

How to use this worksheet. Thirty-two questions, about 40 minutes. Horizontal and vertical motions are **independent** — horizontal speed never affects height or fall time. When a mass appears in a circular motion problem, check whether it cancels before hunting for its value.

Formula sheet

Time of flight = $2u \sin\theta/g$ | **Max height** = $u^2 \sin^2\theta/2g$ | **Range** = $u^2 \sin 2\theta/g$, greatest at 45°

Horizontal velocity stays constant | **horizontal and vertical motions are independent**

Circular motion: $v = r\omega$ | $a = v^2/r$ | **max speed without slipping** = $\sqrt{\mu rg}$

$|a\mathbf{i} + b\mathbf{j}| = \sqrt{a^2 + b^2}$ | **velocity** = $d(\text{position})/dt$

Section A · Level 1 — Projectiles, circular motion and vectors

Ten questions. None should take more than twenty seconds.

- The horizontal component of a projectile's velocity during flight is:
(1) Constantly increasing (2) Constantly decreasing (3) Constant (4) Zero at the top
- At the highest point of its path, the velocity of a projectile is:
(1) Zero (2) Purely horizontal (3) Purely vertical (4) Maximum
- The range of a projectile is maximum when the angle of projection is:
(1) 30° (2) 45° (3) 60° (4) 90°
- The path followed by a projectile under uniform gravity is:
(1) A straight line (2) A circle (3) A parabola (4) A hyperbola
- The acceleration of a projectile at the highest point of its trajectory is:
(1) Zero (2) g , directed downward (3) g , directed upward (4) Maximum
- In uniform circular motion, the speed is constant but the velocity changes because:
(1) The magnitude changes (2) The direction changes (3) Both change (4) The acceleration is zero
- The centripetal acceleration of a body moving in a circle of radius r with speed v is:
(1) v/r (2) v^2/r (3) vr (4) v^2r
- The relation between linear speed v , radius r and angular speed ω is:
(1) $v = \omega/r$ (2) $v = r/\omega$ (3) $v = r\omega$ (4) $v = r\omega^2$
- Two vectors of equal magnitude acting in opposite directions have a resultant of:
(1) Twice the magnitude (2) Zero (3) The same magnitude (4) $\sqrt{2}$ times the magnitude
- The magnitude of the vector $3\mathbf{i} + 4\mathbf{j}$ is:
(1) 3 (2) 4 (3) 5 (4) 7

Working space — Questions 1 to 10

Write the formula before you substitute.

Section B · Level 2 — Direct calculation

Ten questions. Resolve into components before substituting.

- A projectile is launched at 20 m/s at 30° to the horizontal. Taking $g = 10 \text{ m/s}^2$, its time of flight is:
(1) 1 s (2) 2 s (3) 3 s (4) 4 s
- For the same projectile, the maximum height reached is:
(1) 2.5 m (2) 5 m (3) 10 m (4) 20 m

- 13.** For the same projectile, the horizontal range is closest to:
(1) 20 m (2) 28 m (3) 35 m (4) 40 m
- 14.** A body moves in a circle of radius 5 m at 10 m/s. Its centripetal acceleration is:
(1) 2 m/s² (2) 20 m/s² (3) 50 m/s² (4) 100 m/s²
- 15.** A projectile is launched at 20 m/s at 60° to the horizontal. Taking $g = 10 \text{ m/s}^2$, its maximum height is:
(1) 5 m (2) 10 m (3) 15 m (4) 20 m
- 16.** Two projectiles are launched at the same speed at 30° and 60°. Their ranges are:
(1) In the ratio 1 : 2 (2) In the ratio 2 : 1 (3) Equal (4) In the ratio 1 : 3
- 17.** If the position of a particle is $\mathbf{r} = 3t^2\mathbf{i}$, its velocity at $t = 2 \text{ s}$ is:
(1) $6\mathbf{i}$ (2) $12\mathbf{i}$ (3) $3\mathbf{i}$ (4) $24\mathbf{i}$
- 18.** A stone is dropped from a moving train. To an observer on the ground, its path is:
(1) A straight vertical line (2) A parabola (3) A circle (4) A horizontal line
- 19.** The angle between the velocity and the centripetal acceleration in uniform circular motion is:
(1) 0° (2) 45° (3) 90° (4) 180°
- 20.** A body completes 10 revolutions in 5 s. Its frequency is:
(1) 0.5 Hz (2) 2 Hz (3) 5 Hz (4) 50 Hz

Working space — Questions 11 to 20 *Write the formula before you substitute.*

Section C · Level 3 — Independence of motion and limiting conditions

Seven questions. Ask which quantities actually matter and which cancel.

- 21.** Two projectiles have the same range but different angles of projection. Their angles must be:
(1) Equal (2) Complementary (3) Supplementary (4) Both 45°
- 22.** The maximum speed at which a car can round a level curve of radius r without skidding depends on:
(1) The mass of the car (2) The coefficient of friction, the radius and g (3) The engine power (4) The width of the road
- 23.** For a body in uniform circular motion, the work done by the centripetal force in one full revolution is:
(1) Maximum (2) Zero (3) Negative (4) mv^2
- 24.** If the speed of a body in circular motion is doubled while the radius stays the same, the centripetal acceleration becomes:
(1) Twice (2) Half (3) Four times (4) Unchanged
- 25.** A projectile's velocity at any instant can be found by:
(1) Adding the components arithmetically (2) Combining the horizontal and vertical components vectorially (3) Using the horizontal component only (4) Using the vertical component only
- 26.** Relative velocity of a body A with respect to a body B is given by:
(1) $\mathbf{v}_A + \mathbf{v}_B$ (2) $\mathbf{v}_A - \mathbf{v}_B$ (3) $\mathbf{v}_B - \mathbf{v}_A$ (4) $\mathbf{v}_A \times \mathbf{v}_B$
- 27.** A ball is thrown horizontally from a height. The time it takes to reach the ground depends on:
(1) Its horizontal speed (2) Its height above the ground only (3) Both the speed and the height (4) Its mass

Working space — Questions 21 to 27

Write the formula before you substitute.

Section D · Previous year questions — Straight from the AAI ATC papers

Five questions from the 2023 papers, recovered by optical character recognition of the scanned answer sheets and independently re-solved.

28. A ball is projected from the origin in the xy plane with velocity u making an angle θ with the x -axis. The horizontal range of the ball is: **[PYQ 2023 · Morning]**

- (1) $(u^2 / 2g) \sin 2\theta$ (2) $(u^2 / g) \sin 2\theta$ (3) $(u^2 / 2g) \sin \theta$ (4) $(u^2 / g) \sin \theta$

29. A ball is projected from the point $(0, 0)$ at $t = 0$. At a height of 15 m it has velocity $\mathbf{v} = 8.0\mathbf{i} + 10\mathbf{j}$ m/s.

Neglecting air resistance and taking $g = 10 \text{ m/s}^2$, the maximum height the ball rises to is: **[PYQ 2023 · Morning]**

- (1) 30 m (2) 20 m (3) 40 m (4) 25 m

30. A particle trapped in a circular groove of radius 10 cm moves along the groove steadily and completes 14 revolutions in 50 s. The linear speed of the particle is: **[PYQ 2023 · Evening]**

- (1) 13.2 cm/s (2) 8.8 cm/s (3) 17.6 cm/s (4) 4.4 cm/s

31. A particle moves in a plane with position given by $\mathbf{r} = 5t^2\mathbf{i} + 4t\mathbf{j}$, where t is in seconds and $\mathbf{r}$ is in metres. The velocity of the particle at $t = 2$ s is: **[PYQ 2023 · Evening]**

- (1) $10\mathbf{i} + 8\mathbf{j}$ (2) $20\mathbf{i} + 4\mathbf{j}$ (3) $10\mathbf{i} - 8\mathbf{j}$ (4) $20\mathbf{i} - 4\mathbf{j}$

32. A car of mass m is driven along a circular path of radius R . The coefficient of static friction between the tyres and the road is μ . The maximum speed at which it can be driven without slipping is: **[PYQ 2023 · Morning]**

- (1) $\sqrt{Rg / \mu}$ (2) $\sqrt{\mu Rg}$ (3) μRg (4) $\sqrt{\mu R / g}$

Working space — Questions 28 to 32

Write the formula before you substitute.

Stuck on any of these? Bring them to a live class.

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