CHAPTER

03

Projectile Motion

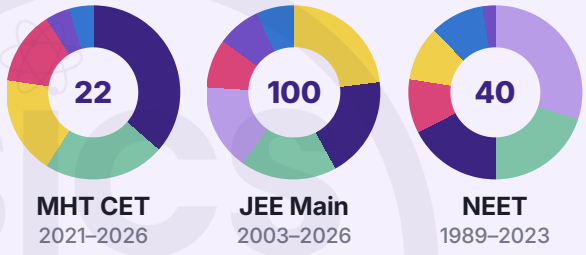
MHT CET · JEE · NEET Physics

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CONTENTS

3.1	Motion in a Plane	2
3.2	Projectile Basics & Trajectory	5
3.3	Velocity, Momentum & Energy in Flight	8
3.4	Time of Flight, Maximum Height & Range	11
3.5	Comparing Two Projectiles	14
3.6	Horizontal Projectile & Inclined Plane	17
3.7	Relative Velocity in Two Dimensions	21
★	**Exam-Day Card & Formula Sheet**	25

EXAM WEIGHTAGE



MHT CET 2021–2026 · **JEE Main** 2003–2026 · **NEET** 1989–2023

	CET	JEE	NEET
Time of Flight, Maximum Height & Range	8 (36%)	19 (19%)	7 (18%)
Comparing Two Projectiles	4 (18%)	23 (23%)	4 (10%)
Relative Velocity in Two Dimensions	5 (23%)	18 (18%)	8 (20%)
Motion in a Plane (2-D Kinematics)	0 (0%)	16 (16%)	12 (30%)
Velocity, Momentum & Energy in Flight	3 (14%)	9 (9%)	4 (10%)
Horizontal Projectile & Inclined Plane	1 (5%)	7 (7%)	4 (10%)
Projectile Basics & Trajectory	1 (5%)	8 (8%)	1 (2%)

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01 CONCEPT Motion in a Plane

IN ONE LINE

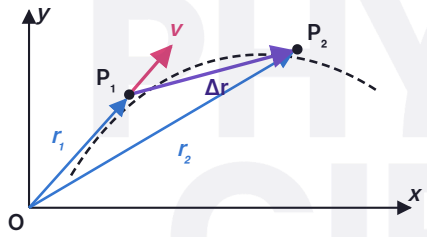
In a plane, treat x and y as two separate straight-line motions joined by vectors: r gives position, its rate gives v, and the rate of v gives a.

3.1.1 Position and displacement

- Two coordinates change with time: the body moves in a plane.
- Examples: a ball thrown at an angle, a car on a turn, a boat crossing a river.

$$\mathbf{r} = x\,\hat{\imath} + y\,\hat{\jmath}$$

$$\Delta\mathbf{r} = \mathbf{r}_2 - \mathbf{r}_1 = \Delta x\,\hat{\imath} + \Delta y\,\hat{\jmath}$$

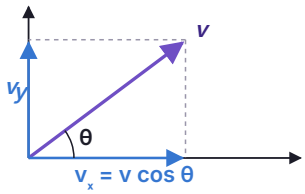


Displacement joins P_1 to P_2; velocity is along the tangent

3.1.2 Velocity and acceleration

$$\mathbf{v} = \frac{d\mathbf{r}}{dt} = v_x\,\hat{\imath} + v_y\,\hat{\jmath}$$

$$v = \sqrt{v_x^2 + v_y^2} \cdot \tan\theta = \frac{v_y}{v_x}$$



Components of velocity

$$\mathbf{a} = \frac{d\mathbf{v}}{dt} = a_x\,\hat{\imath} + a_y\,\hat{\jmath}$$

- Instantaneous velocity is always along the tangent to the path.
- $\mathbf{r} = a\cos\omega t\,\hat{\imath} + a\sin\omega t\,\hat{\jmath}$: $v \perp r$ and $\mathbf{a} = -\omega^2\mathbf{r}$ (circle).

3.1.3 Equation of the path

- Given x(t) and y(t): remove t to get y as a function of x.
- x linear and y quadratic in t ⇒ **parabola**.
- $x = a\sin\omega t$, $y = a\cos\omega t \Rightarrow x^2 + y^2 = a^2$, a **circle**.
- Given **v**: use $\frac{dy}{dx} = \frac{v_y}{v_x}$ and integrate.

3.1.4 Constant acceleration in a plane

- Each component obeys the 1-D equations on its own.

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

$$\mathbf{r} = \mathbf{u}t + \tfrac{1}{2}\mathbf{a}t^2$$

- Write x and y separately: $x = u_x t + \tfrac{1}{2}a_x t^2$, $y = u_y t + \tfrac{1}{2}a_y t^2$.
- Find t from one direction, then use it in the other.

3.1.5 Average velocity and acceleration

$$\mathbf{v}_{av} = \frac{\Delta\mathbf{r}}{\Delta t} \cdot \mathbf{a}_{av} = \frac{\Delta\mathbf{v}}{\Delta t}$$

- Only the end points count for average velocity.
- Speed unchanged but direction turned ⇒ $\Delta\mathbf{v} \neq 0$.
- Turning through 90° at speed v: $|\Delta v| = v\sqrt{2}$.

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Solved Examples 01 Motion in a Plane

SOLVED 1 JEE Main 2025 · 24 Jan · Shift 2

The position vector of a moving body at any instant of time is given as $\mathbf{r} = (5t^2\,\hat{i} - 5t\,\hat{j})$ m. The magnitude and direction of velocity at t = 2 s is

(a) $5\sqrt{17}$ m/s, making an angle of $\tan^{-1}4$ with −ve Y axis
(b) $5\sqrt{15}$ m/s, making an angle of $\tan^{-1}4$ with +ve X axis
(c) $5\sqrt{17}$ m/s, making an angle of $\tan^{-1}4$ with +ve X axis
(d) $5\sqrt{15}$ m/s, making an angle of $\tan^{-1}4$ with −ve Y axis

STEP 1 $\mathbf{v} = \frac{d\mathbf{r}}{dt} = 10t\,\hat{i} - 5\,\hat{j}$; at t = 2 s, $\mathbf{v} = 20\,\hat{i} - 5\,\hat{j}$
STEP 2 $|\mathbf{v}| = \sqrt{400 + 25} = \sqrt{425} = 5\sqrt{17}$ m/s
STEP 3 It points mostly along +x and slightly down: $\tan\alpha = \frac{20}{5} = 4$ from the −Y axis
⇒ **(a)**

Answer: **(a)**

SOLVED 2 AIPMT 1995

The position vector of a particle is $\mathbf{r} = (a\cos\omega t)\,\hat{i} + (a\sin\omega t)\,\hat{j}$. The velocity of the particle is

(a) directed towards the origin
(b) directed away from the origin
(c) parallel to the position vector
(d) perpendicular to the position vector

STEP 1 $\mathbf{v} = -a\omega\sin\omega t\,\hat{i} + a\omega\cos\omega t\,\hat{j}$
STEP 2 $\mathbf{r}\cdot\mathbf{v} = -a^2\omega\sin\omega t\cos\omega t + a^2\omega\sin\omega t\cos\omega t = 0$
STEP 3 So **v** is **perpendicular to the position vector**

Answer: **(d)**

SOLVED 3 AIPMT 2007

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

(a) 45°
(b) 60°
(c) 0°
(d) 30°

STEP 1 Straight line through the origin
STEP 2 $\tan\theta = \frac{y}{x} = \frac{3}{\sqrt{3}} = \sqrt{3}$
STEP 3 $\theta = 60°$

Answer: **(b)**

SOLVED 4 JEE Main 2020 · 8 Jan · Shift 2

A particle moves such that its position vector $\mathbf{r}(t) = \cos\omega t\,\hat{i} + \sin\omega t\,\hat{j}$, where ω is a constant and t is time. Then which of the following is true for the velocity **v** (t) and acceleration **a** (t)?

(a) **v** and **a** both are perpendicular to **r**
(b) **v** and **a** both are parallel to **r**
(c) **v** is perpendicular to **r** and **a** is directed towards the origin
(d) **v** is perpendicular to **r** and **a** is directed away from the origin

STEP 1 $\mathbf{v} = -\omega\sin\omega t\,\hat{i} + \omega\cos\omega t\,\hat{j}$, and $\mathbf{r}\cdot\mathbf{v} = 0$
STEP 2 $\mathbf{a} = -\omega^2\cos\omega t\,\hat{i} - \omega^2\sin\omega t\,\hat{j} = -\omega^2\mathbf{r}$
STEP 3 $\mathbf{v} \perp \mathbf{r}$; **a** points **towards the origin**

Answer: **(c)**

SOLVED 5 JEE Main 2024 · 4 Apr · Shift 1

The co-ordinates of a particle moving in the x-y plane are given by $x = 2 + 4t$, $y = 3t + 8t^2$. The motion of the particle is

(a) uniform motion along a straight line.
(b) non-uniformly accelerated.
(c) uniformly accelerated having motion along a straight line.
(d) uniformly accelerated having motion along a parabolic path.

STEP 1 $a_x = 0$, $a_y = 16$ m/s²: constant acceleration
STEP 2 $t = \frac{x - 2}{4}$; $y = 3t + 8t^2$ is quadratic in x
STEP 3 Uniformly accelerated, **parabolic path**

Answer: **(d)**

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Solved Examples 01 Motion in a Plane (contd.)

SOLVED 6 JEE Main 2019 · 9 Jan · Shift 1

A particle is moving with a velocity $\mathbf{v} = K(y\,\hat{i} + x\,\hat{j})$, where K is a constant. The general equation for its path is

(a) $y = x^2$ + constant (b) $y^2 = x$ + constant
(c) $y^2 = x^2$ + constant (d) xy = constant

STEP 1 $\frac{dx}{dt} = Ky$, $\frac{dy}{dt} = Kx$
STEP 2 $\frac{dy}{dx} = \frac{x}{y} \Rightarrow y\,dy = x\,dx$
STEP 3 Integrate: $\mathbf{y^2 = x^2 + \text{constant}}$

Answer: **(c)**

SOLVED 7 NEET 2017

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 metres and t in seconds. The acceleration of the particle at t = 2 s is

(a) 5 m s^{-2} (b) −4 m s^{-2}
(c) −8 m s^{-2} (d) 0

STEP 1 $a_x = \frac{d^2x}{dt^2} = -4$ m/s^2
STEP 2 $a_y = \frac{d^2y}{dt^2} = 0$
STEP 3 $a = \mathbf{-4}$ **m s^{-2}** (constant)

Answer: **(b)**

SOLVED 8 AIPMT 2012 · Prelims

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

(a) $9\sqrt{2}$ (b) $5\sqrt{2}$
(c) 5 units (d) 9 units

STEP 1 $\mathbf{v} = \mathbf{u} + \mathbf{a}t$
STEP 2 $\mathbf{v} = (2 + 3)\,\hat{i} + (3 + 2)\,\hat{j} = 5\,\hat{i} + 5\,\hat{j}$
STEP 3 $|\mathbf{v}| = \mathbf{5\sqrt{2}}$ units

Answer: **(b)**

SOLVED 9 JEE Main 2020 · 4 Sep · Shift 1

Starting from the origin at t = 0 with initial velocity $5\,\hat{j}$ m s^{-1}, a particle moves in the x-y plane with a constant acceleration $(10\,\hat{i} + 4\,\hat{j})$ m s^{-2}. At time t its coordinates are (20 m, y_0 m). The values of t and y_0 are, respectively

(a) 5 s and 25 m (b) 2 s and 18 m
(c) 2 s and 24 m (d) 4 s and 52 m

STEP 1 x: $20 = 0 + \frac{1}{2}(10)t^2 \Rightarrow t = 2$ s
STEP 2 $y = 5t + \frac{1}{2}(4)t^2$
STEP 3 $y_0 = 10 + 8 = \mathbf{18}$ **m**; $t = \mathbf{2}$ **s**

Answer: **(b)**

SOLVED 10 AIPMT 2014

A particle is moving such that its position coordinates (x, y) are (2 m, 3 m) at t = 0, (6 m, 7 m) at t = 2 s and (13 m, 14 m) at t = 5 s. The average velocity vector from t = 0 to t = 5 s is

(a) $\frac{1}{5}(13\,\hat{i} + 14\,\hat{j})$ (b) $\frac{7}{3}(\hat{i} + \hat{j})$
(c) $2(\hat{i} + \hat{j})$ (d) $\frac{11}{5}(\hat{i} + \hat{j})$

STEP 1 Only the end points count
STEP 2 $\Delta\mathbf{r} = (13 - 2)\,\hat{i} + (14 - 3)\,\hat{j} = 11\,\hat{i} + 11\,\hat{j}$
STEP 3 $\mathbf{v}_{av} = \frac{\Delta\mathbf{r}}{5} = \mathbf{\frac{11}{5}(\hat{i} + \hat{j})}$

Answer: **(d)**

SOLVED 11 AIPMT 2011 · Prelims

A body is moving with velocity 30 m/s towards east. After 10 seconds its velocity becomes 40 m/s towards north. The average acceleration of the body is

(a) 1 m/s^2 (b) 7 m/s^2
(c) $\sqrt{7}$ m/s^2 (d) 5 m/s^2

STEP 1 $\Delta\mathbf{v} = 40\,\hat{j} - 30\,\hat{i}$
STEP 2 $|\Delta\mathbf{v}| = \sqrt{40^2 + 30^2} = 50$ m/s
STEP 3 $a_{av} = \frac{50}{10} = \mathbf{5}$ **m/s^2**

Answer: **(d)**

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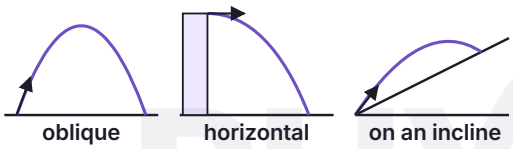
02 CONCEPT Projectile Basics & Trajectory

IN ONE LINE

A projectile moves under gravity alone: uniform motion sideways and free-fall motion up and down, which together trace a parabola.

3.2.1 What is a projectile?

- A body in flight under the effect of gravity alone, with no fuel pushing it.
- Examples: a bullet from a gun, an arrow, a javelin, a bomb released from a plane.



Three types of projectile motion

3.2.2 Assumptions

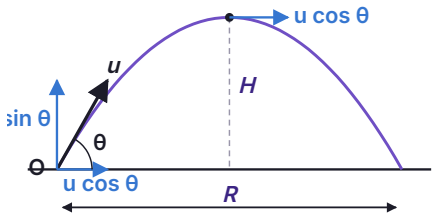
- No air resistance.
- Curvature and rotation of the earth are ignored.
- g is constant in magnitude and direction.

3.2.3 Independence of motions

- Horizontal and vertical motions take place independently.
- **Horizontal**: no force ⇒ uniform velocity u cos θ.
- **Vertical**: acceleration g downward, starting with u sin θ.

Stays constant	Keeps changing
horizontal velocity u cos θ	vertical velocity
acceleration g	speed, velocity, momentum
mechanical energy	KE and PE

3.2.4 Equation of trajectory



Velocity u at angle θ: components, H and R

$$x = (u \cos \theta)\, t$$

$$y = (u \sin \theta)\, t - \tfrac{1}{2} g t^2$$

- Put $t = \dfrac{x}{u \cos \theta}$ in y:

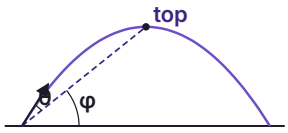
$$y = x \tan \theta - \frac{g x^2}{2u^2 \cos^2 \theta}$$

- Of the form $y = ax - bx^2$: the path is a **parabola**.
- Compare a given equation with it: a = tan θ, b gives u.
- Same equation in terms of the range R:

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

- Position known at a time t: x gives u cos θ, y gives u sin θ.

3.2.5 Elevation of the highest point



Top seen from the point of projection

$$\tan \varphi = \frac{\frac{H}{R}}{2} = \frac{1}{2} \tan \theta$$

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Solved Examples 02 Projectile Basics & Trajectory

SOLVED 1 MHT CET 2026 · 19 Apr · Shift 2

The equation of the trajectory of a ball projected at an angle θ with the horizontal is $y = x - \frac{gx^2}{2}$. The initial velocity of the ball is [Given: tan 45° = 1, cos 45° = $\frac{1}{\sqrt{2}}$]

(a) $2\sqrt{2}$ m/s (b) 2 m/s
(c) $\sqrt{2}$ m/s (d) $\frac{1}{\sqrt{2}}$ m/s

STEP 1 Compare with $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$
STEP 2 $\tan\theta = 1 \Rightarrow \theta = 45°$; $2u^2\cos^2\theta = 2 \Rightarrow u^2 \times \frac{1}{2} = 1$
STEP 3 $u^2 = 2 \Rightarrow u = \sqrt{2}$ **m/s**

Answer: **(c)**

SOLVED 2 JEE Main 2013

A projectile is given an initial velocity of $(\hat{i} + 2\hat{j})$ m/s, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If g = 10 m/s², the equation of its trajectory is

(a) $y = x - 5x^2$ (b) $y = 2x - 5x^2$
(c) $4y = 2x - 5x^2$ (d) $4y = 2x - 25x^2$

STEP 1 $u_x = 1$, $u_y = 2$: $x = t$, $y = 2t - 5t^2$
STEP 2 Put $t = x$
STEP 3 $y = 2x - 5x^2$

Answer: **(b)**

SOLVED 3 JEE Main 2023 · 8 Apr · Shift 2

The trajectory of a projectile projected from the ground is given by $y = x - \frac{x^2}{20}$, where x and y are in metres. The maximum height attained by the projectile will be

(a) 10 m (b) 5 m
(c) 200 m (d) $10\sqrt{2}$ m

STEP 1 y = 0 again at x = 20: R = 20 m
STEP 2 y is maximum at $x = \frac{R}{2} = 10$ m
STEP 3 $H = 10 - \frac{100}{20} = 5$ **m**

Answer: **(b)**

SOLVED 4 JEE Main 2021 · 26 Feb · Shift 2

The trajectory of a projectile in a vertical plane is $y = \alpha x - \beta x^2$, where α and β are constants. The angle of projection θ and the maximum height H are respectively

(a) $\tan^{-1}\alpha$, $\frac{\alpha^2}{4\beta}$ (b) $\tan^{-1}\alpha$, $\frac{4\alpha^2}{\beta}$
(c) $\tan^{-1}(\frac{\beta}{\alpha})$, $\frac{\alpha^2}{\beta}$ (d) $\tan^{-1}\beta$, $\frac{\alpha^2}{2\beta}$

STEP 1 Slope at the origin: $\tan\theta = \alpha$
STEP 2 $\frac{dy}{dx} = 0$ at $x = \frac{\alpha}{2\beta}$
STEP 3 $H = \frac{\alpha^2}{2\beta} - \frac{\alpha^2}{4\beta} = \frac{\alpha^2}{4\beta}$

Answer: **(a)**

SOLVED 5 JEE Main 2019 · 12 Apr · Shift 1

The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0 then (g = 10 m s⁻²)

(a) $\theta_0 = \cos^{-1}(\frac{1}{\sqrt{5}})$ and $v_0 = \frac{5}{3}$ m s⁻¹
(b) $\theta_0 = \cos^{-1}(\frac{2}{\sqrt{5}})$ and $v_0 = \frac{3}{5}$ m s⁻¹
(c) $\theta_0 = \sin^{-1}(\frac{2}{\sqrt{5}})$ and $v_0 = \frac{3}{5}$ m s⁻¹
(d) $\theta_0 = \sin^{-1}(\frac{1}{\sqrt{5}})$ and $v_0 = \frac{5}{3}$ m s⁻¹

STEP 1 $\tan\theta_0 = 2 \Rightarrow \cos\theta_0 = \frac{1}{\sqrt{5}}$
STEP 2 $\frac{g}{2v_0^2\cos^2\theta_0} = 9 \Rightarrow \frac{10 \times 5}{2v_0^2} = 9$
STEP 3 $v_0^2 = \frac{25}{9} \Rightarrow v_0 = \frac{5}{3}$ **m s⁻¹**

Answer: **(a)**

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PROJECTILE MOTION

LEVEL 1 · EASY

Topic-wise Previous Year Questions

MHT CET · NEET · JEE Main

66	20	7
questions	concepts	topics

CONTENTS

01	Motion in a Plane (2-D Kinematics)	Q 1–12	12 Qs
02	Projectile Basics & Trajectory	Q 13–13	1 Qs
03	Velocity, Momentum & Energy in Flight	Q 14–19	6 Qs
04	Time of Flight, Maximum Height & Range	Q 20–38	19 Qs
05	Comparing Two Projectiles	Q 39–52	14 Qs
06	Horizontal Projectile & Inclined Plane	Q 53–57	5 Qs
07	Relative Velocity in Two Dimensions	Q 58–66	9 Qs
	Answer key		

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TOPIC 01

Motion in a Plane (2-D Kinematics)

12 PYQs · Easy 12 · Medium 0 · Difficult 0 | MHT CET 0 · NEET 8 · JEE 4

Concepts covered: Position, velocity & acceleration vectors (3) · Path from x(t) and y(t) (2) · Constant acceleration in a plane (4) · Average velocity & acceleration (3)

LEVEL 1 · EASY 12 questions

◆ Position, velocity & acceleration vectors 3 Qs

1. The position vector of a particle is $\vec{r} = (a\cos\omega t)\hat{i} + (a\sin\omega t)\hat{j}$. The velocity of the particle is

AIPMT 1995

(a) directed towards the origin
(b) directed away from the origin
(c) parallel to the position vector
(d) perpendicular to the position vector

2. The position vector of a moving body at any instant of time is given as $\vec{r} = \left(5t^2\hat{i} - 5t\hat{j}\right)$m. The magnitude and direction of velocity at $t = 2s$ is,

JEE MAIN 2025 · 24 JAN · SHIFT 2

(a) $5\sqrt{17}$ m/s, making an angle of $\tan^{-1}4$ with - ve Y axis
(b) $5\sqrt{15}$ m/s, making an angle of $\tan^{-1}4$ with + ve X axis
(c) $5\sqrt{17}$ m/s, making an angle of $\tan^{-1}4$ with + ve X axis
(d) $5\sqrt{15}$ m/s, making an angle of $\tan^{-1}4$ with $-$ ve Y axis

3. Position of an ant (S in metres) moving in Y-Z plane is given by $S = 2t^2\hat{j} + 5\hat{k}$ (where t is in second). The magnitude and direction of velocity of the ant at t = 1 s will be:

JEE MAIN 2024 · 27 JAN · SHIFT 1

(a) 16 m/s in y-direction
(b) 4 m/s in x-direction
(c) 9 m/s in z-direction
(d) 4 m/s in y-direction

◆ Path from x(t) and y(t) 2 Qs

4. A particle moves in x-y plane according to rule x = asinωt and y = acosωt. The particle follows

AIPMT 2010 · MAINS

(a) an elliptical path
(b) a circular path
(c) a parabolic path
(d) a straight line path inclined equally to x and y-axes

5. 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 $\left(\sqrt{3}, 3\right)$. The path of the particle makes with the x-axis an angle of

AIPMT 2007

(a) 45° (b) 60° (c) 0° (d) 30°.

◆ Constant acceleration in a plane 4 Qs

6. 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 metres and t in seconds. The acceleration of the particle at t = 2 s is

NEET 2017

(a) 5 m s^{-2} (b) – 4 m s^{-2}
(c) –8 m s^{-2} (d) 0

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

AIPMT 2012 · PRELIMS

(a) $9\sqrt{2}$ (b) $5\sqrt{2}$ (c) 5 units (d) 9 units

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

AIPMT 2010 · PRELIMS

(a) 7 units (b) $7\sqrt{2}$ units
(c) 8.5 units (d) 10 units

9. A particle has an initial velocity $3\hat{i} + 4\hat{j}$ and an acceleration of $0.4\hat{i} + 0.3\hat{j}$. Its speed after 10 s is:

AIEEE 2009

(a) $7\sqrt{2}$ units (b) 7 units
(c) 8.5 units (d) 10 units

◆ Average velocity & acceleration 3 Qs

10. A particle is moving such that its position coordinates (x, y) are (2 m, 3 m) at time t = 0, (6 m, 7 m) at time t = 2 s and (13 m, 14 m) at time t = 5 s.
Average velocity vector $\left(\vec{v}_{av}\right)$ from t = 0 to t = 5 s is

AIPMT 2014

(a) $\frac{1}{5}\left(13\hat{i} + 14\hat{j}\right)$ (b) $\frac{7}{3}\left(\hat{i} + \hat{j}\right)$
(c) $2\left(\hat{i} + \hat{j}\right)$ (d) $\frac{11}{5}\left(\hat{i} + \hat{j}\right)$

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11. A body is moving with velocity 30 m/s towards east. After 10 seconds its velocity becomes 40 m/s towards north. The average acceleration of the body is

AIPMT 2011 · PRELIMS

(a) 1 m/s^2 (b) 7 m/s^2 (c) $\sqrt{7}$ m/s^2 (d) 5 m/s^2

12. A particle is moving eastwards with a velocity of 5 m/s. In 10 seconds the velocity changes to 5 m/s northwards. The average acceleration in this time is

AIEEE 2005

(a) $\frac{1}{2}ms^{-2}$ towards north

(b) $\frac{1}{\sqrt{2}}ms^{-2}$ towards north-east

(c) $\frac{1}{\sqrt{2}}ms^{-2}$ towards north-west

(d) zero

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TOPIC 02

Projectile Basics & Trajectory

1 PYQs · Easy 1 · Medium 0 · Difficult 0 | MHT CET 0 · NEET 0 · JEE 1

Concepts covered: Equation of trajectory (1)

LEVEL 1 · EASY 1 questions

13. A projectile is given an initial velocity of $\left(\hat{i} + 2\hat{j}\right)$ m/s, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If g = 10 m/s^2, the equation of its trajectory is:

JEE MAIN 2013

(a) $y = x - 5x^2$ (b) $y = 2x - 5x^2$

(c) $4y = 2x - 5x^2$ (d) $4y = 2x - 25x^2$

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TOPIC 03

Velocity, Momentum & Energy in Flight

6 PYQs · Easy 6 · Medium 0 · Difficult 0 | MHT CET 0 · NEET 4 · JEE 2

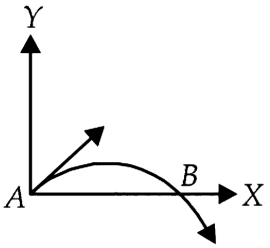
Concepts covered: Velocity at any instant (2) · Velocity at the highest point (3) · Energy in flight (1)

LEVEL 1 · EASY 6 questions

◆ Velocity at any instant 2 Qs

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

NEET 2013



(a) $2\hat{i}-3\hat{j}$ (b) $2\hat{i}+3\hat{j}$
(c) $-2\hat{i}-3\hat{j}$ (d) $-2\hat{i}+3\hat{j}$

15. For a body projected at an angle with the horizontal from the ground, choose the correct statement.

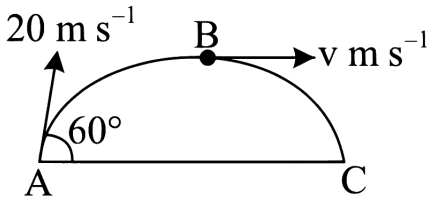
JEE MAIN 2023 · 1 FEB · SHIFT 2

(a) Gravitational potential energy is maximum at the highest point.
(b) The vertical component of momentum is maximum at the highest point.
(c) The horizontal component of velocity is zero at the highest point.
(d) The Kinetic Energy (K.E.) is zero at the highest point of projectile motion.

◆ Velocity at the highest point 3 Qs

16. A ball is projected from point A with velocity $20\ \mathrm{m\ s^{-1}}$ at an angle 60° to the horizontal direction. At the highest point B of the path (as shown in figure), the velocity $v\mathrm{ms^{-1}}$ of the ball will be:

NEET 2023



(a) 20 (b) $10\sqrt{3}$ (c) Zero (d) 10

17. A ball is projected with a velocity, 10 $\mathrm{ms^{-1}}$, at an angle of 60° with the vertical direction. Its speed at the highest point of its trajectory will be

NEET 2022 · PHASE 1

(a) Zero (b) $5\sqrt{3}$ ms−1
(c) 5 ms−1 (d) 10 ms−1

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

AIPMT 2010 · MAINS

(a) 60° (b) 15° (c) 30° (d) 45°

◆ Energy in flight 1 Q

19. A ball of mass 100 g is projected with velocity 20 m/s at 60° with horizontal. The decrease in kinetic energy of the ball during the motion from point of projection to highest point is

JEE MAIN 2025 · 22 JAN · SHIFT 2

(a) 20 J (b) 5 J (c) 15 J (d) zero

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TOPIC 04

Time of Flight, Maximum Height & Range

19 PYQs · Easy 19 · Medium 0 · Difficult 0 | MHT CET 5 · NEET 5 · JEE 9

Concepts covered: Time of flight (3) · Maximum height (4) · Range & maximum range (5) · Relation between R and H (6) · Area covered by bullets (1)

LEVEL 1 · EASY 19 questions

◆ Time of flight 3 Qs

20. A shell is fired at an angle of 30° to the horizontal with velocity $196\ \text{m/s}$. The time of flight is $\left[\sin 30^\circ = \frac{1}{2} = \cos 60^\circ\right]$

MHT CET 2022 · 11 AUG · SHIFT 2

(a) 6.5 s (b) 20 s (c) 16.5 s (d) 10 s

21. A cricket player hit a ball like a projectile but the fielder caught the ball after 2 second. The maximum height reached by a ball is ($g = 10\ \text{m/s}^2$)

MHT CET 2021 · 20 SEP · SHIFT 2

(a) 2 m (b) 5 m (c) 4 m (d) 3 m

22. A player kicks a football with an initial speed of 25 ms^{-1} at an angle of 45° from the ground. What are the maximum height and the time taken by the football to reach at the highest point during motion? (Take $g = 10\ \text{ms}^{-2}$)

JEE MAIN 2021 · 27 AUG · SHIFT 2

(a) $h_{max} = 10$ m
(b) $h_{max} = 15.625$ m T = 2.5 s T = 3.54 s
(c) $h_{max} = 15.625$ m
(d) $h_{max} = 3.54$ m T = 1.77 s T = 0.125 s

◆ Maximum height 4 Qs

23. If the initial velocity of projection be doubled, keeping the angle of projection same, the maximum height reached by it will

MHT CET 2026 · 14 MAY · SHIFT 2

(a) remain the same (b) be doubled
(c) become four times (d) be halved

24. A bullet is fired from a gun at the speed of $280\ \text{ms}^{-1}$ in the direction 30° above the horizontal. The maximum height attained by the bullet is $\left(g = 9.8\ \text{ms}^{-2}, \sin 30^\circ = 0.5\right)$:-

NEET 2023

(a) 2000 m (b) 1000 m (c) 3000 m (d) 2800 m

25. A cricket ball is thrown by a player at a speed of 20 m/s in a direction 30° above the horizontal. The maximum height attained by the ball during its motion is
($g = 10\ \text{m/s}^2$)

NEET 2022 · PHASE 2

(a) 25 m (b) 5 m (c) 10 m (d) 20 m

26. The maximum height reached by a projectile is 64 m. If the initial velocity is halved, the new maximum height of the projectile is _____ m.

JEE MAIN 2024 · 5 APR · SHIFT 2 *(Numerical)*

◆ Range & maximum range 5 Qs

27. A missile is fired for maximum range with an initial velocity of 20 m/s. If g = 10 m/s^2, the range of the missile is

AIPMT 2011 · PRELIMS

(a) 40 m (b) 50 m (c) 60 m (d) 20 m

28. The maximum range of a gun of horizontal terrain is 16 km. If $g = 10\ \text{m s}^{-2}$, then muzzle velocity of a shell must be

AIPMT 1990

(a) $160\ \text{m s}^{-1}$ (b) $200\sqrt{2}\ \text{m s}^{-1}$
(c) $400\ \text{m s}^{-1}$ (d) $800\ \text{m s}^{-1}$

29. The maximum vertical height to which a man can throw a ball is 136 m. The maximum horizontal distance upto which he can throw the same ball is:

JEE MAIN 2023 · 24 JAN · SHIFT 1

(a) 136 m (b) 272 m (c) 68 m (d) 192 m

30. A person can throw a ball upto a maximum range of 100 m. How high above the ground he can throw the same ball?

JEE MAIN 2022 · 29 JUN · SHIFT 2

(a) 25 m (b) 50 m (c) 100 m (d) 200 m

31. A boy can throw a stone up to a maximum height of 10 m. The maximum horizontal distance that the boy can throw the same stone up to will be

AIEEE 2012

(a) $20\sqrt{2}$ m (b) 10 m (c) $10\sqrt{2}$ m (d) 20 m

◆ Relation between R and H 6 Qs

32. For a projectile motion, the range R is 'n' times the maximum height H. So the angle of projection is

MHT CET 2026 · 18 APR · SHIFT 2

(a) $\sin^{-1}\left(\frac{2}{n}\right)$ (b) $\cos^{-1}\left(\frac{4}{n}\right)$
(c) $\tan^{-1}\left(\frac{4}{n}\right)$ (d) $\tan^{-1}\left(\frac{2}{n}\right)$

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33. For a projectile, the maximum height and horizontal range are same. The angle of projection ' θ ' of the projectile is

MHT CET 2024 · 4 MAY · SHIFT 1

(a) $\tan^{-1}\left(\frac{1}{2}\right)$ (b) $\tan^{-1}(2)$
(c) $\tan^{-1}\left(\frac{1}{4}\right)$ (d) $\tan^{-1}(4)$

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

AIPMT 2012 · PRELIMS

(a) $\theta = \tan^{-1}1\left(\frac{1}{4}\right)$ (b) $\theta = \tan^{-1}(4)$
(c) $\theta = \tan^{-1}(2)$ (d) $\theta = 45^{\circ}$

35. The angle of projection for a projectile to have same horizontal range and maximum height is:

JEE MAIN 2024 · 8 APR · SHIFT 2

(a) $\tan^{-1}\left(\frac{1}{2}\right)$ (b) $\tan^{-1}(2)$
(c) $\tan^{-1}\left(\frac{1}{4}\right)$ (d) $\tan^{-1}(4)$

36. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R

Assertion A: When a body is projected at an angle 45°, it's range is maximum.

Reason R: For maximum range, the value of $\sin 2\theta$ should be equal to one.

In the light of the above statements, choose the correct answer from the options given below:

JEE MAIN 2023 · 6 APR · SHIFT 1

(a) Both **A** and **R** are correct and **R** is the correct explanation of **A**
(b) **A** is true but **R** is false
(c) **A** is false but **R** is true
(d) Both **A** and **R** are correct but **R** is NOT the correct explanation of **A**

37. A ball is projected from the ground with a speed 15 ms $^{-1}$ at an angle θ with horizontal so that its range and maximum height are equal,

then 'tan θ' will be equal to:

JEE MAIN 2022 · 25 JUL · SHIFT 2

(a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) 2 (d) 4

◆ Area covered by bullets 1 Q

38. A gun mounted on the ground fires bullets in all directions with same speed. The farthest distance the bullets could reach is 6.4 m. The speed of the bullets from the gun is ____ m/s. (take $g = 10\ m/s^2$)

JEE MAIN 2026 · 4 APR · SHIFT 2 *(Numerical)*

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TOPIC 05

Comparing Two Projectiles

14 PYQs · Easy 14 · Medium 0 · Difficult 0 | MHT CET 1 · NEET 4 · JEE 9

Concepts covered: Complementary angles (2) · Same height or same time (2) · Ratios of R, H and T (10)

LEVEL 1 · EASY 14 questions

◆ Complementary angles 2 Qs

39. The ranges and heights for two projectiles projected with the same initial velocity at angles 42° and 48° with the horizontal are R_1, R_2 and H_1, H_2 respectively. Choose the correct option:

JEE MAIN 2021 · 1 SEP · SHIFT 2

(a) $R_1 > R_2$ and $H_1 = H_2$ (b) $R_1 = R_2$ and $H_1 < H_2$
(c) $R_1 < R_2$ and $H_1 < H_2$ (d) $R_1 = R_2$ and $H_1 = H_2$

40. Two bodies are projected from ground with same speeds $40\ \text{ms}^{-1}$ at two different angles with respect to horizontal. The bodies were found to have same range. If one of the body was projected at an angle of 60°, with horizontal then sum of the maximum heights, attained by the two projectiles, is _____ m. (Given $g = 10\ \text{ms}^{-2}$)

JEE MAIN 2023 · 31 JAN · SHIFT 2 *(Numerical)*

◆ Same height or same time 2 Qs

41. Two projectiles are fired with same initial speed from same point on ground at angles of $(45^\circ - \alpha)$ and $(45^\circ + \alpha)$, respectively, with the horizontal direction. The ratio of their maximum heights attained is:

JEE MAIN 2025 · 29 JAN · SHIFT 1

(a) $\frac{1+\sin\alpha}{1-\sin\alpha}$ (b) $\frac{1+\sin 2\alpha}{1-\sin 2\alpha}$ (c) $\frac{1-\tan\alpha}{1+\tan\alpha}$ (d) $\frac{1-\sin 2\alpha}{1+\sin 2\alpha}$

42. Two projectiles are projected at 30° and 60° with the horizontal with the same speed. The ratio of the maximum height attained by the two projectiles respectively is:

JEE MAIN 2023 · 10 APR · SHIFT 2

(a) $1 : \sqrt{3}$ (b) $\sqrt{3} : 1$ (c) $1 : 3$ (d) $2 : \sqrt{3}$

◆ Ratios of R, H and T 10 Qs

43. Two objects are projected with same velocity 'u' at different angles α and β with the horizontal. If $\alpha + \beta = 90^\circ$, the ratio of horizontal range of the first object to the second object will be $[\sin(\pi - \theta) = \sin\theta]$

MHT CET 2026 · 16 APR · SHIFT 2

(a) $4 : 1$ (b) $2 : 1$ (c) $1 : 1$ (d) $1 : 2$

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

AIPMT 2006

(a) 2: 1 (b) 1: 1 (c) 2: 3 (d) 1: 2.

45. 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

AIPMT 2000

(a) time of flight
(b) range of projectile
(c) maximum height acquired
(d) all of them.

46. If a body A of mass M is thrown with velocity v at an angle of 30° to the horizontal and another body B of the same mass is thrown with the same speed at an angle of 60° to the horizontal, the ratio of horizontal range of A to B will be

AIPMT 1992

(a) 1: 3 (b) 1: 1 (c) $1 : \sqrt{3}$ (d) $\sqrt{3} : 1$

47. If a body A of mass M is thrown with velocity v at an angle of 30° to the horizontal and another body B of the same mass is thrown with the same speed at an angle of 60° to the horizontal, the ratio of horizontal range of A to B will be

AIPMT 1990

(a) 1: 3 (b) 1: 1 (c) $1 : \sqrt{3}$ (d) $\sqrt{3} : 1$

48. The two projectiles are projected with the same initial velocities at the 15° and 30° with respect to the horizontal. The ratio of their ranges is $1 : x$. The value of x is

JEE MAIN 2026 · 4 APR · SHIFT 1

(a) $\sqrt{2}$ (b) $\sqrt{3}$ (c) $2\sqrt{3}$ (d) $\frac{1}{\sqrt{2}}$

49. Two projectiles are fired from ground with same initial speeds from same point at angles $(45^\circ + \alpha)$ and $(45^\circ - \alpha)$ with horizontal direction. The ratio of their times of flights is

JEE MAIN 2025 · 7 APR · SHIFT 1

(a) $\frac{1+\tan\alpha}{1-\tan\alpha}$ (b) $\frac{1+\sin 2\alpha}{1-\sin 2\alpha}$ (c) $\frac{1-\tan\alpha}{1+\tan\alpha}$ (d) 1

50. The range of the projectile projected at an angle of 15° with horizontal is 50 m. If the projectile is projected with same velocity at an angle of 45° with horizontal, then its range will be

JEE MAIN 2023 · 10 APR · SHIFT 1

(a) $50\sqrt{2}$ m (b) 100 m (c) $100\sqrt{2}$ m (d) 50 m

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51. Two objects are projected with same velocity 'u' however at different angles α and β with the horizontal. If $\alpha + \beta = 90^\circ$, the ratio of horizontal range of the first object to the 2nd object will be:

JEE MAIN 2023 · 25 JAN · SHIFT 2

(a) 1: 1 (b) 2: 1 (c) 1: 2 (d) 4: 1

52. Two projectiles are thrown with same initial velocity making an angle of 45° and 30° with the horizontal respectively. The ratio of their respective ranges will be:

JEE MAIN 2022 · 26 JUL · SHIFT 2

(a) $1 : \sqrt{2}$ (b) $\sqrt{2} : 1$ (c) $2 : \sqrt{3}$ (d) $\sqrt{3} : 2$

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TOPIC 06

Horizontal Projectile & Inclined Plane

5 PYQs · Easy 5 · Medium 0 · Difficult 0 | MHT CET 1 · NEET 2 · JEE 2

Concepts covered: Bomb from an aeroplane (2) · Body thrown from a tower (3)

LEVEL 1 · EASY 5 questions

◆ Bomb from an aeroplane 2 Qs

53. A bomb is dropped by an aeroplane flying horizontally with a velocity $200\ \text{km/hr}$ and at a height of $980\ \text{m}$. At the time of dropping a bomb, the distance of the aeroplane from the target on the ground to hit directly is $(g = 9.8\ \text{m/s}^2)$

MHT CET 2021 · 21 SEP · SHIFT 1

(a) $\frac{\sqrt{2}\times10^4}{9}$ m (b) $\frac{10^4}{9}$ m

(c) $\frac{10^4}{9\sqrt{2}}$ m (d) $\frac{10^4}{18}$ m

54. A helicopter is flying horizontally with a speed 'v' at an altitude 'h' has to drop a food packet for a man on the ground. What is the distance of helicopter from the man when the food packet is dropped?

JEE MAIN 2021 · 31 AUG · SHIFT 1

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

(c) $\sqrt{\frac{2v^2h}{g}+h^2}$ (d) $\sqrt{\frac{2gh}{v^2}+h^2}$

◆ Body thrown from a tower 3 Qs

55. A particle A is dropped from a height and another particle B is projected in horizontal direction with speed of 5 m/sec from the same height then correct statement is

AIPMT 2002

(a) particle A will reach at ground first with respect to particle B

(b) particle B will reach at ground first with respect to particle A

(c) both particles will reach at ground simultaneously

(d) both particles will reach at ground with same speed.

56. A solid sphere and a hollow sphere are thrown horizontally from a cliff with equal velocities, respectively. Then which sphere reaches first on earth?

AIPMT 2000

(a) Solid sphere

(b) Hollow sphere

(c) Both sphere simultaneously

(d) We cannot say because masses of spheres are not given

57. A child stands on the edge of the cliff $10\ \text{m}$ above the ground and throws a stone horizontally with an initial speed of $5\ \text{ms}^{-1}$. Neglecting the air resistance, the speed with which the stone hits the ground will be _____ ms^{-1} (given, $g = 10\ \text{ms}^{-2}$).

JEE MAIN 2023 · 1 FEB · SHIFT 1

(a) 20 (b) 25 (c) 30 (d) 15

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TOPIC 07

Relative Velocity in Two Dimensions

9 PYQs · Easy 9 · Medium 0 · Difficult 0 | MHT CET 0 · NEET 5 · JEE 4

Concepts covered: River & boat (8) · Seen from a moving frame (1)

LEVEL 1 · EASY 9 questions

◆ River & boat 8 Qs

58. The speed of a swimmer in still water is 20 m/s. The speed of river water is 10 m/s and is flowing due east. If he is standing on the south bank and wishes to cross the river along the shortest path, the angle at which he should make his strokes w.r.t. north is given by:

NEET 2019

(a) 0° (b) 60° (c) 45° west (d) 30° west

59. The width of river is 1 km. The velocity of boat is 5 km/hr. The boat covered the width of river along the shortest path in 15 min. Then the velocity of river stream is

AIPMT 2000

(a) 3 km/hr (b) 4 km/hr
(c) $\sqrt{29}$ km/hr (d) $\sqrt{41}$ km/hr.

60. The speed of a boat is $5\ \mathrm{km/h}$ in still water. It crosses a river of width $1.0\ \mathrm{km}$ along the shortest possible path in $15\ \mathrm{min}$. The velocity of the river water is (in $\mathrm{km/h}$)

AIPMT 1998

(a) 5 (b) 1 (c) 3 (d) 4

61. A boat is sent across a river with a velocity of $8\ \mathrm{km\,h^{-1}}$. If the resultant velocity of boat is $10\ \mathrm{km\,h^{-1}}$, then velocity of river is

AIPMT 1994

(a) $12.8\ \mathrm{km\,h^{-1}}$ (b) $6\ \mathrm{km\,h^{-1}}$
(c) $8\ \mathrm{km\,h^{-1}}$ (d) $10\ \mathrm{km\,h^{-1}}$

62. A boat is sent across a river with a velocity of $8\ \mathrm{km\,h^{-1}}$. If the resultant velocity of boat is $10\ \mathrm{km\,h^{-1}}$, then velocity of river is

AIPMT 1993

(a) $12.8\ \mathrm{km\,h^{-1}}$ (b) $6\ \mathrm{km\,h^{-1}}$
(c) $8\ \mathrm{km\,h^{-1}}$ (d) $10\ \mathrm{km\,h^{-1}}$

63. The stream of a river is flowing with a speed of 2km/h. A swimmer can swim at a speed of 4km/h. What should be the direction of the swimmer with respect to the flow of the river to cross the river straight?

JEE MAIN 2019 · 9 APR · SHIFT 1

(a) 150° (b) 120° (c) 60° (d) 90°

64. The speed of a swimmer is $4\ \mathrm{km\,h^{-1}}$ in still water. If the swimmer makes his strokes normal to the flow of river of width $1\ \mathrm{km}$, he reaches a point $750\ \mathrm{m}$ down the stream on the opposite bank. The speed of the river water is _____ $\mathrm{km\,h^{-1}}$

JEE MAIN 2023 · 31 JAN · SHIFT 1 *(Numerical)*

65. A swimmer can swim with velocity of 12 km/h in still water. Water flowing in a river has velocity 6 km/h. The direction with respect to the direction of flow of river water he should swim in order to reach the point on the other bank just opposite to his starting point is _____°. (Round off to the Nearest Integer) (Find the angle in degrees)

JEE MAIN 2021 · 16 MAR · SHIFT 2 *(Numerical)*

◆ Seen from a moving frame 1 Q

66. A bomb is dropped by fighter plane flying horizontally. To an observer sitting in the plane, the trajectory of the bomb is a:

JEE MAIN 2021 · 26 AUG · SHIFT 2

(a) hyperbola
(b) parabola in the direction of motion of plane
(c) straight line vertically down the plane
(d) parabola in a direction opposite to the motion of plane

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ANSWER KEY

Shaded by level: **Easy**

01 Motion in a Plane (2-D Kinematics)

1. (d)	2. (a)	3. (d)	4. (b)	5. (b)	6. (b)	7. (b)	8. (b)	9. (a)	10. (d)
11. (d)	12. (c)								

02 Projectile Basics & Trajectory

13. (b)									

03 Velocity, Momentum & Energy in Flight

14. (a)	15. (a)	16. (d)	17. (b)	18. (a)	19. (c)				

04 Time of Flight, Maximum Height & Range

20. (b)	21. (b)	22. (c)	23. (c)	24. (b)	25. (b)	26. 16	27. (a)	28. (c)	29. (b)
30. (b)	31. (d)	32. (c)	33. (d)	34. (b)	35. (d)	36. (a)	37. (d)	38. 8	

05 Comparing Two Projectiles

39. (b)	40. 80	41. (d)	42. (c)	43. (c)	44. (b)	45. (b)	46. (b)	47. (b)	48. (b)
49. (a)	50. (b)	51. (a)	52. (c)						

06 Horizontal Projectile & Inclined Plane

53. (c)	54. (c)	55. (c)	56. (c)	57. (d)					

07 Relative Velocity in Two Dimensions

58. (d)	59. (a)	60. (c)	61. (b)	62. (b)	63. (b)	64. 3	65. 120	66. (c)	

Note: *"Bonus" = no option is correct as the question is printed (dropped in the official key). Numerical questions show the numerical answer.*

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