

Chapter 4

Motion in a Plane

Solutions

SECTION - A

Objective Type Questions

(Motion in a Plane, Motion in a Plane with Constant Acceleration, Relative Velocity in Two Dimensions)

1. Two particles A and B start moving with velocities 20 m/s and $30\sqrt{2}$ m/s along x-axis and at an angle 45° with x-axis respectively in xy-plane from origin. The relative velocity of B w.r.t. A

- (1) $(10\hat{i} + 30\hat{j})$ m/s
 (2) $(30\hat{i} + 10\hat{j})$ m/s
 (3) $(30\hat{i} - 20\sqrt{2}\hat{j})$ m/s
 (4) $(30\sqrt{2}\hat{i} + 10\sqrt{2}\hat{j})$ m/s

Sol. Answer (1)

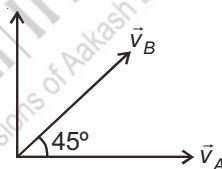
$$v_A = 20 \text{ m/s}$$

$$v_B = 30\sqrt{2} \text{ m/s along } 45^\circ \text{ with x-axis}$$

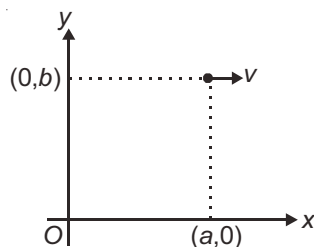
$$\vec{v}_B = v_B \cos 45^\circ \hat{i} + v_B \sin 45^\circ \hat{j} = 30\hat{i} + 30\hat{j}$$

$$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A = 30\hat{i} + 30\hat{j} - 20\hat{i}$$

$$\boxed{\vec{v}_{BA} = 10\hat{i} + 30\hat{j}}$$



2. A particle is moving with constant speed v in xy plane as shown in figure. The magnitude of its angular velocity about point O is



(1) $\frac{v}{\sqrt{a^2 + b^2}}$

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

(3) $\frac{vb}{(a^2 + b^2)}$

(4) $\frac{v}{a}$

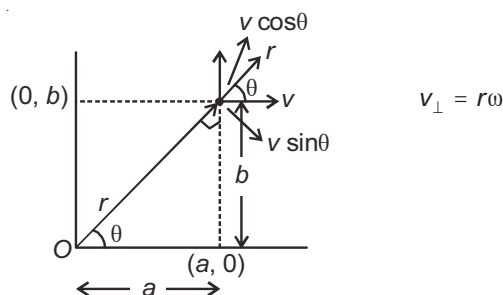
Sol. Answer (3)

$$v \sin \theta = r \omega$$

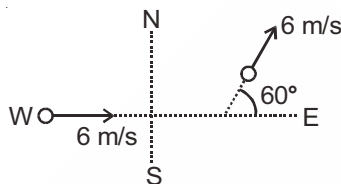
$$v \sin \theta = \sqrt{a^2 + b^2} \times \omega$$

$$\frac{v}{\sqrt{a^2 + b^2}} \frac{b}{\sqrt{a^2 + b^2}} = \omega$$

$$\boxed{\frac{vb}{(a^2 + b^2)} = \omega}$$



3. A particle is moving eastwards with a speed of 6 m/s. After 6 s, the particle is found to be moving with same speed in a direction 60° north of east. The magnitude of average acceleration in this interval of time is



(1) 6 m/s^2

(2) 3 m/s^2

(3) 1 m/s^2

(4) Zero

Sol. Answer (3)

$$|\Delta \vec{v}| = 2v \sin \frac{\theta}{2} = 2v \sin \left(\frac{60^\circ}{2} \right) = 2v \sin 30^\circ = v$$

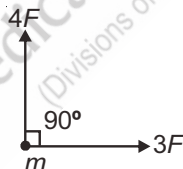
$$|\Delta \vec{v}| = 6 \text{ ms}^{-1}$$

$$\Delta t = 6 \text{ s}$$

$$\text{so, } a_{av} = \frac{6}{6} = 1 \text{ ms}^{-2}$$



4. When a force F acts on a particle of mass m , the acceleration of particle becomes a . Now if two forces of magnitude $3F$ and $4F$ acts on the particle simultaneously as shown in figure, then the acceleration of the particle is



(1) a

(2) $2a$

(3) $5a$

(4) $8a$

Sol. Answer (3)

$$F_{\text{net}} = \sqrt{3^2 + 4^2} = 5F$$

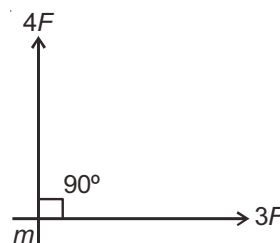
$$\text{So, } F_{\text{net}} = ma$$

$$5F = ma'$$

$$\Rightarrow a' = \frac{5F}{m}$$

$$\boxed{a' = 5a}$$

$$\frac{F}{m} = a$$



5. Out of the two cars A and B, car A is moving towards east with a velocity of 10 m/s whereas B is moving towards north with a velocity 20 m/s, then velocity of A w.r.t. B is (nearly)

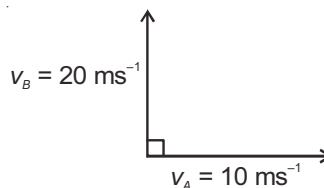
- (1) 30 m/s (2) 10 m/s (3) 22 m/s (4) 42 m/s

Sol. Answer (3)

$$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$$

$$v_{AB} = \sqrt{v_A^2 + v_B^2}$$

$$|\vec{v}_{AB}| = \sqrt{10^2 + 20^2} = \sqrt{100 + 400} = \sqrt{500} \approx 22 \text{ ms}^{-1}$$



6. A man moves in an open field such that after moving 10 m on a straight line, he makes a sharp turn of 60° to his left. The total displacement just at the start of 8th turn is equal to

- (1) 12 m (2) 15 m (3) 17.32 m (4) 14.14 m

Sol. Answer (3)

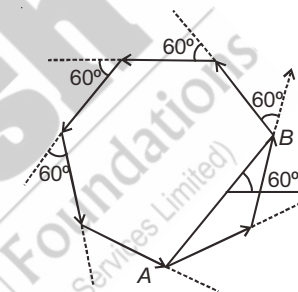
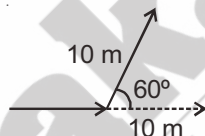
After 8 such turns object is at 'B'.

Displacement = AB

Two vectors are at 60°

$$\sqrt{10^2 + 10^2 + 2 \times 10^2 \times \frac{1}{2}} = 10\sqrt{3} \text{ m}$$

$$\Rightarrow \boxed{17.32 \text{ m} = AB}$$



7. Four persons P, Q, R and S are initially at the four corners of a square of side d . Each person now moves with a constant speed v in such a way that P always moves directly towards Q, Q towards R, R towards S, and S towards P. The four persons will meet after time

- (1) $\frac{d}{2v}$ (2) $\frac{d}{v}$
(3) $\frac{3d}{2v}$ (4) They will never meet

Sol. Answer (2)

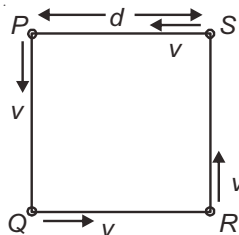
$$T = \frac{d}{v_{rel}}$$

$$v_{rel} = v - v \cos 90^\circ$$

$$= v - 0$$

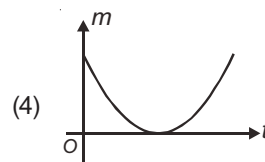
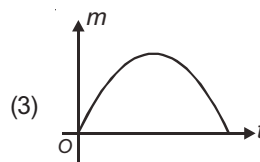
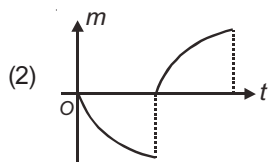
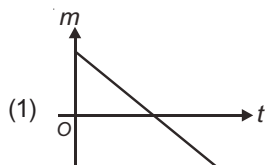
$$= v$$

$$T = \frac{d}{v}$$



(Projectile Motion)

8. A particle is projected at angle θ with horizontal from ground. The slope (m) of the trajectory of the particle varies with time (t) as



Sol. Answer (1)

Slope of trajectory

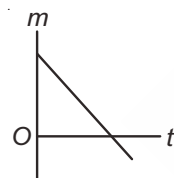
$$\tan \phi = \frac{u \sin \theta - gt}{u \cos \theta}$$

$$\text{So, } m = \frac{u \sin \theta}{u \cos \theta} - \frac{gt}{u \cos \theta}$$

$$m = \tan \theta - \frac{g}{u \cos \theta} t$$

$$\Rightarrow y = a - bx$$

Therefore,



9. If H_1 and H_2 be the greatest heights of a projectile in two paths for a given value of range, then the horizontal range of projectile is given by

(1) $\frac{H_1 + H_2}{2}$

(2) $\frac{H_1 + H_2}{4}$

(3) $4\sqrt{H_1 H_2}$

(4) $4[H_1 + H_2]$

Sol. Answer (3)

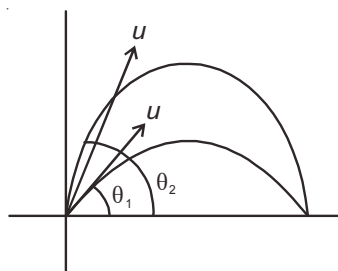
$$\theta_1 + \theta_2 = 90^\circ$$

$$H_1 = \frac{u^2 \sin^2 \theta_1}{2g}$$

$$H_2 = \frac{u^2 \sin^2 (90^\circ - \theta_1)}{2g}$$

$$H_1 H_2 = \frac{R^2}{16}$$

$$\therefore R = \frac{u^2 \sin^2 \theta_1}{g}$$



$$R = 4\sqrt{H_1 H_2}$$

10. If R and H are the horizontal range and maximum height attained by a projectile, then its speed of projection is

(1) $\sqrt{2gR + \frac{4R^2}{gH}}$

(2) $\sqrt{2gH + \frac{R^2g}{8H}}$

(3) $\sqrt{2gH + \frac{8H}{Rg}}$

(4) $\sqrt{2gH + \frac{R^2}{H}}$

Sol. Answer (2)

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

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

$$R = \frac{2u^2}{g} \sqrt{\frac{2gH}{u^2}} \times \sqrt{1 - \frac{2gH}{u^2}}$$

$$R = \frac{2u^2}{g} \sqrt{\frac{2gH}{u^2}} \times \sqrt{\frac{u^2 - 2gH}{u^2}}$$

$$\frac{gR}{2\sqrt{2gH}} = \sqrt{u^2 - 2gH}$$

Squaring both the sides,

$$\frac{gR^2}{4 \times 2gH} = u^2 - 2gH$$

$$\Rightarrow u^2 = 2gH + \frac{gR^2}{8H}$$

$$u = \sqrt{2gH + \frac{gR^2}{8H}}$$

11. A particle projected from ground moves at angle 45° with horizontal one second after projection and speed is minimum two seconds after the projection. The angle of projection of particle is [Neglect the effect of air resistance]

(1) $\tan^{-1}(3)$

(2) $\tan^{-1}(2)$

(3) $\tan^{-1}(\sqrt{2})$

(4) $\tan^{-1}(4)$

Sol. Answer (2)

$$\theta = 45^\circ, t = 1 \text{ s}$$

$$\tan \phi = \frac{v_y}{u_y} = \frac{u \sin \theta - gt}{u \cos \theta}$$

$$\tan 45^\circ = \frac{u \sin \theta - g \times 1}{u \cos \theta} \Rightarrow u \cos \theta = u \sin \theta - g$$

also, $v_y = 0$, after two seconds (as speed is minimum)

$$u \sin \theta - g \times 2 = 0 \Rightarrow \boxed{u \sin \theta = 2g} \quad \dots(i)$$

$$\text{so, } u \cos \theta = 2g - g$$

$$\boxed{u \cos \theta = g} \quad \dots(ii)$$

From equation (i) and (ii)

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

$$\Rightarrow \tan \theta = 2$$

$$\boxed{\theta = \tan^{-1}(2)}$$

12. A ball is projected from ground at an angle 45° with horizontal from distance d_1 from the foot of a pole and just after touching the top of pole it falls on ground at distance d_2 from pole on other side, the height of pole is

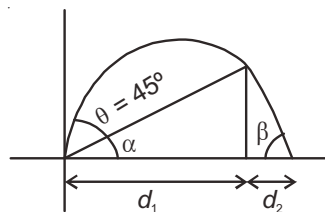
(1) $2\sqrt{d_1 d_2}$

(2) $\frac{d_1 + d_2}{4}$

(3) $\frac{2d_1 d_2}{d_1 + d_2}$

(4) $\frac{d_1 d_2}{d_1 + d_2}$

Sol. Answer (4)



$$\tan \theta + \tan \beta = \tan \theta$$

$$\frac{y}{d_1} + \frac{y}{d_2} = \tan 45^\circ$$

$$y = \left(\frac{d_1 d_2}{d_1 + d_2} \right)$$

13. A particle is projected with speed u at angle θ with horizontal from ground. If it is at same height from ground at time t_1 and t_2 , then its average velocity in time interval t_1 to t_2 is

(1) Zero

(2) $u \sin \theta$

(3) $u \cos \theta$

(4) $\frac{1}{2}[u \cos \theta]$

Sol. Answer (3)

When projectile is at same height, average velocity = $u \cos \theta$.

14. A particle is projected from ground at an angle θ with horizontal with speed u . The ratio of radius of curvature of its trajectory at point of projection to radius of curvature at maximum height is

(1) $\frac{1}{\sin^2 \theta \cos \theta}$

(2) $\cos^2 \theta$

(3) $\frac{1}{\sin^3 \theta}$

(4) $\frac{1}{\cos^3 \theta}$

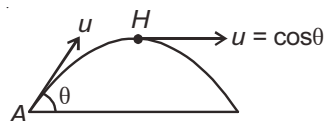
Sol. Answer (4)

At the point of projection

$$r_A = \frac{u^2}{g \cos \theta}$$

$$r_H = \frac{u^2 \cos^2 \theta}{g}$$

$$\text{Ratio, } \frac{r_A}{r_H} = \frac{\frac{u^2}{g \cos \theta}}{\frac{u^2 \cos^2 \theta}{g}} = \frac{1}{\cos^3 \theta} = \frac{r_A}{r_H}$$



15. An object of mass 10 kg is projected from ground with speed 40 m/s at an angle 60° with horizontal. The rate of change of momentum of object one second after projection in SI unit is [Take $g = 9.8 \text{ m/s}^2$]

(1) 73 (2) 98 (3) 176 (4) 140

Sol. Answer (2)

$$\text{Force} = \frac{\Delta p}{\Delta t}, \text{ force remains constant} = mg$$

$$\Rightarrow 10 \times 9.8 \Rightarrow 98 \text{ N}$$

At $t = 1$, particle is at its maximum height.

16. An object is projected from ground with speed 20 m/s at angle 30° with horizontal. Its centripetal acceleration one second after the projection is [Take $g = 10 \text{ m/s}^2$]

(1) 10 m/s^2 (2) Zero (3) 5 m/s^2 (4) 12 m/s^2

Sol. Answer (1)

$$\text{Centripetal acceleration} = \frac{v^2}{r} = g = 10 \text{ m/s}^2$$

17. A particle is moving on a circular path with constant speed v . It moves between two points A and B , which subtends an angle 60° at the centre of circle. The magnitude of change in its velocity and change in magnitude of its velocity during motion from A to B are respectively

(1) Zero, Zero (2) $v, 0$ (3) $0, v$ (4) $2v, v$

Sol. Answer (2)

$$\Delta v = 2v \sin \frac{\theta}{2}$$

$$= 2v \times \sin \left(\frac{60}{2} \right)$$

$$|\Delta v| = v$$

Change in magnitude of velocity = 0

18. What is the path followed by a moving body, on which a constant force acts in a direction other than initial velocity (*i.e.* excluding parallel and antiparallel direction)?

(1) Straight line (2) Parabolic (3) Circular (4) Elliptical

Sol. Answer (2)

The path will be parabolic.

19. Two stones are thrown with same speed u at different angles from ground in air. If both stones have same range and height attained by them are h_1 and h_2 , then $h_1 + h_2$ is equal to

(1) $\frac{u^2}{g}$ (2) $\frac{u^2}{2g}$ (3) $\frac{u^2}{3g}$ (4) $\frac{u^2}{4g}$

Sol. Answer (2)

If range is same then, one angle is θ and other angle is $(90 - \theta)$

$$\Rightarrow h_1 = \frac{u^2 \sin^2 \theta}{2g}, \quad h_2 = \frac{u^2 \sin^2 (90 - \theta)}{2g}$$

$$h_1 = \frac{u^2 \sin^2 \theta}{2g}, \quad h_2 = \frac{u^2 \cos^2 \theta}{2g}$$

$$\text{So, } h_1 + h_2 \Rightarrow \frac{u^2 \sin^2 \theta}{2g} + \frac{u^2 \cos^2 \theta}{2g} = \frac{u^2}{2g} (\sin^2 \theta + \cos^2 \theta)$$

$$\boxed{h_1 + h_2 = \frac{u^2}{2g}}$$

20. A projectile is projected with speed u at an angle θ with the horizontal. The average velocity of the projectile between the instants it crosses the same level is

- (1) $u \cos \theta$ (2) $u \sin \theta$ (3) $u \cot \theta$ (4) $u \tan \theta$

Sol. Answer (1)

21. A ball is thrown at an angle θ with the horizontal. Its horizontal range is equal to its maximum height. This is possible only when the value of $\tan \theta$ is

- (1) 4 (2) 2 (3) 1 (4) 0.5

Sol. Answer (1)

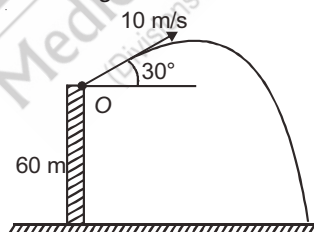
$$\frac{H}{R} = \frac{1}{4} \tan \theta$$

$$\Rightarrow H = R, \text{ given,}$$

$$\boxed{\tan \theta = 4}$$

$$\Rightarrow \boxed{\theta = \tan^{-1}(4)}$$

22. A ball is projected from a point O as shown in figure. It will strike the ground after ($g = 10 \text{ m/s}^2$)

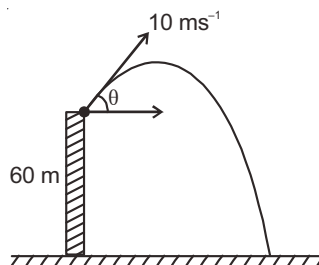


- (1) 4 s (2) 3 s (3) 2 s (4) 5 s

Sol. Answer (1)

$$s_y = u_x T + \frac{1}{2} a_y T^2$$

$$-60 = 10 \sin 30^\circ \cdot T - \frac{1}{2} g T^2$$

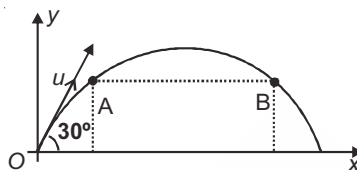


$$-60 = 5T - 5T^2$$

$$T^2 - T - 2 = 0$$

$$\boxed{T = 4 \text{ s}}$$

23. A particle is thrown with a velocity of u m/s. It passes A and B as shown in figure at time $t_1 = 1$ s and $t_2 = 3$ s. The value of u is ($g = 10 \text{ m/s}^2$)



(1) 20 m/s

(2) 10 m/s

(3) 40 m/s

(4) 5 m/s

Sol. Answer (3)

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

$$1 + 3 = \frac{2u \times \sin 30^\circ}{10}$$

$$20 \times 2 = u$$

$$\Rightarrow \boxed{u = 40 \text{ ms}^{-1}}$$

24. Which one of the following statements is not true about the motion of a projectile?

- (1) The time of flight of a projectile is proportional to the speed with which it is projected at a given angle of projection
- (2) The horizontal range of a projectile is proportional to the square root of the speed with which it is projected
- (3) For a given speed of projection, the angle of projection for maximum range is 45°
- (4) At maximum height, the acceleration due to gravity is perpendicular to the velocity of the projectile

Sol. Answer (2)

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

25. A projectile is thrown with speed 40 ms^{-1} at angle θ from horizontal. It is found that projectile is at same height at 1 s and 3 s. What is the angle of projection?

(1) $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$

(2) $\tan^{-1}\left(\frac{1}{\sqrt{3}}\right)$

(3) $\tan^{-1}(\sqrt{3})$

(4) $\tan^{-1}(\sqrt{2})$

Sol. Answer (2)

$$\tan \theta = \frac{v_y}{v_x}$$

$$\text{Also, } t_1 + t_2 = \frac{2u \sin \theta}{g}$$

$$4 = \frac{2 \times 40 \times \sin \theta}{10}$$

$$\sin \theta = \frac{1}{2} \Rightarrow \theta = 30^\circ$$

$$\text{So, } \tan \theta = \tan 30^\circ \Rightarrow \frac{1}{\sqrt{3}}$$

$$\theta = \tan^{-1} \left(\frac{1}{\sqrt{3}} \right)$$

26. A particle projected from origin moves in x-y plane with a velocity $\vec{v} = 3\hat{i} + 6x\hat{j}$, where \hat{i} and \hat{j} are the unit vectors along x and y axis. Find the equation of path followed by the particle

(1) $y = x^2$

(2) $y = \frac{1}{x^2}$

(3) $y = 2x^2$

(4) $y = \frac{1}{x}$

Sol. Answer (1)

Method 1:

$$\vec{v} = 3\hat{i} + 6x\hat{j}$$

$$\text{also } \vec{v} = \frac{dx}{dt} \hat{i} + \frac{dy}{dt} \hat{j}$$

$$\Rightarrow \frac{dx}{dt} = 3,$$

$$\int dx = \int 3 dt$$

$$x = 3t$$

$$\frac{dy}{dt} = 6x$$

$$dy = 6x \times dt$$

$$\int dy = \int 6 \times 3t dt$$

$$= 18 \int t dt \Rightarrow 18 \times \frac{t^2}{2}$$

$$y = 9t^2$$

$$= 9 \times \frac{x^2}{9}$$

$$y = x^2$$

Method 2:

$$V_x \hat{i} + V_y \hat{j} = \vec{v}$$

$$V_x = 3$$

$$V_y = 6x$$

We know

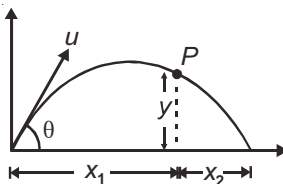
$$\frac{dy}{dx} = \tan \theta = \frac{V_y}{V_x}$$

$$\frac{dy}{dx} = \frac{6x}{3}$$

$$\int_0^y dy = \int_0^x 2x dx$$

$$y = x^2$$

27. In the given figure for a projectile



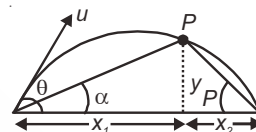
(1) $y = \left[\frac{x_1 x_2}{x_1 - x_2} \right] \tan \theta$ (2) $y = \left[\frac{x_1 x_2}{x_1 + x_2} \right] \tan \theta$ (3) $y = \left[\frac{2x_1 x_2}{x_1 + x_2} \right] \cos \theta$ (4) $y = \left[\frac{2x_1 x_2}{x_1 + x_2} \right] \tan \theta$

Sol. Answer (2)

The equation of trajectory for point 'P' can be written as :

$$y = x \tan \theta \left(1 - \frac{x}{R} \right) = x_1 \tan \theta \left(1 - \frac{x_1}{x_1 + x_2} \right) = x_1 \tan \theta \left(\frac{x_1 + x_2 - x_1}{x_1 + x_2} \right)$$

$$y = \frac{x_1 x_2}{x_1 + x_2} \tan \theta$$



28. An object is projected from ground with speed u at angle θ with horizontal. the radius of curvature of its trajectory at maximum height from ground is

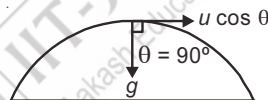
(1) $\frac{u^2 \sin 2\theta}{g}$ (2) $\frac{u^2 \cos^2 \theta}{g}$ (3) $\frac{u^2 \sin^2 \theta}{g}$ (4) $\frac{u^2 \sin^2 \theta}{2g}$

Sol. Answer (2)

$$a_c = \frac{v^2}{r}$$

$$r = \frac{v^2}{a_c}, \frac{u^2 \cos^2 \theta}{g}$$

$$r = \frac{u^2 \cos^2 \theta}{g}$$



(Uniform Circular Motion)

29. A particle is moving in xy-plane in a circular path with centre at origin. If at an instant the position of particle is

given by $\frac{1}{\sqrt{2}}(\hat{i} + \hat{j})$, then velocity of particle is along

(1) $\frac{1}{\sqrt{2}}(\hat{i} - \hat{j})$ (2) $\frac{1}{\sqrt{2}}(\hat{j} - \hat{i})$ (3) $\frac{1}{\sqrt{2}}(\hat{i} + \hat{j})$ (4) Either (1) or (2)

Sol. Answer (4)

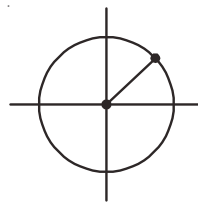
$$\vec{r} = \frac{1}{2}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}$$

$\vec{v} \cdot \vec{r} = 0$ as velocity is always tangential to the path.

$$(v_x \hat{i} + v_y \hat{j}) \cdot \frac{1}{2}(\hat{i} + \hat{j}) = 0$$

$$v_x + v_y = 0 \quad \Rightarrow \quad \boxed{v_x = -v_y}$$

or $\boxed{v_y = -v_x}$



$$v = \sqrt{v_x^2 + v_y^2} \quad \Rightarrow \quad \sqrt{2}v_x = v \quad \Rightarrow \quad \boxed{v_x = \frac{v}{\sqrt{2}}}$$

$$v_y = -\frac{v}{\sqrt{2}}$$

$$\text{or } v_x = -\frac{v}{\sqrt{2}}, v_y = \frac{v}{\sqrt{2}}$$

$$\text{So, possible value of } v \Rightarrow v_x \hat{i} + v_y \hat{j} \Rightarrow \frac{v}{\sqrt{2}} \hat{i} - \frac{v}{\sqrt{2}} \hat{j} \text{ or } -\frac{v}{\sqrt{2}} \hat{i} + \frac{v}{\sqrt{2}} \hat{j}$$

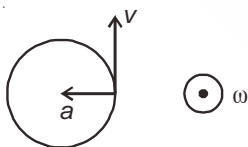
30. Consider the two statements related to circular motion in usual notations

A. In uniform circular motion $\vec{\omega}$, \vec{v} and \vec{a} are always mutually perpendicular

B. In non-uniform circular motion, $\vec{\omega}$, \vec{v} and \vec{a} are always mutually perpendicular

- (1) Both A and B are true
- (2) Both A and B are false
- (3) A is true but B is false
- (4) A is false but B is true

Sol. Answer (3)



Only first statement is correct.

$\omega \rightarrow$ mutually perpendicular to v and a .

31. Which of the following quantities remains constant during uniform circular motion?

- (1) Centripetal acceleration
- (2) Velocity
- (3) Momentum
- (4) Speed

Sol. Answer (4)

Speed remains constant.

SECTION - B

Previous Years Questions

1. The x and y coordinates of the particle at any time are $x = 5t - 2t^2$ and $y = 10t$ respectively, where x and y are in meters and t in seconds. The acceleration of the particle at $t = 2$ s is [NEET-2017]

- (1) 0 (2) 5 m/s^2 (3) -4 m/s^2 (4) -8 m/s^2

Sol. Answer (3)

$$x = 5t - 2t^2$$

$$y = 10t$$

$$\frac{dx}{dt} = 5 - 4t$$

$$\frac{dy}{dt} = 10$$

$$v_x = 5 - 4t$$

$$v_y = 10$$

$$\frac{dv}{dt} x = -4$$

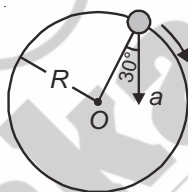
$$\frac{dv}{dt} y = 10$$

$$a_x = -4$$

$$a_y = 0$$

Acceleration of particle at $t = 2$ s is -4 m/s^2

2. In the given figure, $a = 15 \text{ m/s}^2$ represents the total acceleration of a particle moving in the clockwise direction in a circle of radius $R = 2.5$ m at a given instant of time. The speed of the particle is [NEET (Phase-2) 2016]



- (1) 4.5 m/s (2) 5.0 m/s (3) 5.7 m/s (4) 6.2 m/s

Sol. Answer (3)

$$a \cos 30^\circ = \frac{v^2}{r} \Rightarrow 15 \frac{\sqrt{3}}{2} = \frac{v^2}{2.5} \Rightarrow v = 5.7 \text{ m/s}$$

3. If the magnitude of sum of two vectors is equal to the magnitude of difference of the two vectors, the angle between these vectors is [NEET-2016]

- (1) 180° (2) 0° (3) 90° (4) 45°

Sol. Answer (3)

$$|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}| \Rightarrow \cos \theta = 0 \Rightarrow \theta = 90^\circ$$

4. A particle moves so that its position vector is given by $\vec{r} = \cos \omega t \hat{x} + \sin \omega t \hat{y}$, where ω is a constant. Which of the following is true? [NEET-2016]

- (1) Velocity is perpendicular to \vec{r} and acceleration is directed away from the origin
 (2) Velocity and acceleration both are perpendicular to \vec{r}
 (3) Velocity and acceleration both are parallel to \vec{r}
 (4) Velocity is perpendicular to \vec{r} and acceleration is directed towards the origin

Sol. Answer (4)

$$\left. \begin{aligned} \vec{r} &= \cos \omega t \hat{x} + \sin \omega t \hat{y}, \\ \vec{v} &= \frac{d\vec{r}}{dt} = -\omega \sin \omega t \hat{x} + \omega \cos \omega t \hat{y} \end{aligned} \right| \Rightarrow \vec{v} \cdot \vec{r} = 0$$

$$\vec{a} = -\omega^2 \cos \omega t \hat{x} - \omega^2 \sin \omega t \hat{y} = -\omega^2 \vec{r}$$

5. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion? **[NEET-2016]**

- (1) 0.2 m/s² (2) 0.1 m/s² (3) 0.15 m/s² (4) 0.18 m/s²

Sol. Answer (2)

$$m = 0.01 \text{ kg}, \quad r = 6.4 \text{ cm}$$

$$\frac{1}{2}mv^2 = 8 \times 10^{-4} \text{ J}$$

$$v^2 = \frac{16 \times 10^{-4}}{0.01} = 16 \times 10^{-2}$$

$$\text{Speed } v^2 = 2a_t s$$

$$v^2 = 2a_t 4\pi r \Rightarrow a_t = \frac{v^2}{8\pi r} = \frac{16 \times 10^{-2}}{8 \times 3.14 \times 6.4 \times 10^{-2}} = 0.1 \text{ m/s}^2$$

6. The position vector of a particle \vec{R} as a function of time is given by $\vec{R} = 4 \sin(2\pi t)\hat{i} + 4 \cos(2\pi t)\hat{j}$, where R is in meters, t is in seconds and \hat{i} and \hat{j} denote unit vectors along x - and y -directions, respectively. Which one of the following statements is wrong for the motion of particle? **[Re-AIPMT-2015]**

- (1) Path of the particle is a circle of radius 4 meter
 (2) Acceleration vector is along $-\vec{R}$
 (3) Magnitude of acceleration vector is $\frac{v^2}{R}$, where v is the velocity of particle
 (4) Magnitude of the velocity of particle is 8 meter/second

Sol. Answer (4)

$$\vec{R} = 4 \sin(2\pi t)\hat{i} + 4 \cos(2\pi t)\hat{j} = x\hat{i} + y\hat{j}$$

Now, $x^2 + y^2 = 4^2$ which is equation of circle of radius R .

So, the motion is UCM with speed

$$v = 8\pi\sqrt{2} \text{ m/s}$$

7. Two particles A and B , move with constant velocities \vec{v}_1 and \vec{v}_2 . At the initial moment their position vectors are \vec{r}_1 and \vec{r}_2 respectively. The condition for particles A and B for their collision is [Re-AIPMT-2015]

(1) $\vec{r}_1 - \vec{r}_2 = \vec{v}_1 - \vec{v}_2$ (2) $\frac{\vec{r}_1 - \vec{r}_2}{|\vec{r}_1 - \vec{r}_2|} = \frac{\vec{v}_2 - \vec{v}_1}{|\vec{v}_2 - \vec{v}_1|}$ (3) $\vec{r}_1 \cdot \vec{v}_1 = \vec{r}_2 \cdot \vec{v}_2$ (4) $\vec{r}_1 \times \vec{v}_1 = \vec{r}_2 \times \vec{v}_2$

Sol. Answer (2)

For collision final positions should be same

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

$$\Rightarrow \vec{r}_1 - \vec{r}_2 = (\vec{v}_2 - \vec{v}_1)t$$

$$\Rightarrow \vec{r}_1 - \vec{r}_2 = (\vec{v}_2 - \vec{v}_1) \frac{|\vec{r}_1 - \vec{r}_2|}{|\vec{v}_2 - \vec{v}_1|}$$

8. A ship A is moving Westwards with a speed of 10 km h^{-1} and a ship B 100 km South of A , is moving Northwards with a speed of 10 km h^{-1} . The time after which the distance between them becomes shortest, is [AIPMT-2015]

(1) $10\sqrt{2} \text{ h}$ (2) 0 h (3) 5 h (4) $5\sqrt{2} \text{ h}$

Sol. Answer (3)

9. A projectile is fired from the surface of the earth with a velocity of 5 ms^{-1} and angle θ with the horizontal. Another projectile fired from another planet with a velocity of 3 ms^{-1} at the same angle follows a trajectory which is identical with the trajectory of the projectile fired from the earth. The value of the acceleration due to gravity on the planet is (in ms^{-2}) is (Given $g = 9.8 \text{ ms}^{-2}$) [AIPMT-2014]

(1) 3.5 (2) 5.9 (3) 16.3 (4) 110.8

Sol. Answer (1)

Since trajectory is same, so range and maximum height both will be identical from earth and planet. So equating maximum height (Answer can be obtained by equating range also)

$$\frac{u_e^2 \sin^2 \theta}{2g_e} = \frac{u_p^2 \sin^2 \theta}{2g_p}$$

$$\frac{2.5}{9.8} = \frac{9}{g_p} \Rightarrow g_p = 3.5 \text{ m/s}^2$$

10. A particle is moving such that its position coordinates (x, y) are

$(2 \text{ m}, 3 \text{ m})$ at time $t = 0$,

$(6 \text{ m}, 7 \text{ m})$ at time $t = 2 \text{ s}$ and

$(13 \text{ m}, 14 \text{ m})$ at time $t = 5 \text{ s}$.

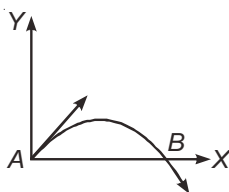
Average velocity vector (\vec{v}_{av}) from $t = 0$ to $t = 5 \text{ s}$ is [AIPMT-2014]

(1) $\frac{1}{5}(13\hat{i} + 14\hat{j})$ (2) $\frac{7}{3}(\hat{i} + \hat{j})$ (3) $2(\hat{i} + \hat{j})$ (4) $\frac{11}{5}(\hat{i} + \hat{j})$

Sol. Answer (4)

11. The velocity of a projectile at the initial point A is $(2\hat{i} + 3\hat{j})$ m/s. Its velocity (in m/s) at point B is

[NEET-2013]



- (1) $-2\hat{i} + 3\hat{j}$ (2) $2\hat{i} - 3\hat{j}$ (3) $2\hat{i} + 3\hat{j}$ (4) $-2\hat{i} - 3\hat{j}$

Sol. Answer (2)

The change is only in the y -component

So, $\boxed{v_f = 2\hat{i} - 3\hat{j}}$ $\because a_x = 0$

12. The horizontal range and the maximum height of a projectile are equal. The angle of projection of the projectile is

[AIPMT (Prelims)-2012]

- (1) $\theta = \tan^{-1}(2)$ (2) $\theta = 45^\circ$ (3) $\theta = \tan^{-1}\left(\frac{1}{4}\right)$ (4) $\theta = \tan^{-1}(4)$

Sol. Answer (4)

$$H = R$$

$$\tan\theta = 4 \quad \left(\because \frac{H}{R} = \frac{1}{4} \tan\theta \right)$$

$$\boxed{\theta = \tan^{-1}(4)}$$

13. A particle has initial velocity $(2\vec{i} + 3\vec{j})$ and acceleration $(0.3\vec{i} + 0.2\vec{j})$. The magnitude of velocity after 10 s will be

[AIPMT (Prelims)-2012]

- (1) 5 units (2) 9 units (3) $9\sqrt{2}$ units (4) $5\sqrt{2}$ units

Sol. Answer (4)

$$\vec{u} = 3\hat{i} + 3\hat{j}, \quad \vec{a} = 0.3\hat{i} + 0.2\hat{j}$$

$$\Delta t = 10 \text{ s}$$

$$\vec{v} = \vec{u} + \vec{a}t$$

$$\vec{v} = 2\hat{i} + 3\hat{j} + (0.3\hat{i} + 0.2\hat{j}) \times 10$$

$$= 2\hat{i} + 3\hat{j} + 3\hat{i} + 2\hat{j}$$

$$\vec{v} = 5\hat{i} + 5\hat{j}$$

$$v = \sqrt{5^2 + 5^2} = \sqrt{50}$$

$$\boxed{v \Rightarrow 5\sqrt{2} \text{ ms}^{-1}}$$

14. A particle moves in a circle of radius 5 cm with constant speed and time period 0.2π s. The acceleration of the particle is [AIPMT (Prelims)-2011]

- (1) 5 m/s^2 (2) 15 m/s^2
(3) 25 m/s^2 (4) 36 m/s^2

Sol. Answer (1)

$$r = 5 \text{ cm}, v = ?, T = 0.2\pi \text{ s}$$

$$T = \frac{2\pi}{\omega} \Rightarrow \omega = \frac{20\pi}{0.2\pi} = 10 \text{ rad s}^{-1}$$

$$a = r\omega^2 = 5 \times 10^{-2} \times 100$$

$$\boxed{a = 5 \text{ ms}^{-2}}$$

15. A body is moving with velocity 30 m/s towards east. After 10 s its velocity becomes 40 m/s towards north. The average acceleration of the body is [AIPMT (Prelims)-2011]

- (1) 5 m/s^2 (2) 1 m/s^2
(3) 7 m/s^2 (4) $\sqrt{7} \text{ m/s}^2$

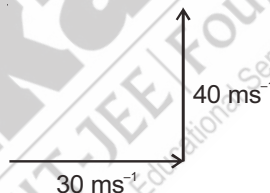
Sol. Answer (1)

$$a_{av} = \frac{|\Delta \vec{v}|}{\Delta t}$$

$$\Delta v = (\vec{v}_2 - \vec{v}_1) = \sqrt{v_2^2 + v_1^2} \quad (\because \theta = 90^\circ)$$

$$= 5\sqrt{30^2 + 40^2} = 50 \text{ ms}^{-1}$$

$$\text{so, } a_{av} = \frac{50}{10} \Rightarrow \boxed{5 \text{ ms}^{-2} = a_{av}}$$



16. A missile is fired for maximum range with an initial velocity of 20 m/s. If $g = 10 \text{ m/s}^2$, the range of the missile is [AIPMT (Prelims)-2011]

- (1) 20 m (2) 40 m (3) 50 m (4) 60 m

Sol. Answer (2)

For maximum range $\theta = 45^\circ$

$$v = 20 \text{ ms}^{-1}$$

$$R = \frac{u^2}{g} = \frac{20 \times 20}{10} \quad [\because \theta = 45^\circ]$$

$$\boxed{R = 40 \text{ m}}$$

17. A projectile is fired at an angle of 45° with the horizontal. Elevation angle of the projectile at its highest point as seen from the point of projection is

[AIPMT (Mains)-2011]

- (1) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (2) 45° (3) 60° (4) $\tan^{-1}\frac{1}{2}$

Sol. Answer (4)

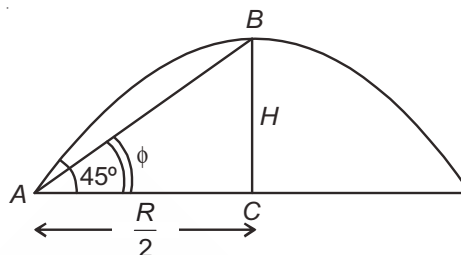
$$\frac{1}{4}\tan\theta = \frac{H}{R}$$

$$4H = R$$

...(i)

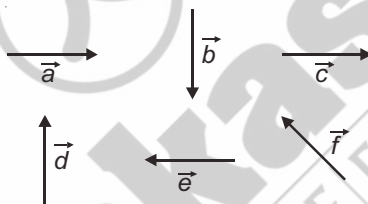
$$\text{In } \triangle ABC, \tan\phi = \frac{H}{\frac{R}{2}} = \frac{2H}{R}$$

$$\tan\phi = \frac{2H}{4H} = \frac{1}{2} \Rightarrow \phi = \tan^{-1}\left(\frac{1}{2}\right)$$



18. Six vectors, \hat{a} through \hat{f} have the magnitudes and directions indicated in the figure. Which of the following statements is true?

[AIPMT (Prelims)-2010]



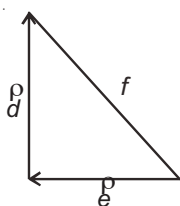
(1) $\vec{b} + \vec{c} = \vec{f}$

(2) $\vec{d} + \vec{c} = \vec{f}$

(3) $\vec{d} + \vec{e} = \vec{f}$

(4) $\vec{b} + \vec{e} = \vec{f}$

Sol. Answer (3)



$$\vec{d} + \vec{e} = \vec{f}$$

19. The speed of a projectile at its maximum height is half of its initial speed. The angle of projection is

[AIPMT (Mains)-2010]

(1) 60°

(2) 15°

(3) 30°

(4) 45°

Sol. Answer (1)

$$u_H = u \cos\theta$$

$$\frac{u}{2} = u \cdot \cos\theta \Rightarrow \cos\theta = \frac{1}{2}$$

$$\theta = 60^\circ$$

20. A particle moves in x-y plane according to rule $x = a \sin \omega t$ and $y = a \cos \omega t$. The particle follows

[AIPMT (Mains)-2010]

- (1) An elliptical path
- (2) A circular path
- (3) A parabolic path
- (4) A straight line path inclined equally to x and y-axes

Sol. Answer (2)

$$x = a \sin \omega t \Rightarrow x^2 = a^2 \sin^2 \omega t$$

$$y = a \cos \omega t \Rightarrow y^2 = a^2 \cos^2 \omega t$$

$$x^2 + y^2 = a^2 (\sin^2 \omega t + \cos^2 \omega t)$$

$$\boxed{x^2 + y^2 = a^2} \rightarrow \text{equation of circle.}$$

21. A particle has initial velocity $(3\hat{i} + 4\hat{j})$ and has acceleration $(0.4\hat{i} + 0.3\hat{j})$. Its speed after 10 s is

[AIPMT (Prelims)-2010]

- (1) 7 units
- (2) $7\sqrt{2}$ units
- (3) 8.5 units
- (4) 10 units

Sol. Answer (2)

22. A particle of mass m is projected with velocity v making an angle of 45° with the horizontal. When the particle lands on the level ground the magnitude of the change in its momentum will be

[AIPMT (Prelims)-2008]

- (1) Zero
- (2) $2mv$
- (3) $\frac{mv}{\sqrt{2}}$
- (4) $mv\sqrt{2}$

Sol. Answer (4)

$$\Delta p = -2mv \sin \theta \hat{j}$$

$$|\Delta \vec{p}| = 2mv \sin \theta = 2mv \times \frac{1}{\sqrt{2}}$$

$$\boxed{|\Delta \vec{p}| = \sqrt{2} mv}$$

23. A particle starting from the origin (0, 0) moves in a straight line in the (x, y) plane. Its coordinates at a later time are $(\sqrt{3}, 3)$. The path of the particle makes with the x-axis an angle of

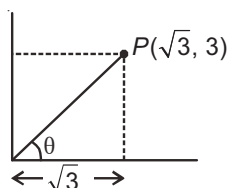
[AIPMT (Prelims)-2007]

- (1) 0°
- (2) 30°
- (3) 45°
- (4) 60°

Sol. Answer (4)

$$\tan \theta = \frac{P}{B} = \frac{3}{\sqrt{3}}$$

$$\boxed{\theta = 60^\circ}$$



24. \vec{A} and \vec{B} are two vectors and θ is the angle between them, if $|\vec{A} \times \vec{B}| = \sqrt{3}(\vec{A} \cdot \vec{B})$, the value of θ is

[AIPMT (Prelims)-2007]

- (1) 90° (2) 60° (3) 45° (4) 30°

Sol. Answer (2)

25. For angles of projection of a projectile at angles $(45^\circ - \theta)$ and $(45^\circ + \theta)$, the horizontal ranges described by the projectile are in the ratio of

[AIPMT (Prelims)-2006]

- (1) 1 : 1 (2) 2 : 3 (3) 1 : 2 (4) 2 : 1

Sol. Answer (1)

26. A car runs at a constant speed on a circular track of radius 100 m, taking 62.8 s for every circular lap. The average velocity and average speed for each circular lap respectively is

[AIPMT (Prelims)-2006]

- (1) 0, 0 (2) 0, 10 m/s (3) 10 m/s, 10 m/s (4) 10 m/s, 0

Sol. Answer (2)

$$T = 62.8 \text{ s}$$

$$r = 100 \text{ m}$$

$$T = \frac{2\pi}{\omega}$$

$$\omega = \frac{2\pi}{T} = \frac{2 \times 3.14 \times 10}{62.8 \times 100}$$

$$\omega = 0.1 \text{ rad s}^{-1}$$

$$v = r\omega$$

$$v = 100 \times 0.1$$

$$v = 10 \text{ ms}^{-1}$$

$$\text{Average velocity} = 0$$

$$\text{Average speed} = 10 \text{ ms}^{-1}$$

27. The vectors \vec{A} and \vec{B} are such that: $|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$. The angle between the two vectors is

[AIPMT (Prelims)-2006]

- (1) 90° (2) 60° (3) 75° (4) 45°

Sol. Answer (1)

$$|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$$

$$\sqrt{A^2 + B^2 + 2AB\cos\theta} = \sqrt{A^2 + B^2 - 2AB\cos\theta}$$

Squaring both the sides,

$$A^2 + B^2 + 2AB\cos\theta = A^2 + B^2 - 2AB\cos\theta$$

$$4AB\cos\theta = 0 \Rightarrow \cos\theta = 0 \Rightarrow \theta = 90^\circ$$

28. If a vector $2\hat{i} + 3\hat{j} + 8\hat{k}$ is perpendicular to the vector $4\hat{j} - 4\hat{i} + \alpha\hat{k}$, then the value of α is

[AIPMT (Prelims)-2005]

- (1) -1 (2) $\frac{1}{2}$ (3) $-\frac{1}{2}$ (4) 1

Sol. Answer (3)

29. A stone tied to the end of a string of 1 m long is whirled in a horizontal circle with a constant speed. If the stone makes 22 revolutions in 44 s, what is the magnitude and direction of acceleration of the stone?

[AIPMT (Prelims)-2005]

- (1) $\frac{\pi^2}{4} \text{ ms}^{-2}$ and direction along the radius towards the centre
 (2) $\pi^2 \text{ ms}^{-2}$ and direction along the radius away from centre
 (3) $\pi^2 \text{ ms}^{-2}$ and direction along the radius towards the centre
 (4) $\pi^2 \text{ ms}^{-2}$ and direction along the tangent to the circle

Sol. Answer (3)

$$\omega = \frac{22 \times 2\pi}{44 \text{ s}} \Rightarrow \pi \text{ rad s}^{-1}$$

Centripetal acceleration, $a = r\omega^2$

$$a = 1 \times \pi^2 \text{ ms}^{-2} \text{ along the radius towards the centre}$$

30. Two boys are standing at the ends A and B of a ground, where $AB = a$. The boy at B starts running in a direction perpendicular to AB with velocity v_1 . The boy at A starts running simultaneously with velocity v and catches the other boy in a time t , where t is

[AIPMT (Prelims)-2005]

- (1) $\frac{a}{\sqrt{v^2 + v_1^2}}$ (2) $\frac{a}{\sqrt{v^2 - v_1^2}}$ (3) $\frac{a}{(v - v_1)}$ (4) $\frac{a}{(v + v_1)}$

Sol. Answer (2)

The distance travelled by body at B ,

$$= \text{Speed} \times t$$

$$= v_1 t$$

So, $BC = v_1 t$, similarly, $AC = vt$

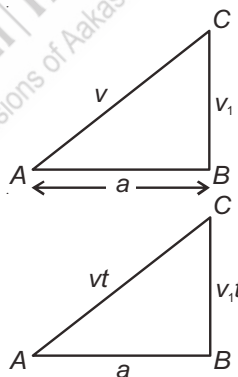
Applying pythagoras in $\triangle ABC$,

$$v^2 t^2 = v_1^2 t^2 + a^2$$

$$(v^2 - v_1^2) t^2 = a^2$$

$$t^2 = \frac{a^2}{v^2 - v_1^2}$$

$$t = \frac{a}{\sqrt{v^2 - v_1^2}}$$



31. If the angle between the vectors \vec{A} and \vec{B} is θ , the value of the product $(\vec{B} \times \vec{A}) \cdot \vec{A}$ is equal to

[AIPMT (Prelims)-2005]

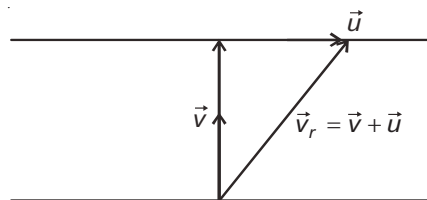
- (1) $BA^2 \cos\theta$ (2) $BA^2 \sin\theta$
 (3) $BA^2 \sin\theta \cos\theta$ (4) Zero

Sol. Answer (4)

32. A boat is sent across a river with a velocity of 8 km/h. If the resultant velocity of the boat is 10 km/h, then velocity of the river is

- (1) 8 km/h (2) 10 km/h (3) 12.8 km/h (4) 6 km/h

Sol. Answer (4)



$$v_r = \sqrt{v^2 + u^2}$$

$$v_r = 10 \text{ kmh}^{-1}, v = 8 \text{ kmh}^{-1}$$

$$u = ?$$

$$100 = 8^2 + u^2$$

$$\Rightarrow u^2 = 36 \Rightarrow \boxed{u = 6 \text{ km/h}}$$

33. Which of the following is correct relation between an arbitrary vector \vec{A} and null vector $\vec{0}$?

- (1) $\vec{A} + \vec{0} + \vec{A} \times \vec{0} = \vec{A}$ (2) $\vec{A} + \vec{0} + \vec{A} \times \vec{0} \neq \vec{A}$ (3) $\vec{A} + \vec{0} + \vec{A} \times \vec{0} = \vec{0}$ (4) None of these

Sol. Answer (1)

Knowledge based.

34. An object is being thrown at a speed of 20 m/s in a direction 45° above the horizontal. The time taken by the object to return to the same level is

- (1) $20/g$ (2) $20 g$ (3) $20\sqrt{2}/g$ (4) $20\sqrt{2}g$

Sol. Answer (3)

$$u = 20 \text{ ms}^{-1}$$

$$\theta = 45^\circ$$

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

$$T = \frac{2u}{g} \times \frac{1}{\sqrt{2}} = \frac{\sqrt{2}}{10} u$$

$$T = \frac{2 \times 20}{g} \frac{1}{\sqrt{2}} \Rightarrow \boxed{\frac{20\sqrt{2}}{g} = T}$$

35. A body is whirled in a horizontal circle of radius 20 cm. It has an angular velocity of 10 rad/s. What is its linear velocity at any point on circular path?

- (1) 20 m/s
 (2) $\sqrt{2}$ m/s
 (3) 10 m/s
 (4) 2 m/s

Sol. Answer (4)

$$v = r\omega = 20 \times 10^{-2} \times 10$$

$$v = 2 \text{ ms}^{-1}$$

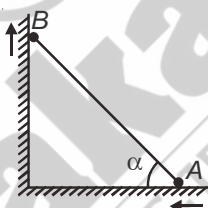
36. Identify the vector quantity among the following.

- (1) Distance
 (2) Angular momentum
 (3) Heat
 (4) Energy

Sol. Answer (2)

Angular momentum is an axial vector.

37. Two particles A and B are connected by a rigid rod AB. The rod slides along perpendicular rails as shown here. The velocity of A to the left is 10 m/s. What is the velocity of B when angle $\alpha = 60^\circ$?



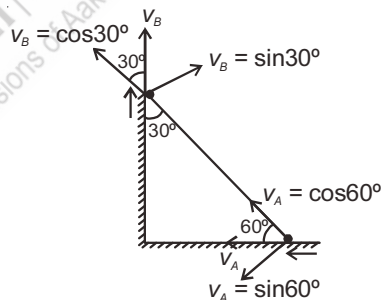
- (1) 10 m/s (2) 9.8 m/s (3) 5.8 m/s (4) 17.3 m/s

Sol. Answer (3)

$$v_A \cos 60^\circ = v_B \cos 30^\circ$$

$$10 \times \frac{1}{2} = v_B \times \frac{\sqrt{3}}{2}$$

$$v_B = \frac{10}{\sqrt{3}}$$



38. The speed of a boat is 5 km/h in still water. It crosses a river of width 1.0 km along the shortest possible path in 15 minutes. The velocity of the river water (in km/h) is

- (1) 3 (2) 1 (3) 4 (4) 5

Sol. Answer (1)

$$v = 5 \text{ kmh}^{-1}$$

$$d = 1.0 \text{ km}$$

$$t = 15 \text{ min}$$

39. Two racing cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively. Their speeds are such that each makes a complete circle in the same time t . The ratio of the angular speeds of the first to the second car is

- (1) $r_1 : r_2$
 (2) $m_1 : m_2$
 (3) $1 : 1$
 (4) $m_1 m_2 : r_1 r_2$

Sol. Answer (3)

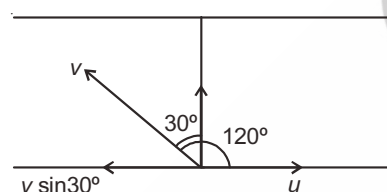
If time is same then,

$$\omega_1 : \omega_2 \Rightarrow 1 : 1 \quad \left[\because \omega = \frac{2\pi}{T} \right]$$

40. A person aiming to reach exactly opposite point on the bank of a stream is swimming with a speed of 0.5 m/s at an angle of 120° with the direction of flow of water. The speed of water in the stream is

- (1) 0.25 m/s
 (2) 0.5 m/s
 (3) 1.0 m/s
 (4) 0.433 m/s

Sol. Answer (1)



$$v \sin 30^\circ = u$$

$$0.5 \times \frac{1}{2} = u \Rightarrow \boxed{u = 0.25 \text{ ms}^{-1}}$$

41. Two projectiles of same mass and with same velocity are thrown at an angle 60° and 30° with the horizontal, then which will remain same

- (1) Time of flight
 (2) Range of projectile
 (3) Maximum height acquired
 (4) All of these

Sol. Answer (2)

Range is same for complimentary angles.

42. Two particles having mass M and m are moving in a circular path having radius R and r . If their time periods are same, then the ratio of their angular velocities will be

- (1) $\frac{r}{R}$
 (2) $\frac{R}{r}$
 (3) 1
 (4) $\sqrt{\frac{R}{r}}$

Sol. Answer (3)

43. If $|\vec{A} + \vec{B}| = |\vec{A}| = |\vec{B}|$ then angle between A and B will be

(1) 90° (2) 120° (3) 0° (4) 60°

Sol. Answer (2)

$$|\vec{A} + \vec{B}| = |\vec{A}| = |\vec{B}|$$

$$|\vec{A} + \vec{B}| = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

$$A^2 = A^2 + A^2 + 2A^2\cos\theta$$

$$-\frac{1}{2} = \cos\theta \Rightarrow \boxed{\theta = 120^\circ}$$

44. A particle moves along a circle of radius $\left(\frac{20}{\pi}\right)$ m with constant tangential acceleration. If the velocity of the particle is 80 m/s at the end of the second revolution after motion has begun, the tangential acceleration is

(1) 40 m/s^2 (2) $640\pi \text{ m/s}^2$ (3) $160\pi \text{ m/s}^2$ (4) $40\pi \text{ m/s}^2$

Sol. Answer (1)

$$r = \frac{20}{\pi} \text{ m}$$

$$a_T \rightarrow \text{constant}$$

$$v = 80 \text{ ms}^{-1}, \theta = 4\pi \text{ rad}$$

$$v = r\omega$$

$$80 = \frac{20}{\pi} \cdot \omega \Rightarrow \boxed{\omega = 4\pi \text{ rad s}^{-1}}$$

$$\omega = 0,$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$4\pi \times 4\pi = 2 \times \alpha \times 4\pi$$

$$\Rightarrow \boxed{\alpha = 2\pi \text{ rad s}^{-2}}$$

$$a = r\alpha = \frac{20}{\pi} \times 2\pi$$

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

45. The vector sum of two forces is perpendicular to their vector differences. In that case, the forces

(1) Are equal to each other

(2) Are equal to each other in magnitude

(3) Are not equal to each other in magnitude

(4) Cannot be predicted

Sol. Answer (2)

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

$$A^2 - B^2 - AB + BA = 0$$

$$A^2 = B^2 \Rightarrow \boxed{A = B}$$

$$\text{so, } \boxed{|\vec{A}| = |\vec{B}|}$$

46. A wheel has angular acceleration of 3.0 rad/s^2 and an initial angular speed of 2.00 rad/s . In a time of 2 s it has rotated through an angle (in radian) of

- (1) 10 (2) 12
(3) 4 (4) 6

Sol. Answer (1)

$$\alpha = 3 \text{ rad s}^{-2}$$

$$\omega_0 = 2 \text{ rad s}^{-1}$$

$$t = 2 \text{ s}$$

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

$$\omega = 2 + 3 \times 2$$

$$\boxed{\omega = 8 \text{ rad s}^{-1}}$$

$$\omega^2 - \omega_0^2 = 2 \times \theta$$

$$64 - 4 = 2 \times 3 \times \theta$$

$$\frac{60}{6} = \theta \Rightarrow \boxed{\theta = 10 \text{ rad s}^{-1}}$$

47. A particle is moving such that its position coordinates (x, y) are

$(2 \text{ m}, 3 \text{ m})$ at time $t = 0$,

$(6 \text{ m}, 7 \text{ m})$ at time $t = 2 \text{ s}$ and

$(13 \text{ m}, 14 \text{ m})$ at time $t = 5 \text{ s}$

Average velocity vector (\vec{V}_{av}) from $t = 0$ to $t = 5 \text{ s}$ is

- (1) $\frac{1}{5}(13\hat{i} + 14\hat{j})$ (2) $\frac{7}{3}(\hat{i} + \hat{j})$ (3) $2(\hat{i} + \hat{j})$ (4) $\frac{11}{5}(\hat{i} + \hat{j})$

Sol. Answer (4)

$$\vec{V}_{av} = \frac{\vec{r}_f - \vec{r}_i}{\Delta t} = \frac{(13-2)\hat{i} + (14-3)\hat{j}}{(5-0)} = \frac{11}{5}(\hat{i} + \hat{j})$$

SECTION - C

Assertion - Reason Type Questions

1. A : If $\vec{A} \perp \vec{B}$, then $|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$.

R : If $\vec{A} \perp \vec{B}$, then $(\vec{A} + \vec{B})$ is perpendicular to $\vec{A} - \vec{B}$.

Sol. Answer (3)

2. A : The addition of two vectors \vec{P} and \vec{Q} is commutative.

R : By triangle law of vector addition we can prove $\vec{P} + \vec{Q} = \vec{Q} + \vec{P}$.

Sol. Answer (1)

3. A : A vector cannot be divided by other vector.

R : A vector can be divided by a scalar.

Sol. Answer (2)

4. A : At the highest point the velocity of projectile is zero.

R : At maximum height projectile comes to rest.

Sol. Answer (4)

5. A : Horizontal range of a projectile is always same for angle of projection θ with horizontal or θ with vertical.

R : Horizontal range depends only on angle of projection.

Sol. Answer (4)

6. A : Horizontal motion of projectile without effect of air is uniform motion.

R : Without air effect the horizontal acceleration of projectile is zero.

Sol. Answer (1)

7. A : Path of a projectile with respect to another projectile is straight line.

R : Acceleration of a projectile with respect to another projectile is zero.

Sol. Answer (1)

8. A : In the case of ground to ground projection of a projectile from ground the angle of projection with horizontal is $\theta = 30^\circ$. There is no point on its path such that instantaneous velocity is normal to the initial velocity.

R : Maximum deviation of the projectile is $2\theta = 60^\circ$.

Sol. Answer (1)

9. A : Three vectors having magnitudes 10, 10 and 25 cannot produce zero resultant.

R : If three vectors are producing zero resultant, then sum of magnitude of any two is more than or equal to magnitude of third and difference is less than or equal to the magnitude of third.

Sol. Answer (1)

10. A : Uniform circular motion is accelerated motion still speed remains unchanged.

R : Instantaneous velocity is always normal to instantaneous acceleration in uniform circular motion.

Sol. Answer (1)

11. A : When a body moves on a curved path with increasing speed, then angle between instantaneous velocity and acceleration is acute angle.

R : When the speed is increasing, its tangential acceleration is in the direction of instantaneous velocity.

Sol. Answer (1)

12. A : A uniform circular motion have non uniform acceleration.

R : The direction of acceleration of a particle in uniform circular motion changes continuously.

Sol. Answer (1)

13. A : Angular displacement is vector quantity only for small values.

R : The direction of angular displacement is perpendicular to plane of rotation of object.

Sol. Answer (2)

