AVIRAL CLASSES
IIT-JEE | NEET | FOUNDATIONS

PHYSICS
CRASH COURSE

LECTURE - 05

# TOPICS : Kinematics Motion- 2D

1. A particle moves in xy plane according to the law $x = 4 \sin 6t$ and $y = 4 (t - \cos 6t)$. The distance traversed by the particle in 4 s is (x and y are in metres)

   (a) 96 m (b) 48 m

   (c) 24 m (d) 108 m

2. A particle is moving along circular path of radius 5 m with uniform speed of 5 $ms^{-1}$. What will be average acceleration when the particle completes half revolution ?

   (a) zero (b) 10 $ms^{-2}$

   (c) 10 $\pi$ $ms^{-2}$ (d) $\frac{10}{\pi} ms^{-2}$

3. When the angle of projection is 75°, a ball falls 10 m short of the target. When the angle of projection is 45°, it falls 10 m ahead of the target. Both are projected from the same point with the same speed in the same direction, the distance of the target from the point of projection is

   (a) 15 m (b) 30 m

   (c) 45 m (d) 10 m

4. A coastguard ship locates a pirate ship at a distance 560 m. It fires a cannon ball with an initial speed 82 $ms^{-1}$. At what angle from horizontal the ball must be fired so that it hits the pirate ship ?

   (Take g = 10 $ms^{-2}$)

   (a) 54° (b) 125°

   (c) 28° (d) 18°

5. A man standing on a road has to hold his umbrella at 30° with the vertical to keep the rain away. he throws the umbrella and starts running at 10 km $h^{-1}$. He find that raindrops are hitting his head vertically. The actual speed of raindrops is

   (a) 20 km $h^{-1}$ (b) $10\sqrt{3}$ km $h^{-1}$

   (c) $20\sqrt{3}$ km $h^{-1}$ (d) 10 km $h^{-1}$

6. Resultant of two vectors $\vec{A}$ and $\vec{B}$ is of magnitude. P if $\vec{B}$ is reversed, then resultant is of magnitude Q. What is the value of $p^2 + Q^2$ ?

   (a) $2(A^2 + B^2)$ (b) $2(A^2 - B^2)$

   (c) $A^2 - B^2$ (d) $A^2 + B^2$

7. In a two dimensional motion, instantaenous speed $v_0$ is a positive constant. Then which of the following are necessarily true ?

   (a) The acceleration of the particle is zero

   (b) The acceleration of the particle is bounded.

   (c) The acceleration of the particle is necessarily in the plane of motion

   (d) The particle must be undergoing a uniform circular motion.

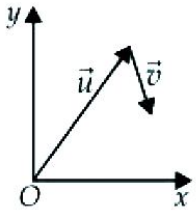
8. The horizontal range of a projectile fired at an angle of 15° is 50 m. If it is fired with the same speed at an angle of 45°, its range will be

   (a) 60 m (b) 71 m

   (c) 100 m (d) 141 m

9. Figure shows the orientation of two vectors $\vec{u}$ and $\vec{v}$ in the xy plane.

   If $\vec{u} = a\hat{i} + b\hat{j}$ and $\vec{v} = p\hat{i} + q\hat{j}$




   Which of the following is correct ?

   (a) a and p are positive while b and q are negative

   (b) a, p and b are positive while q is negative

   (c) a, q and b are positive while p is negative

   (d) a, b, p and q are all positive

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# TOPICS : Kinematics Motion- 2D (SOLUTION)

1. **(a) :** Here, $x = 4\sin 6t$, $y = 4(1 - \cos 6t)$

$$v_x = \frac{dx}{dt} = \frac{d}{dt}(4\sin 6t) = 24\cos 6t$$

$$v_y = \frac{dy}{dt} = \frac{d}{dt}4(1-\cos 6t) = 24\sin 6t$$

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(24\cos 6t)^2 + (24\sin 6t)^2} = 24 \text{ m s}^{-1}$$

*i.e.*, speed of the particle is constant. Hence, the distance traversed by the particle in 4 s is

$s = vt = (24 \times 4)$ m = 96 m

2. **(d):** Change in velocity when the particle completes half revolution is

$\Delta v = 5 \text{ m s}^{-1} - (-5 \text{ m s}^{-1}) = 10 \text{ m s}^{-1}$

Time taken to complete the half revolution is

$$t = \frac{\pi r}{v} = \frac{\pi \times 5 \text{ m}}{5 \text{ m s}^{-1}} = \pi \text{ s}$$

Average acceleration $= \frac{\Delta v}{t} = \frac{10 \text{ m s}^{-1}}{\pi \text{ s}} = \frac{10}{\pi} \text{ m s}^{-2}$

3. **(b):** Let $d$ be distance of the target from the point of projection.

$$\therefore \quad \frac{u^2 \sin(2 \times 75°)}{g} = d - 10$$

$$\text{or} \quad \frac{u^2}{2g} = d - 10 \qquad \ldots(i)$$

$$\text{and} \quad \frac{u^2 \sin(2 \times 45°)}{g} = d + 10$$

$$\text{or} \quad \frac{u^2}{g} = d + 10 \qquad \ldots(ii)$$

Divide (i) by (ii), we get

$$\frac{d-10}{d+10} = \frac{1}{2} \quad \text{or} \quad d = 30 \text{ m}$$

4. **(c) :** $\text{Range} = \frac{u^2 \sin 2\theta}{g}$

$$\therefore \quad 560 = \frac{(82)^2 \sin 2\theta}{10}$$

$$\text{or} \quad \sin 2\theta = \frac{5600}{(82)^2} = 0.832$$

or $2\theta = \sin^{-1}(0.832) = 56.30°$ [$\sin 56.30° = 0.832$]
$\Rightarrow \theta \approx 28°$

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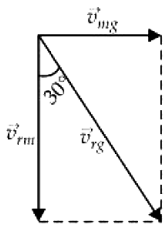
**5.** **(a) :** When the man is at rest with respect to the ground, the rain comes to him at an angle 30° with the vertical. This is the direction of the velocity of raindrops with respect to the ground.
Here, $\vec{v}_{rg}$ = velocity of the rain with respect to the ground.
From figure,




$$\sin 30° = \frac{v_{mg}}{v_{rg}}$$

$$\text{or } v_{rg} = \frac{v_{mg}}{\sin 30°}$$

$$= \frac{10 \text{ km h}^{-1}}{(1/2)} = 20 \text{ km h}^{-1}$$

**6.** **(a) :** Let $\theta$ be angle between $\vec{A}$ and $\vec{B}$.
Resultant of $\vec{A}$ and $\vec{B}$ is

$$P = \sqrt{A^2 + B^2 + 2AB\cos\theta} \quad \ldots(i)$$

When $\vec{B}$ is reversed, then the angle between $\vec{A}$ and $-\vec{B}$ is $(180° - \theta)$.

$\therefore$ Resultant of $\vec{A}$ and $-\vec{B}$ is

$$Q = \sqrt{A^2 + B^2 + 2AB\cos(180° - \theta)}$$

$$Q = \sqrt{A^2 + B^2 - 2AB\cos\theta} \quad \ldots(ii)$$

Squaring and adding (i) and (ii), we get

$$P^2 + Q^2 = 2(A^2 + B^2)$$

**7.** **C**

**8.** **(c) :** Horizontal range, $R = \frac{u^2 \sin 2\theta}{g}$

For the same speed,

$R \propto \sin 2\theta$

$$\therefore \quad \frac{R_1}{R_2} = \frac{\sin 2\times 15^\circ}{\sin 2\times 45^\circ} = \frac{\sin 30^\circ}{\sin 90^\circ}$$

$$\text{or} \quad R_2 = R_1 \frac{\sin 90^\circ}{\sin 30^\circ} = 50 \text{ m} \times \frac{1}{\left(\frac{1}{2}\right)} = 100 \text{ m}$$

**9.** B