range $R_{\text{max}} = 1$ m

$\frac{u^2}{g} = 1$

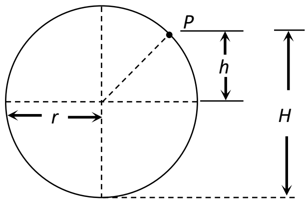
$u^2 = 1 \times 9.8$

$u = \sqrt{9.8} = 3.13\ \text{ms}^{-1}$

3 **(c)**

As we know for hemisphere the particle will leave the sphere at height $h = 2r/3$

$h = \frac{2}{3} \times 21 = 14m$



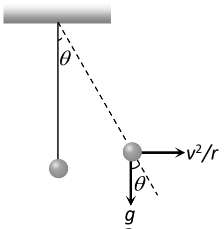
But from the bottom

$H = h + r = 14 + 21 = 35\ metre$

4 **(c)**

Speeds at the top point of each wheel will equal and is equal to the speed of centre of mass.

5 **(c)**



$\tan\theta = \frac{v^2}{rg}$

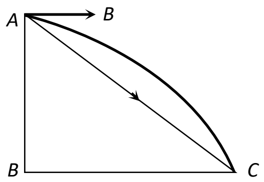
$\therefore \theta = \tan^{-1}\left(\frac{v^2}{rg}\right) = \tan^{-1}\left(\frac{10 \times 10}{10 \times 10}\right)$

$\therefore \theta = \tan^{-1}(1) = 45°$

6 **(a)**

The horizontal distance covered by the bomb,

$BC = v_H \times \sqrt{\frac{2h}{g}} = 150\sqrt{\frac{2 \times 80}{10}} = 600\ m$



∴ The distance of target from dropping point of bomb,

$AC = \sqrt{AB^2 + BC^2} = \sqrt{(80)^2 + (600)^2} = 605.3\ m$

7 **(b)**

By using equation $\omega^2 = \omega_0^2 - 2\alpha\theta$

$\left(\frac{\omega_0}{2}\right)^2 = \omega_0^2 - 2\alpha(2\pi n) \Rightarrow \alpha = \frac{3}{4}\frac{\omega_0^2}{4\pi\times 36}, (n = 36)$ ..(i)

Now let fan completes total n' revolution from the starting to come to rest

$0 = \omega_0^2 - 2\alpha(2\pi n') \Rightarrow n' = \frac{\omega_0^2}{4\alpha\pi}$

Substituting the value of α from equation (i)

$n' = \frac{\omega_0^2}{4\pi}\frac{4\times 4\pi\times 36}{3\omega_0^2} = 48$ revolution

Number of rotation $= 48 - 36 = 12$

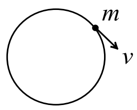
8 **(c)**

$F = m\omega^2 R \ \therefore F \propto \omega^2$ (m and R are constant)

If angular velocity is doubled force will becomes four times

9 **(a)**

$\frac{v^2}{r} = a$, the centripetal acceleration [Given]



If v is doubled, $a'' = \frac{4v^2}{r} = 4a$

10 **(b)**

Using the relation

$\frac{mv^2}{r} = \mu R, \qquad R = mg$

$\frac{mv^2}{r} = \mu mg \Longrightarrow v^2 = \mu rg$

$v^2 = 0.6 \times 150 \times 10$

$v = 30\ \text{ms}^{-1}$

11 **(c)**

As seen from the cart the projectile moves vertically upward and comes back.

The time taken by cart to cover 80 m

$= \frac{s}{v} = \frac{80}{30} = \frac{8}{3}\text{s}$

Given, $u = ?, v = 0, a = -g = 10\text{ms}^{-2}$

(for a projectile going upward)

and $t = \frac{8/3}{2} = \frac{4}{3}\text{s}$

From first equation of motion

$v = u + at$

$0 = u - 10 \times \frac{4}{3}$

$= \frac{40}{3} \text{ms}^{-1}$

12 **(a)**

$T = \frac{2u\sin\theta}{g} \Rightarrow u = \frac{T \times g}{2\sin\theta} = \frac{2 \times 9.8}{2 \times \sin 30} = 19.6\, m/s$

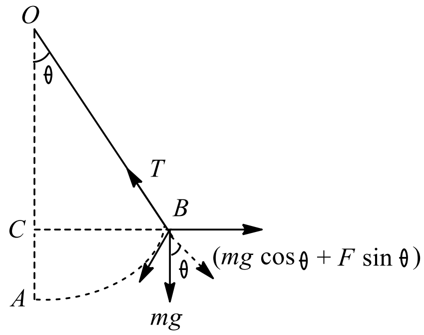
13 **(b)**

$v = \sqrt{\mu r g} = \sqrt{0.6 \times 150 \times 10} = 30 m/s$

14 **(c)**

Centrifugal force on rod, $F = \frac{mv^2}{r}$ along BF. Let θ be the angle which the rod makes with the vertical.

Forces acting on the rod are shown in figure



Resolving mg and F into two rectangular components, we have,

Forces parallel to rod,

$mg\cos\theta + \frac{mv^2}{r}\sin\theta = T$

Force perpendicular rod

$= mg\sin\theta - \frac{mv^2}{r}\cos\theta$

The rod will be balanced if

$mg\sin\theta = \frac{mv^2}{r}\cos\theta = 0$

or $mg\sin\theta = \frac{mv^2}{r}\cos\theta$

or $\tan\theta = \frac{v^2}{rg} = \frac{(10)^2}{10\times10} = 1 = \tan 45°$ or $\theta = 45°$

15 **(c)**

Horizontal range of the object fired,

$R = \frac{u^2 \sin 2\theta}{g}$

At the highest point, when object is exploded into two equal masses, then

$2mu\cos\theta = m(0) + mv$

or $v = 2u\cos\theta$

It means, the horizontal velocity becomes double at the highest point, hence it will cover double the distance during the remaining flight.

∴ Total horizontal range of the other part

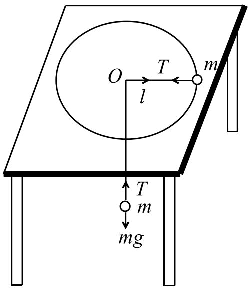
$= \frac{R}{2} + R = \frac{3R}{2}$

$= \frac{3}{2}\frac{u^2\sin 2\theta}{g}$

$= \frac{3}{2} \times \frac{(100)^2 \times 2\sin\theta\cos\theta}{g}$

$= \frac{3}{2} \times \frac{(100)^2 \times 2 \times \frac{3}{5} \times \frac{4}{5}}{10} = 1440 \text{ m}$

16 **(b)**



Tension T in the string will provide centripetal force

$\Rightarrow \frac{mv^2}{l} = T$ ...(i)

Also, tension T is provided by the hanging ball of mass m,

$\Rightarrow T = mg$ ...(ii)

$mg = \frac{mv^2}{l} \Rightarrow g = \frac{v^2}{l}$

It is the centripetal acceleration of a moving ball

17 **(b)**

$mg = 20N$ and $\frac{mv^2}{r} = \frac{2\times(4)^2}{1} = 32N$

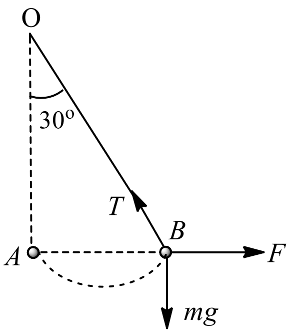
It is clear that 52 N tension will be at the bottom of the circle. Because we know that $T_{\text{Bottom}} = mg + \frac{mv^2}{r}$

18 **(d)**

$T\cos 30° = mg$

or $T = \frac{mg}{\cos 30°} = \frac{\sqrt{3}\times 9.8}{\sqrt{3}/2} = 19.6\text{N}$

$F = T\sin 30° = 19.6 \times \frac{1}{2} = 9.8\text{N}$



19 **(a)**

When particle moves in circle, then the resultant force must act towards the center and its magnitude F must satisfy

$F = \frac{mv^2}{l}$

This resultant force is directed towards the center and it is called centripetal force. This force originates form tension T.

$\therefore F = \frac{mv^2}{l} = T$

20 **(c)**

Horizontal component of velocity at angle 60° = Horizontal component of velocity at angle 45°

$ie, \cos 60° = u \cos 45°$

$$147 \times \frac{1}{2} = v \times \frac{1}{\sqrt{2}}$$

or $v = \frac{147}{\sqrt{2}} \text{ms}^{-1}$

vertical component of velocity at angle 60°

$$u = u \sin 60° = \frac{147\sqrt{3}}{2} \text{ m}$$

vertical component of velocity at angle 45° $= v \sin 45°$

$$= \frac{147}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{147}{2} \text{m}$$

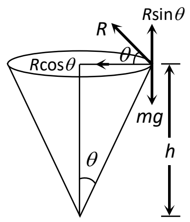
But $v_y = u_y + at$

$$\therefore \frac{147}{2} = \frac{147\sqrt{3}}{2} - 9.8t$$

or $9.8t = \frac{147}{2}\left(\sqrt{3} - 1\right)$

$\therefore \ t = 5.49 \text{ s}$

21 **(d)**



The particle is moving in circular path

From the figure, $mg = R \sin\theta$ ... (i)

$\frac{mv^2}{r} = R\cos\theta$ ... (ii)

From equation (i) and (ii) we get

$\tan\theta = \frac{rg}{v^2}$ but $\tan\theta = \frac{r}{h}$

$$\therefore h = \frac{v^2}{g} = \frac{(0.5)^2}{10} = 0.025m = 2.5 \ cm$$

22 **(c)**

In projectile motion, horizontal component of velocity remains constant

$\therefore v\cos\theta = u\cos 2\theta$

$$\Rightarrow v = \frac{u\cos 2\theta}{\cos\theta} = \frac{u(2\cos^2\theta - 1)}{\cos\theta} = u(2\cos\theta - \sec\theta)$$

23 **(a)**

Since $v^2 - v_0^2 = 2\vec{a}.\vec{s} = 2\vec{a}.\left(\frac{\vec{v}+\vec{v}_0}{2}\right)t$

or $\vec{v}.\vec{v} - \vec{v}_0.\vec{v}_0 = (\vec{v} + \vec{v}_0).\vec{a}t$

or $\vec{v}.(\vec{v} - \vec{a}t) = \vec{v}_0.(\vec{v}_0 + \vec{a}t)$

24 **(d)**

In complete revolution change in velocity becomes zero so average acceleration will be zero

25 **(a)**

$$\omega = \frac{v}{r} = \frac{100}{100} = 1 \, rad/s$$

26 **(d)**

$$\text{Range } = \frac{u^2 \sin 2\theta}{g} = 200 \ m$$

$\Rightarrow \frac{u^2(2\sin\theta\cos\theta)}{g} = 200\ m$ ...(i)

Time of flight $= \frac{2u\sin\theta}{g} = 5s$ ...(ii)

From equations (i) and (ii)

$u\cos\theta = 40\ m/s$

27 **(c)**

Equating the moments about R

$6 \times PR = 4 \times RQ$

$PR = \frac{4}{6}RQ = \frac{2}{3}RQ$

28 **(c)**

$H = \frac{u^2\sin^2\theta}{2g} \Rightarrow \frac{H_1}{H_2} = \frac{u^2\sin^2\theta_1}{u^2\sin^2\theta_2}$

$\frac{3}{1} = \frac{\sin^2\theta_1}{\sin^2\theta_2} \Rightarrow \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sqrt{3}}{1}$

Logically, we can conclude that

$\theta_1 = 60°, \quad \theta_2 = 30°$

Again $R = \frac{u^2\sin2\theta}{g}$

$\therefore \frac{R_1}{R_2} = \frac{4\,u^2\sin2\theta_1}{u^2\sin2\theta_2}$

$\frac{R_1}{R_2} = \frac{4\sin2(60°)}{\sin2(30°)} = \frac{4\sin120°}{\sin60°}$

or $\frac{R_1}{R_2} = \frac{4 \times \frac{\sqrt{3}}{2}}{\frac{\sqrt{3}}{2}} = 4$

29 **(b)**

$\frac{v}{g} = 20$ or $v^2 = 20g = 20 \times 9.8 = 196, v = 14\ \text{ms}^{-1}$

30 **(d)**

$h_{\max} = \frac{u^2}{2g} = 10 \quad [\because \theta = 90^o]$

$u^2 = 200$

$R_{\max} = \frac{u^2}{g} = 20m$

31 **(a)**

$\vec{P}.\vec{Q} = 0 \Rightarrow \vec{P} \perp \vec{Q}$ or $\theta = 90°$

$|\overrightarrow{P \times Q}| = PQ\sin90° = PQ$ or $|\vec{P}|\,|\vec{Q}|$

32 **(a)**

Here, $r = 100\text{m}, v = 7\text{ms}^{-1}, m = 60\text{kg}$

Reading registered= resultant force =?

Two force are acting, weight mg and centripetal force $\frac{mv^2}{r}$ at 90° to each other

$\therefore$ Resultant force $= \sqrt{(mg)^2 + \left(\frac{mv^2}{r}\right)^2} = mg\left[1 + \left(\frac{v^2}{rg}\right)^2\right]^{1/2}$

$= 60 \times 9.8\left[1 + \left(\frac{7 \times 7}{100 \times 9.8}\right)^2\right]^{1/2}$

$= 60.075 \times 9.8\ \text{N} = 60.075$ kg-wt

33 **(d)**

$$R = \frac{v^2 \sin 2\theta}{g}$$

In the given problem $v^2 \sin 2\theta =$ constant

$$v^2 \sin 2\theta = \left(\frac{v}{2}\right)^2 \sin 30° = \frac{v^2}{8}$$

or $\sin 2\theta = \frac{1}{8}$ or $2\theta = \sin^{-1}\left[\frac{1}{8}\right]$ or $\theta = \frac{1}{2}\sin^{-1}\left[\frac{1}{8}\right]$

34 **(b)**

$$\omega^2 R = 4\pi^2 n^2 r = 4\pi^2 \left(\frac{1200}{60}\right)^2 \times 30 \times 10^{-2} = 4732\ m/s^2$$

35 **(d)**

$\theta = 30°$

$$\frac{R}{H} = \frac{v^2(2\sin\theta\cos\theta)}{g} \times \frac{2g}{v^2 \sin^2\theta} = \frac{4\cos\theta}{\sin\theta}$$

or $R = 4\cot 30° \times H = 4\sqrt{3}$

36 **(b)**

$$\omega = \frac{v}{r} = \frac{10}{100} = 0.1 rad/s$$

37 **(d)**

Height, $h = \frac{1}{2}gt^2 \implies t = \sqrt{\frac{2 \times 1960}{9.8}} = 20\text{s}$

$$s = AB = ut = 600 \times \frac{20}{60 \times 60} = 3.33 \text{ km}$$

38 **(c)**

The vector is $\hat{i} - [\vec{A} + \vec{B} + \vec{C}]$

$= \hat{i} - [(2\hat{i} - 4\hat{j} + 7\hat{k}) + (7\hat{i} + 2\hat{j} - 5\hat{k}) + (-4\hat{i} + 7\hat{j} + 3\hat{k})]$

$= -4\hat{i} - 5\hat{j} - 5\hat{k}$

39 **(c)**

$|\vec{A} \times \vec{B}| = AB \sin\theta$. As $\sin\theta \le 1$, therefore $AB \sin\theta$ can not be more than AB.

40 **(c)**

$R^2 = R^2 + R^2 + 2R^2 \cos\theta$ or $R^2 = 2R^2 + 2R^2 \cos\theta$

$\frac{1}{2} = 1 + \cos\theta$ or $\cos\theta = -\frac{1}{2}$ or $\theta = 120°$

41 **(a)**

Linear velocity,

$v = \omega r = 2\pi n r = 2 \times 3.14 \times 3 \times 0.1 = 1.88\ m/s$

Acceleration, $a = \omega^2 r = (6\pi)^2 \times 0.1 = 35.5\ m/s^2$

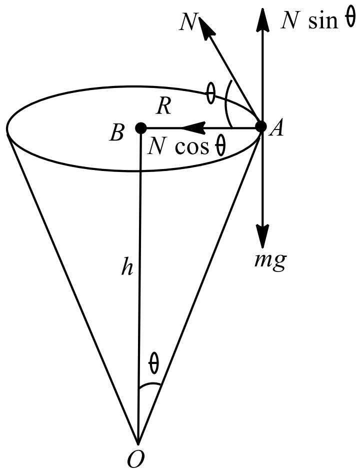
Tension in string, $T = m\omega^2 r = 1 \times (6\pi)^2 \times 0.1 = 35.5\ N$

42 **(b)**

Work done by centripetal force is always zero

43 **(d)**

The various forces acting on the particle, are its weight mg acting vertically downwards, normal reaction N. Equating the vertical forces, we have



$N \sin \theta = mg$ ... (i)

Also, centripetal force,

$\frac{mv^2}{R} = N \cos \theta$ .... (ii)

From Eqs. (i) and (ii), we get

$\tan \theta = \frac{Rg}{v^2}$ .... (iii)

Also, from triangle OAB,

$\tan \theta = \frac{R}{h}$ ..... (iv)

Equating Eqs. (iii) and (iv), we get

$h = \frac{v^2}{g}$

Given, $v = 0.5 \text{ ms}^{-1}$ and $g = 10 \text{ ms}^{-2}$

$\therefore \ h \frac{(0.5)^2}{10} = 0.025 \text{ m} = 2.5 \text{ cm}$

44 **(d)**

$T = mg + m\omega^2 r = m\{g + 4\pi^2 n^2 r\}$

$= m\left\{g + \left(4\pi^2 \left(\frac{n}{60}\right)^2 r\right)\right\} = m\left\{g + \left(\frac{\pi^2 n^2 r}{900}\right)\right\}$

45 **(b)**

$10A^2 = 4A^2 + 2A^2 + 2 \times 2A \times \sqrt{2}A \times \cos\theta$

or $4A^2 = 4\sqrt{2}A \cos\theta$

or $\cos\theta = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45°$

46 **(d)**

$R = \frac{u^2 \sin 2\theta}{g}$ $\therefore R \propto u^2$. If initial velocity be doubled then range will become four times

47 **(a)**

$t = \sqrt{\frac{2 \times 2000}{10}} = \sqrt{400} = 20 \text{ s}$

$x = 100\text{ms}^{-1} \times 20\text{s} = 2000 \text{ m} = 2\text{km}$

48 **(d)**

At maximum height H, the horizontal component of the velocity of the bullet $= u \cos \theta = u \cos 60° = u/2$

49 **(d)**

Tension at the top of the circle, $T = m\omega^2 r - mg$

$T = 0.4 \times 4\pi^2 n^2 \times 2 - 0.4 \times 9.8 = 122.2N \approx 115.86N$

50 **(a)**

$a = 4\pi^2 n^2 r = 4\pi^2 \left(\frac{1}{2}\right)^2 \times 50 = 493\ cm/s^2$