Single Correct Answer Type

1. **(c)**
Because vertical downward displacement of both (target and bullet) will be equal

2. **(c)**
$\alpha = \frac{d\omega}{dt} = 0$ [As ω = constant]

3. **(a)**
If the horizontal range is the same then the angle of projection of an object is θ or $(90° - \theta)$ with the horizontal direction. So, the angle of projection of first particle is θ and the other particle is $(90° - \theta)$

$$t_1 = \frac{2u\sin\theta}{g}$$

$$t_2 = \frac{2u\sin\theta(90° - \theta)}{g}$$

$$t_2 = \frac{2u\cos\theta}{g}$$

$$\because\ t_1 t_2 = \frac{2u\sin\theta}{g} \cdot \frac{2u\cos\theta}{g}$$

$$t_1 t_2 = \frac{2u^2\sin 2\theta}{g^2}$$

or $t_1 t_2 = \frac{2R}{g}$ $\left(\because R = \frac{u^2\sin 2\theta}{g}\right)$

4. **(b)**
Since the projectile is released its initial velocity is the same as the velocity of the plane at the time of release
Take the origin at the point of release
Let x and $y(= -730\text{m})$ be the coordinates of the point on the ground where the projectile hits and let t be the time when it hits. Then

$$y = -v_0 t \cos\theta - \frac{1}{2}gt^2$$

where $\theta = 53.0°$
This equation gives

$$v_0 = -\frac{y + \frac{1}{2}gt^2}{t\cos\theta}$$

$$= -\frac{-730 + \frac{1}{2}(9.8)(5)^2}{5\cos 53°} = 202\ \text{ms}^{-1}$$

5. **(b)**
Only horizontal component of velocity $(u\cos\theta)$

6. **(a)**
Water will not fall down, if weight, mg = centrifugal force

$$= mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2$$

7. **(a)**
$(0.5)^2 + (0.8)^2 + c^2 = 1$
$0.25 + 0.64 + c^2 = 1$
or $c^2 = 1 - 0.25 - 0.64 = 0.11$
or $c = \sqrt{0.11}$

8. **(c)**

$$\mu = \frac{v^2}{rg} = \frac{(4.9)^2}{4 \times 9.8} = 0.61$$

9. **(b)**

If $|\vec{A}| = |\vec{B}| = x$, then $|\vec{C}| = \sqrt{2}x$

Now, $\vec{A} + \vec{B} = -\vec{C}$

or $(\vec{A} + \vec{B}) \cdot (\vec{A} + \vec{B}) = (-\vec{C}) \cdot (-\vec{C})$

or $\cos\theta = 0$ or $\theta = 90°$

or $\vec{A} \cdot \vec{A} + \vec{C} \cdot \vec{C} + 2\vec{A} \cdot \vec{C} = B^2$

or $x^2 + 2x^2 + 2x^2\sqrt{2}\cos\theta = x^2$

or $\cos\theta = -\frac{1}{\sqrt{2}}$

∴ or $\theta = 135°$

Again, $\vec{B} + \vec{C} = -\vec{A}$

or $(\vec{B} + \vec{C}) \cdot (\vec{B} + \vec{C}) = -(-\vec{A}) \cdot (-\vec{A})$

or $x^2 + 2x^2 + 2x^2\sqrt{2}\cos\theta = x^2$

or $\cos\theta = -\frac{2x^2}{2x^2\sqrt{2}\cos\theta} = -\frac{1}{2}$ or $\theta = 135°$

10. **(d)**

Tension in the string $T = m\omega^2 r = 4\pi^2 n^2 mr$

$$\therefore T \propto n^2 \Rightarrow \frac{n_2}{n_1} = \sqrt{\frac{T_2}{T_1}} \Rightarrow n_2 = 5\sqrt{\frac{2T}{T}} = 7\ rpm$$

11. **(b)**

For same range angle of projection should be θ and $90 - \theta$

So, time of flights $t_1 = \frac{2u\sin\theta}{g}$ and

$$t_2 = \frac{2u\sin(90-\theta)}{g} = \frac{2u\cos\theta}{g}$$

By multiplying $= t_1 t_2 = \frac{4u^2\sin\theta\cos\theta}{g^2}$

$$t_1 t_2 = \frac{2}{g}\frac{(u^2\sin 2\theta)}{g} = \frac{2R}{g} \Rightarrow t_1 t_2 \propto R$$

12. **(d)**

Radial force $= \frac{mv^2}{r} = \frac{m}{r}\left(\frac{p}{m}\right)^2 = \frac{p^2}{mr}$[As $p = mv$]

13. **(a)**

When body is released from the position p (inclined at angle θ from vertical) then velocity at mean position

$v = \sqrt{2gl(1-\cos\theta)}$

∴ Tension at the lowest point $= mg + \frac{mv^2}{l}$

$$= mg + \frac{m}{l}[2gl(1-\cos 60)] = mg + mg = 2mg$$

14. **(a)**

$\vec{B} + (\hat{\imath} + 2\hat{\jmath} - 3\hat{k}) = \hat{\imath}$

or $\vec{B} = -2\hat{\jmath} + 3\hat{k}$

15. **(d)**

$\cos\theta = \frac{(\hat{\imath}+2\hat{\jmath}+2\hat{k}).\hat{\imath}}{(1^2+2^2+2^2)^{1/2}} = \frac{1}{\sqrt{3}} = \frac{1}{3}$

$= 0.4472 = \cos 63°12'$

16. **(a)**

Centripetal velocity at highest point $= \sqrt{gR} = \sqrt{10 \times 1.6} = 4 m/s$

17. **(c)**

The velocity of the particle at any time t

$\vec{\mathbf{v}} = \vec{\mathbf{v}}0 + \vec{\mathbf{a}}t$

The x-component is

$v_x = v_{ax} + a_x t$

The y-component is

$v_y = v_{ay} + a_x = (-0.5t)\text{ms}^{-1}$

When the particle reaches its maximum x-coordinates, $v_x = 0$. That is

$3 - t = 0$

$\Rightarrow t = 3\text{s}$

The y-component of the velocity of this time is

$v_y = -0.5 \times 3 = -1.5 \text{ ms}^{-1}$

18. **(b)**

$\vec{A} = 2\hat{\imath} - \hat{\jmath} + 3\hat{k}$; $\vec{B} = 3\hat{\imath} - 2\hat{\jmath} - 2\hat{k}$; $\vec{C} = ?$

$\vec{R} = \hat{k} = \vec{A} + \vec{B} + \vec{C}$

$\hat{k} = (2\hat{\imath} - \hat{\jmath} + 3\hat{k}) + (3\hat{\imath} - 2\hat{\jmath} - 2\hat{k}) + \vec{C}$

$= 5\hat{\imath} - 3\hat{\jmath} + \hat{k} + \vec{C}$

$\therefore \vec{C} = -5\hat{\imath} + 3\hat{\jmath}$

19. **(a)**

Tangential acceleration $a = L\alpha$

$\therefore$ Normal relation $N = Ma = ML\alpha$

$\therefore$ Frictional force $F = mN = \mu ML\alpha$

For no sliding along the length frictional force ≥ centripetal force

$ie, \mu ML\alpha \geq ML\omega^2$

As $\omega = \omega_0 + \alpha t = \alpha t$

$\therefore \mu ML\alpha \geq ML(\alpha t)^2 \Rightarrow t = \sqrt{\frac{\mu}{\alpha}}$

20. **(b)**

$\frac{mv^2}{r} \propto \frac{K}{r} \Rightarrow v \propto r^o$

$i.e.$ speed of the particle is independent of r

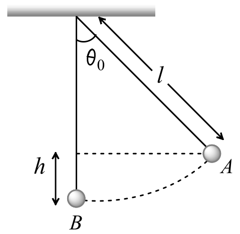
21. **(b)**

$E'_k = E_k \cos^2 30° = \frac{3E_k}{4}$

22. **(d)**

Maximum tension in the string is

$T_{\max} = mg + \frac{mv_B^2}{l}$



$= mg + \frac{2mgl}{l}(1 - \cos\theta_0)$

$= mg + \frac{2mgl}{l}. 2\sin^2\frac{\theta_0}{2}$

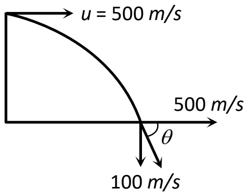
$\because \left(1 - \cos\theta_0 = 2\sin^2\frac{\theta_0}{2}\right)$

[Since θ_0 is small]

$= mg(1 + \theta_0^2)$

23. **(a)**

Horizontal component of velocity $v_x = 500\ m/s$ and vertical components of velocity while striking the ground



$v_y = 0 + 10 \times 10 = 100\ m/s$

∴ Angle with which it strikes the ground

$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{100}{500}\right) = \tan^{-1}\left(\frac{1}{5}\right)$

24. **(a)**

Here, Mass of a stone, $m = 2kg$

Length of a string, $r = 0.5\ m$

Breaking tension, $T = 900\ N$

As $T = mr\omega^2$ or $\omega^2 = \frac{T}{mr} = \frac{900}{2\times0.5} = 900$

$\omega = 30$ rad s^{-1}

25. **(b)**

$v_{\max} = \sqrt{\mu r g} = \sqrt{0.5 \times 40 \times 9.8} = 14\ m/s$

26. **(c)**

For projectile A

Maximum height, $H_A = \frac{u_A^2 \sin^2 45°}{2g}$

For projectile B

Maximum height $H_B = \frac{u_B^2 \sin^2\theta}{2g}$

As per equation

$H_A = H_B$

$\frac{u_A^2 \sin^2 45°}{2g} = \frac{u_B^2 \sin^2\theta}{2g}$

$\Rightarrow \frac{\sin^2\theta}{\sin^2 45°} = \frac{u_A^2}{u_B^2}$

$\Rightarrow \sin^2\theta = \left(\frac{u_A}{u_B}\right)^2 \sin^2 45°$

$\Rightarrow \sin^2\theta = \left(\frac{1}{\sqrt{2}}\right)^2\left(\frac{1}{\sqrt{2}}\right)^2 \left[\because \frac{u_A}{u_B} = \frac{1}{\sqrt{2}} \text{ (Given)}\right]$

$\Rightarrow \sin\theta = \frac{1}{2} \Rightarrow \theta \sin^{-1}\left(\frac{1}{2}\right) = 30°$

27. **(c)**

Centripetal acceleration $= 4\pi^2 n^2 r = 4\pi^2 \left(\frac{1}{2}\right)^2 \times 4 = 4\pi^2$

28. **(b)**

$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4 = (5\hat{i} - 5\hat{j} + 5\hat{k}) + (2\hat{i} + 8\hat{j} + 6\hat{k})$

$+(-6\hat{i} + 4\hat{j} - 7\hat{k}) + (-\hat{i} - 3\hat{j} - 2\hat{k})$

$= 4\hat{i} + 2\hat{k}$

This fore is in $y - z$ plane. Therefore, particle will move in $y - z$ plane.

29. **(a)**

Given, $r = (20/\pi)\text{m}$

$v = 80\text{ m/s}$

$\theta = 2\text{ rev} = 4\pi\text{ rad}$

$\omega_0 = 0$

From the equation

$\omega^2 = \omega_0^2 + 2\alpha\theta$, we have

$\omega^2 = 2\alpha\theta$

or $\frac{v^2}{r^2} = 2 \cdot \frac{a}{r}\theta$

or $a = \frac{v^2}{2r\theta} = \frac{(80)^2}{2\times(20/\pi)\times 4\pi}$

$= 40\text{ ms}^{-2}$

30. **(d)**

31. **(d)**

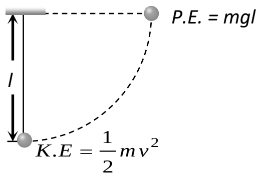
Here, $r = 5\text{ m}, \mu = 0.5, \omega = ?, g = 10\text{ms}^{-2}$

$mr\omega^2 = F = \mu R = \mu mg$

$\omega = \sqrt{\frac{\mu g}{r}} = \sqrt{\frac{0.5\times 10}{5}} = 1\text{ rad s}^{-1}$

32. **(d)**

Kinetic energy given to a sphere at lowest point = potential energy at the height of suspension



$\Rightarrow \frac{1}{2}mv^2 = mgl$

$\therefore v = \sqrt{2gl}$

33. **(b)**

Centripetal force $= mr\omega^2 = 5 \times 1 \times 4 = 20\text{N}$

34. **(c)**

A particle performing a uniform circular motion has a transverse velocity and radial acceleration

35. **(a)**

$\frac{mv^2}{r} = \frac{k}{r^2} \Rightarrow mv^2 = \frac{k}{r} \therefore \text{K.E.} = \frac{1}{2}mv^2 = \frac{k}{2r}$

P.E. $= \int F\,dr = \int \frac{k}{r^2}\,dr = -\frac{k}{r}$

$\therefore$ Total energy $=$ K.E. $+$ P.E. $= \frac{k}{2r} - \frac{k}{r} = -\frac{k}{2r}$

36. **(c)**

Difference in K.E. = Difference in P.E. $= 2mgr$

37. **(c)**

$v = \sqrt{\mu rg} = \sqrt{0.64 \times 20 \times 10} = 11.2 \text{ ms}^{-1}$

38. **(d)**

$\vec{A} \cdot (\vec{B} \times \vec{A}) = (\vec{A} \times \vec{A}) \cdot \vec{B} = (\vec{0}) \cdot \vec{B} = 0$

39. **(d)**

$r_1 = v/\omega; r_2 = 2v/(\omega/2) = 4v/\omega = 4r_1$

$a_1 = v^2/r_1; a_2 = (2v)^2/r_2 = 4v^2/r_1 = v^2/r_1 = a_1$

40. **(d)**

Angular acceleration $= \frac{d^2\theta}{dt^2} = 2\theta_2$

41. **(b)**

Since range is max, therefore $\theta = 45°$

Hence, $V_x = V \cos\theta = V \cos 45° = \frac{V}{\sqrt{2}}$

At the highest point, the net velocity of the projectile is

$V_x = V \cos 45°$

$\therefore \text{K. E.} = \frac{1}{2} m V_x^2 = \frac{1}{2} m \frac{V^2}{2} = 0.5\, K$

42. **(b)**

Acceleration of electron

$= \frac{v^2}{r} = \frac{(2.18 \times 10^6)^2}{0.528 \times 10^{-10}} = 9 \times 10^{22} \text{ ms}^{-2}$

43. **(d)**

Given, equation is

$y = 9x^2$ .... (i)

Since, x-component of velocity remains constant, we have

$\frac{dx}{dt} = \frac{1}{3} \text{ms}^{-1}$ ... (ii)

From Eq. (i), we have y-component of velocity.

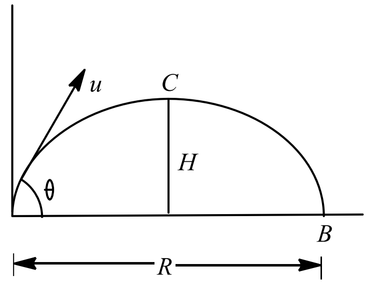
$\frac{dy}{dt} = 18x \cdot \left(\frac{dx}{dt}\right)^2$

$\frac{dy}{dt} = 18 \left(\frac{dx}{dt}\right)^2 = 18 \times \left(\frac{1}{3}\right)^2 = 2\text{ms}^{-2}$

$\therefore \mathbf{a}_y = 2\,\hat{\mathbf{j}} \text{ ms}^{-2}$

44. **(b)**

Let a body be projected at a velocity u at an angle θ with the horizontal. Then horizontal range covered is given by



$R = \frac{u^2 \sin 2\theta}{g}$ ... (i)

and height H is

$H = \frac{u^2 \sin^2\theta}{2g}$ ... (ii)

Given, $R = 3H$

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

Also, $\sin 2\theta = 2 \sin\theta \cos\theta$

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

or $2 \cos\theta = 1.5 \sin\theta$

or $\tan\theta = \frac{2}{1.5} = 1.33$

or $\theta = 53°7''$

Hence, angle of projection is $53°7'$

45. **(d)**

When the string makes an angle θ with the vertical, then

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

Substituting the values, we obtain

$$6 - (1)(10) \cos\theta = \frac{1 \times (4)^2}{1}$$

or $6 - 10 \cos\theta = 16$

or $\cos\theta = -1 = \cos 180°$

$\therefore = 180°$

46. **(b)**

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

$$\therefore 20 = \frac{u^2 \sin(2 \times 30°)}{g}$$

$$\Rightarrow \frac{u^2}{g} = \frac{20}{\sin 60°} = \frac{20}{\sqrt{3}} \times 2 = \frac{40}{\sqrt{3}}$$

Now, $H = \frac{u^2 \sin^2\theta}{2g}$

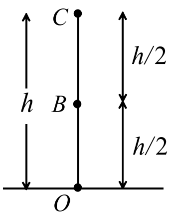
$$= \frac{40}{\sqrt{3}} \times \frac{\sin^2 30°}{2}$$

$$= \frac{40}{\sqrt{3}} \times \frac{\left(\frac{1}{2}\right)^2}{2} = \frac{5}{\sqrt{3}} \text{ m}$$

47. **(b)**

48. **(b)**

$v^2 = u^2 + 2as$ ...(i)



At $B, u = 10\ m/s$

at max. height, $v = 0$

$a = -10\ m/s^2; s = h/2$

From equation (i)

$0 = (10)^2 + 2(-10)h/2 \Rightarrow h = 10\ m$

49. **(b)**

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

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

$$\therefore\ \frac{dH}{H} = \frac{2du}{u} = 2 \times \frac{1}{10}$$

$\therefore$% increase in $H = \frac{dH}{H} \times 100$

$$= \frac{2}{10} \times 100 = 20\%$$

50. **(d)**

For vertically upward motion of a projectile,

$$y = (u \sin \alpha)t - \frac{1}{2} g t^2$$

or $h = (u \sin \alpha)t - \frac{1}{2} g t^2$

or $g t^2 - (2u \sin\alpha)t + 2h = 0$

$$\therefore t = \frac{2u \sin\alpha \pm \sqrt{(4u^2 \sin^2\alpha) - 8gh}}{2g}$$

If two roots of quadratic Eq.(i) are t_1, t_2 then

$$t_1 = \frac{2u \sin\alpha + \sqrt{4u^2 \sin^2\alpha - 8gh}}{2g}$$

$$t_2 = \frac{2u \sin\alpha - \sqrt{4u^2 \sin^2\alpha - 8gh}}{2g}$$

If particle crosses the wall at times t_1 and t_2 respectively, then time of flight t is

$$t = \sqrt{t_1 t_2}$$

or $t^2 = t_1 t_2$

$$\therefore\ \left(\frac{2u \sin\alpha}{g}\right)^2 = \frac{(2u \sin\alpha)^2 - (4u^2 \sin^2\alpha - 8gh)}{4g^2}$$

or $\frac{4u^2 \sin^2\alpha}{g^2} = \frac{8gh}{4g^2}$

or $2u^2 \sin^2\alpha = gh$

Given, $u = \sqrt{2gh}$

$\therefore\ 2(2gh)\sin^2\alpha = gh$

or $\sin^2\alpha = \frac{1}{4}$

or $\sin\alpha = \frac{1}{2}$

$\therefore\ \alpha = 30°$