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① motion

② $D/\vec{a}$

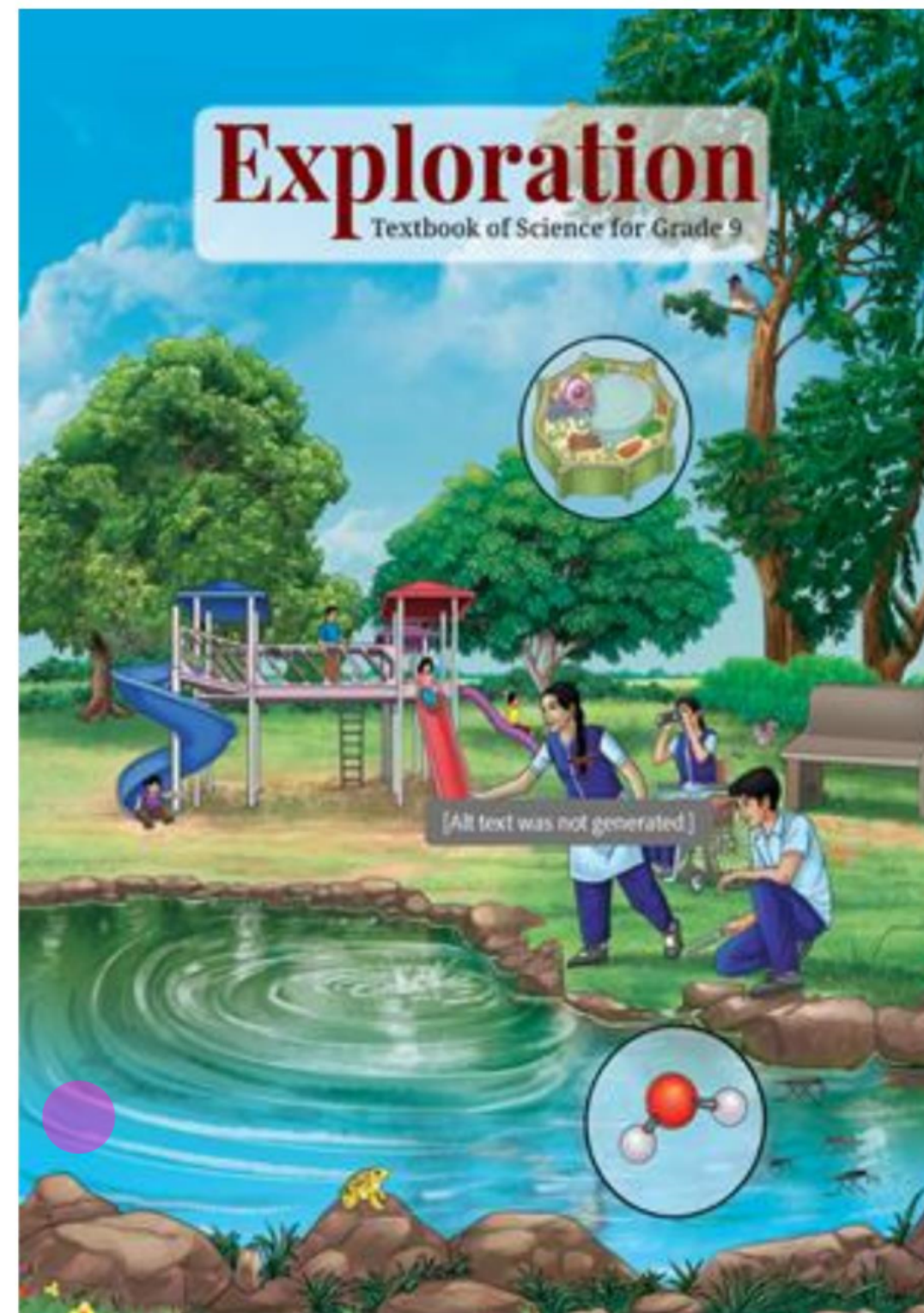
③ $S/\vec{v}$

④ $\vec{a}$

⑤ Equation

⑥ graph

⑦ $m \times \vec{a}$



CIRCULAR MOTION

(वृताकार गति)



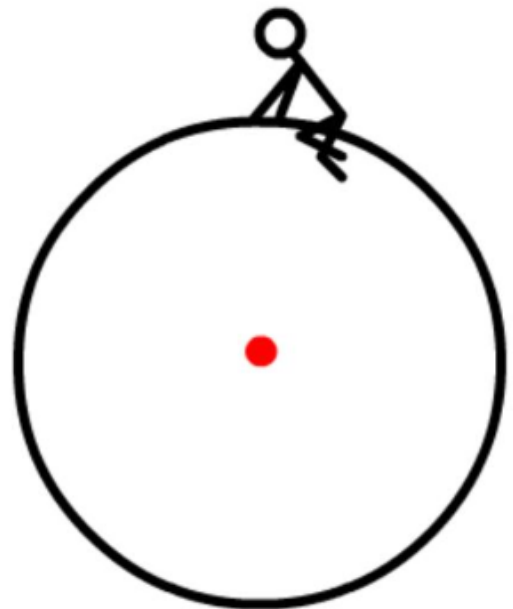
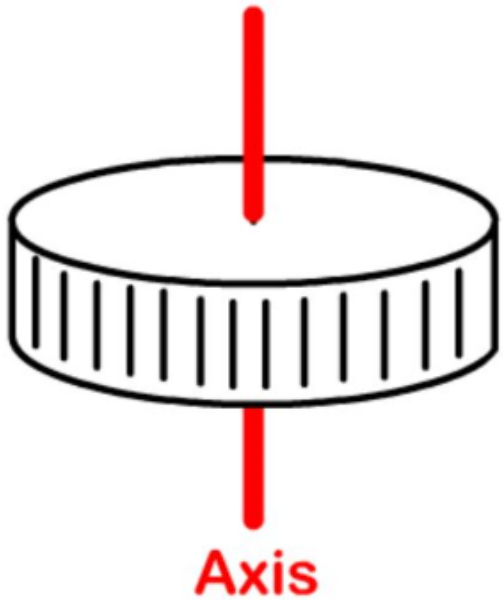


CIRCULAR MOTION (वृत्ताकार गति)

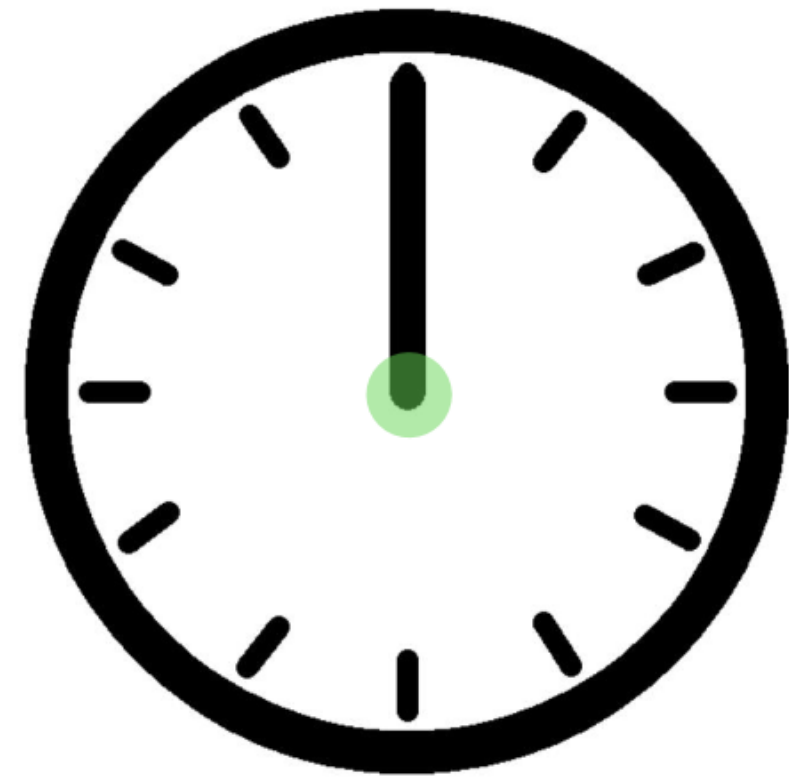
जब कोई वस्तु (Object) किसी निश्चित केंद्र (Fixed Centre) के चारों ओर एक **वृत्ताकार पथ (Circular Path)** में चलती है, तो उसकी गति को **Circular Motion (वृत्ताकार गति)** कहा जाता है।

When An Object Moves Along A Circular Path Around A Fixed Point Or Axis, The Motion Is Called **Circular Motion**.

Rotation



Revolution



CIRCULAR MOTION

EXAMPLES IN REAL LIFE

1 Car on a Curved Road



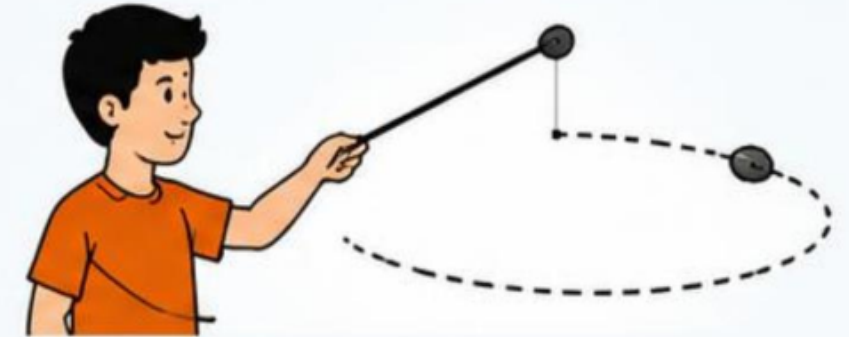
When a car takes a turn, it moves along a circular path. The **friction** between the tires and the road provides the **centripetal force**.

2 Ceiling Fan



The blades of a ceiling fan rotate in a circle. The motor applies a **force towards the center**, causing circular motion.

3 Stone Whirled on a String



When a stone is whirled in a circle, the **tension** in the string acts towards the center and keeps the stone moving in a circle.

4 Satellite in Orbit



A satellite moves around the Earth in a circular **orbit**. **Gravity** acts as the centripetal force, pulling it towards the Earth.

5 Roundabout



Vehicles moving on a roundabout follow a circular path. **Friction** between the tires and the road provides the centripetal force.

6 Ferris Wheel

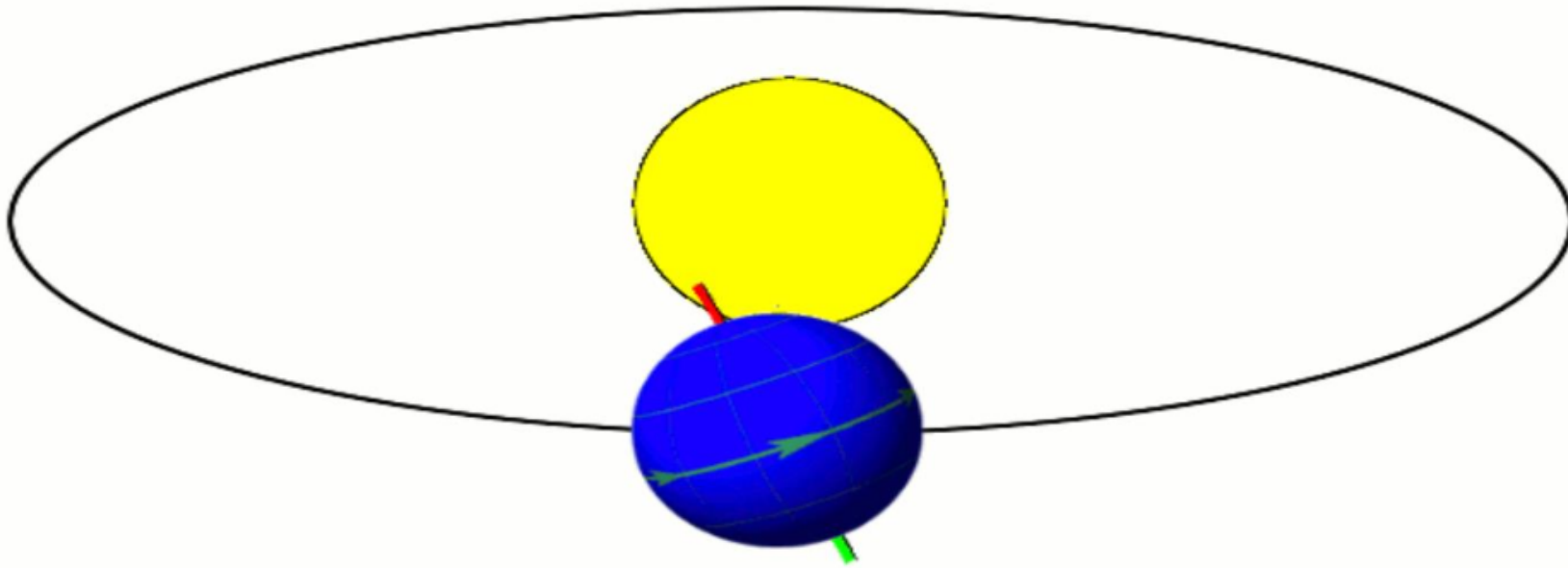


Each seat of a Ferris wheel moves in a circle. The rotation is due to the **motor**, which provides the necessary force towards the center.



Circular motion^x (वृत्ताकार)^x

→ Ellipse (दीर्घवृत्ताकार)



Rotation / घूर्णन
Circular

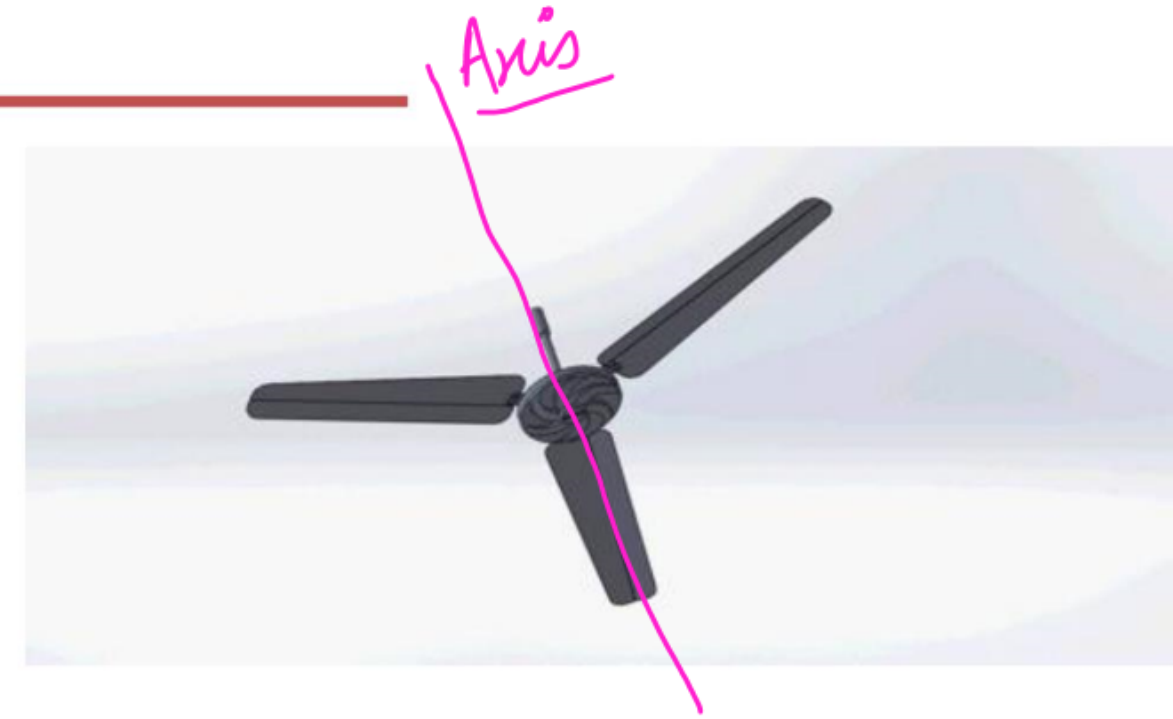




CIRCULAR MOTION (वृताकार गति)

1 Uniform Circular Motion (समान वृताकार गति)

- गति में वेग (speed) समान रहता है।
- दिशा (direction) बदलती रहती है।
- उदाहरण: पंखे के ब्लेड की गति।



2 Non-Uniform Circular Motion (असमान वृताकार गति)

- गति में वेग (speed) बदलता है।
- उदाहरण: गोल चक्कर पर चलती गाड़ी जिसकी गति बदलती रहती है।



CIRCULAR MOTION – EXAMPLES

UNIFORM CIRCULAR MOTION (UCM)

The object moves in a circle with **CONSTANT SPEED**.

EXAMPLES

1 Ceiling Fan



The blades rotate in a circle with constant speed.

2 Wall Clock (Second Hand)



The second hand of a clock moves in a circle with constant speed.

3 Moving Car on a Circular Track



A car moving on a circular track at constant speed.

4 Satellite in Circular Orbit



A satellite moving around the Earth in a circular orbit with constant speed.

5 Ferris Wheel (Constant Speed)



When the Ferris wheel rotates with constant speed.

6 CD/DVD in a Player



The CD/DVD rotates in a circle with constant speed.

NON-UNIFORM CIRCULAR MOTION

The object moves in a circle with **CHANGING SPEED**.

EXAMPLES

1 Car on a Curved Road



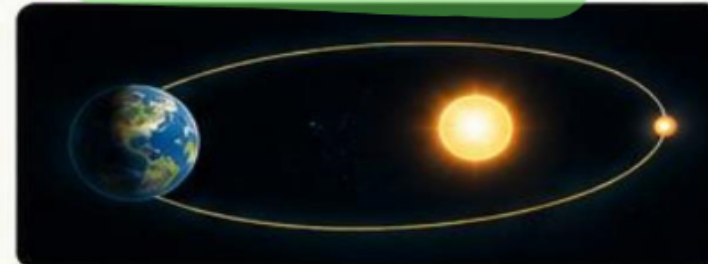
A car takes a turn. Its speed may increase or decrease.

2 Roller Coaster Loop



The speed of the coaster changes at different points in the loop.

3 Planet Around the Sun



Planets move in nearly circular paths with varying speed.

4 Swing (Pendulum)



The swing moves in an arc (part of a circle) with speed changing continuously.

5 Ball Tied with a String



If the string is pulled in or released, the speed of the ball changes.

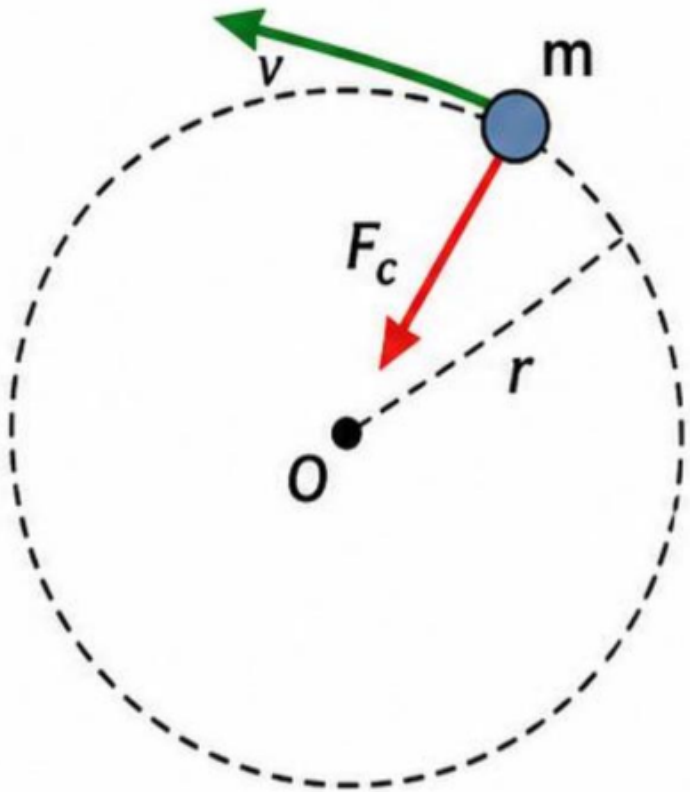
6 Cyclist on a Circular Track (Changing Speed)



A cyclist speeding up or slowing down while moving on a circular track.

CIRCULAR MOTION

MOTION OF AN OBJECT ALONG A CIRCULAR PATH



m = Mass
 r = Radius
 v = Linear speed
 ω = Angular speed
 T = Time period
 f = Frequency
 F_c = Centripetal force
 a_c = Centripetal acceleration

Note: All formulas are for uniform circular motion (constant speed).

1. LINEAR SPEED (v)

$$v = \frac{2\pi r}{T} = 2\pi r f$$

Unit: m/s

2. ANGULAR SPEED (ω)

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

Unit: rad/s

3. CENTRIPETAL ACCELERATION (a_c)

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

Unit: m/s²

4. CENTRIPETAL FORCE (F_c)

$$F_c = \frac{mv^2}{r} = m\omega^2 r$$

Unit: N

5. TIME PERIOD (T)

$$T = \frac{2\pi r}{v} = \frac{2\pi}{\omega} = \frac{1}{f}$$

Unit: s

6. FREQUENCY (f)

$$f = \frac{1}{T} = \frac{\omega}{2\pi}$$

Unit: Hz

KEY RELATIONS

$$v = \omega r$$

(Linear speed)

$$a_c = \omega^2 r$$

(Centripetal acceleration)

$$F_c = ma_c$$

(Centripetal force)

$$\omega = 2\pi f$$

(Angular speed)

$$T = \frac{1}{f}$$

(Time period)

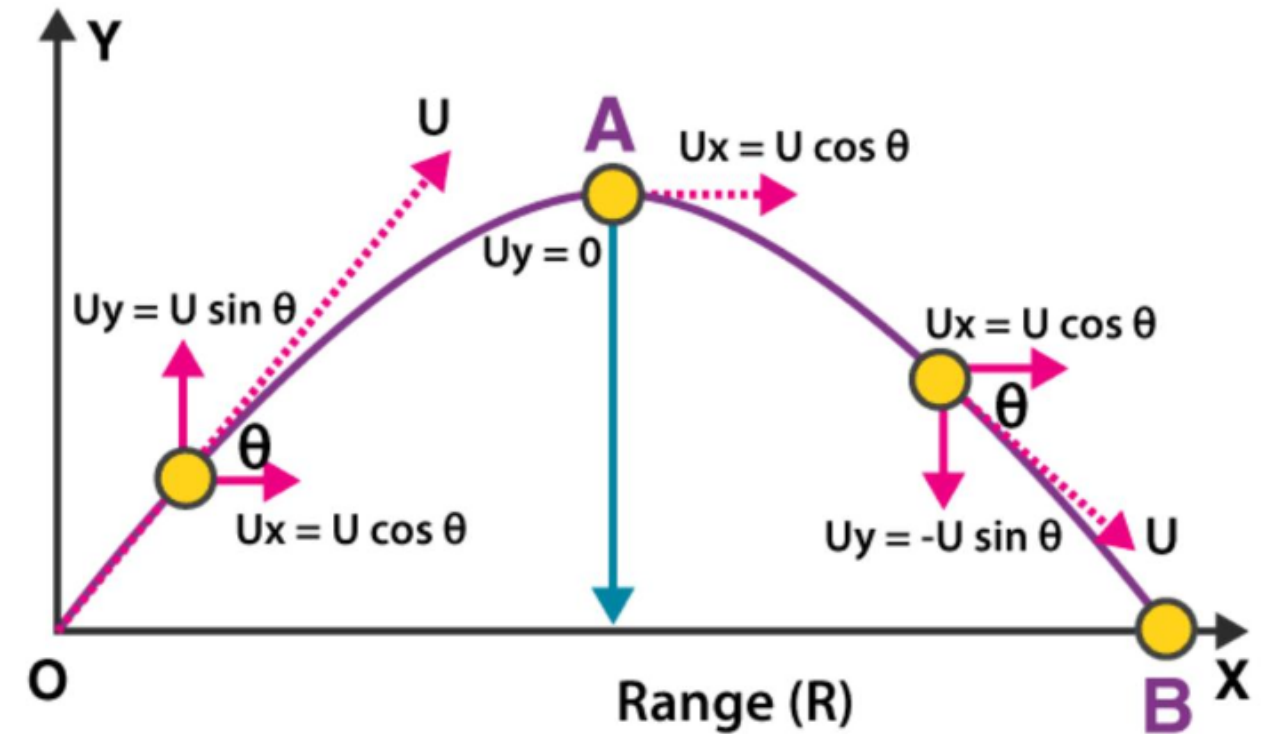
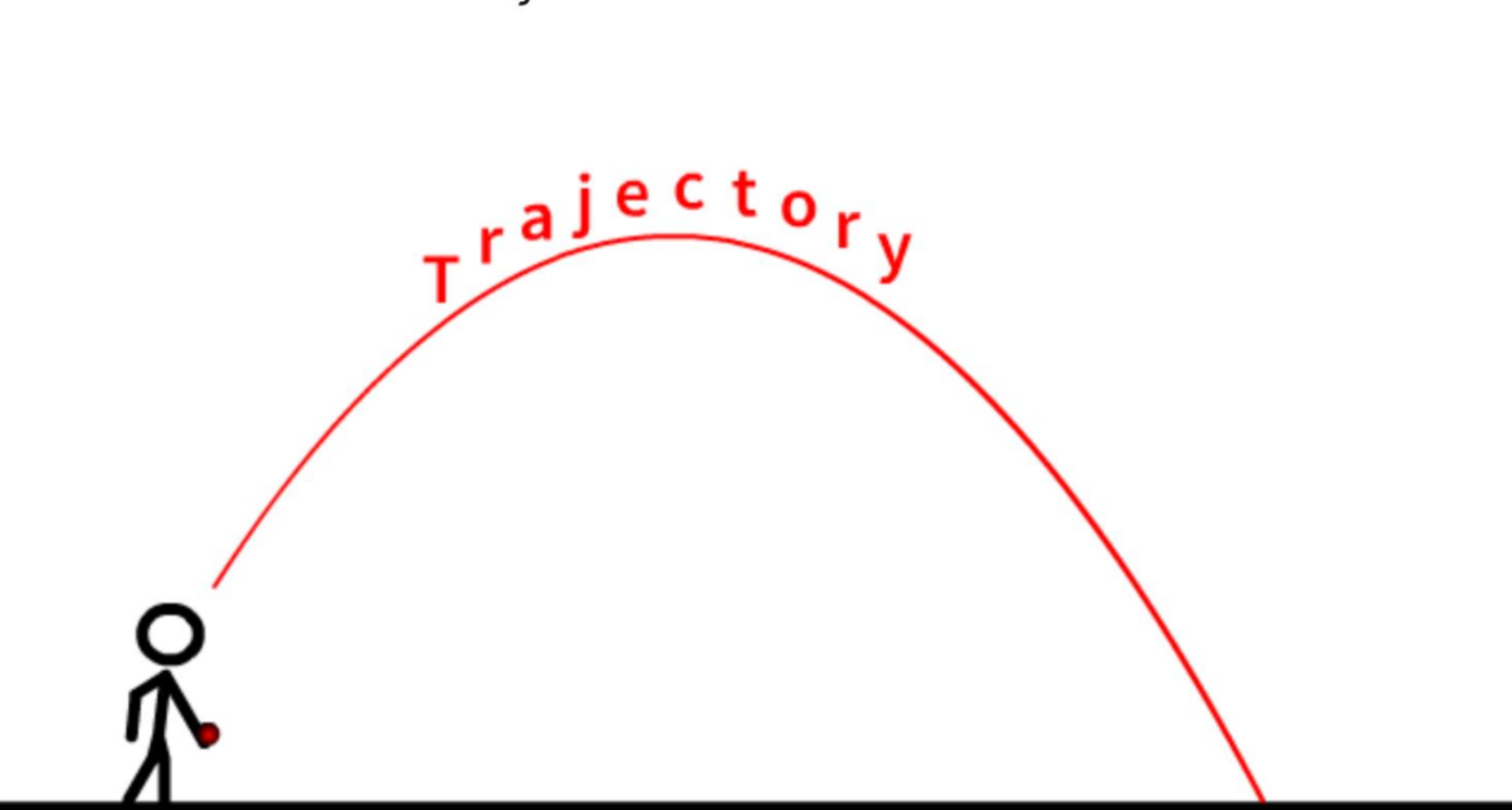


Projectile Motion (प्रक्षेप्य गति)

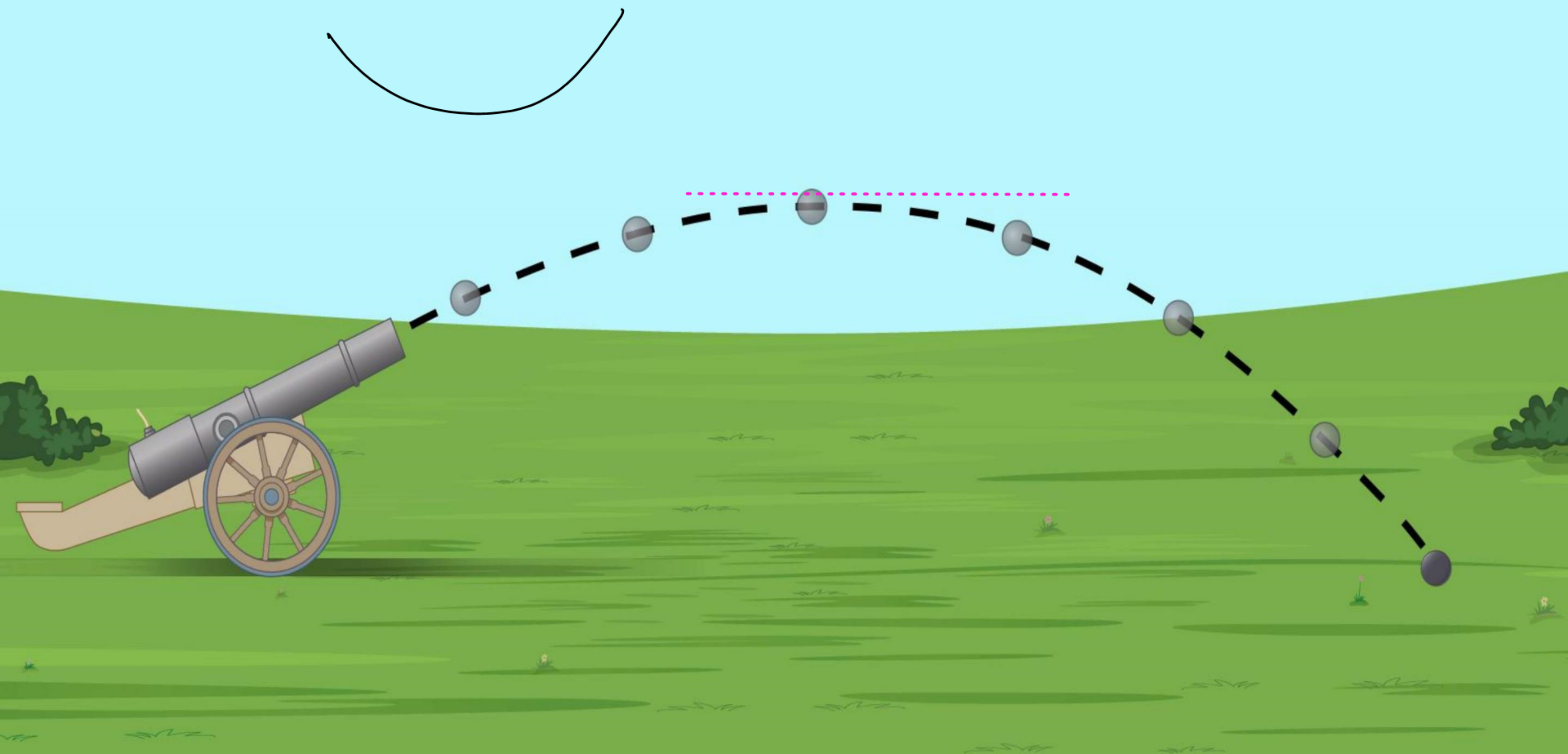
CDS/NOA / State Exam

जब कोई वस्तु (object) को किसी **आरंभिक वेग (initial velocity)** के साथ **क्षैतिज से किसी कोण (angle θ)** पर फेंका जाता है और उस पर केवल **गुरुत्वाकर्षण बल (gravity)** कार्य करता है, तो उसकी गति को **Projectile Motion (प्रक्षेप्य गति)** कहा जाता है।

When an object is thrown into the air making an angle θ with the horizontal and moves under the influence of gravity only, its motion is called *Projectile Motion*.



Parabola







APPLICATIONS IN REAL LIFE

SPORTS



Motion of a kicked football

BALL GAMES



Basketball shot towards the hoop

WEAPONS & DEFENSE



Path of a shell fired from a cannon

FOUNTAINS



Water particles follow projectile motion

FIREWORKS



Fireworks in the sky follow a parabolic path



Remember: In ideal projectile motion, only gravity acts on the object after projection.

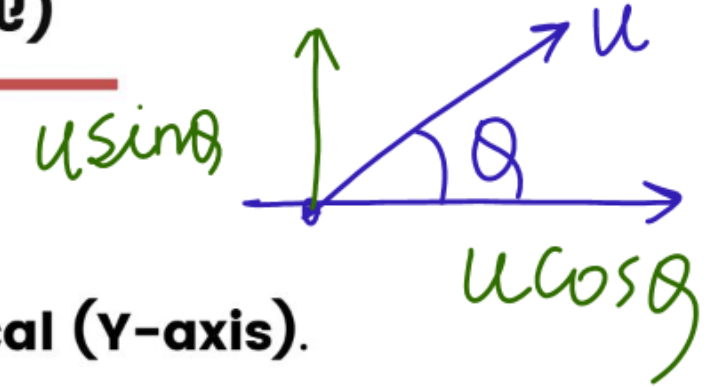


⚙ Properties of Projectile Motion (प्रक्षेप्य गति के गुण / विशेषताएँ)

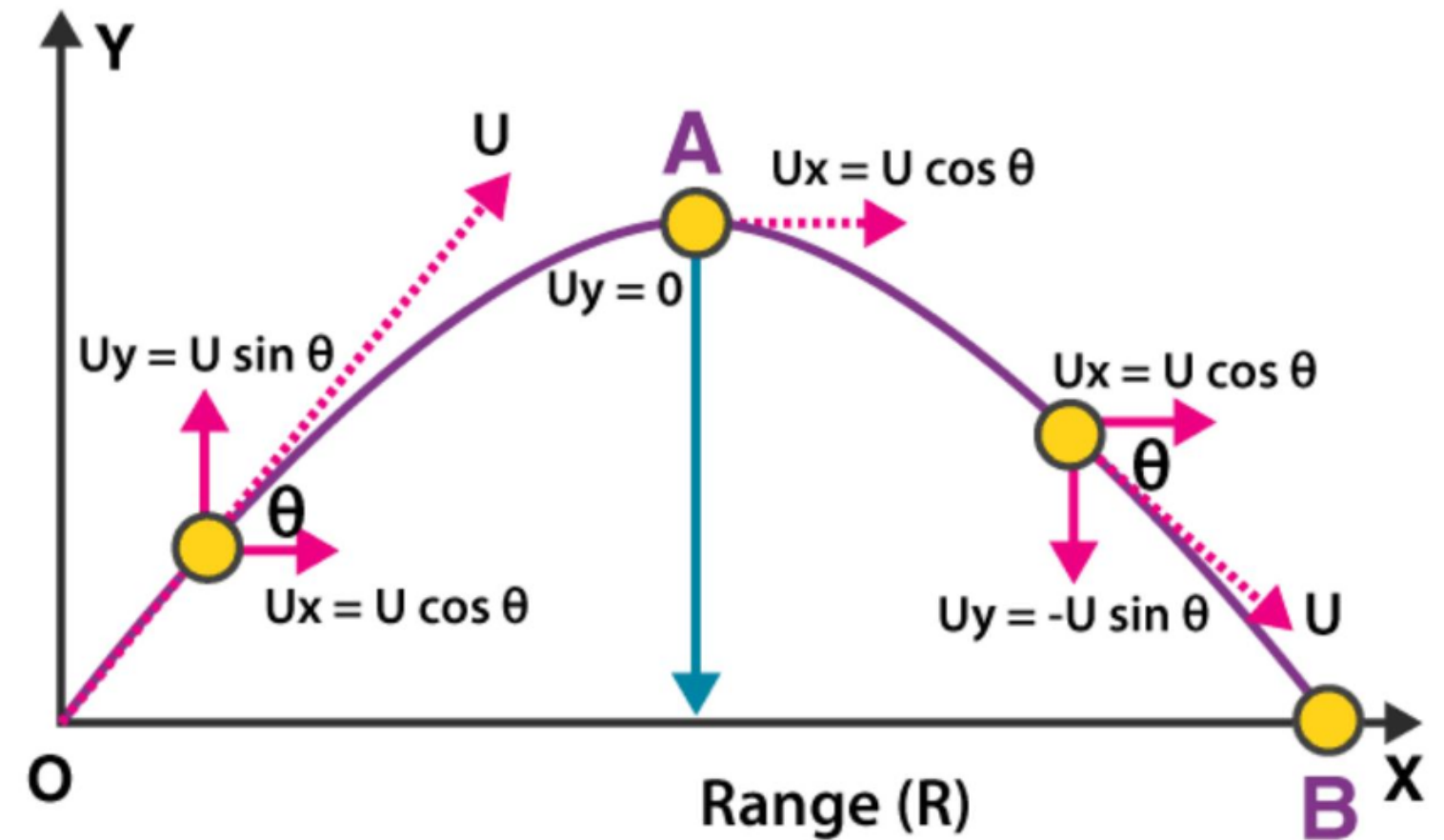
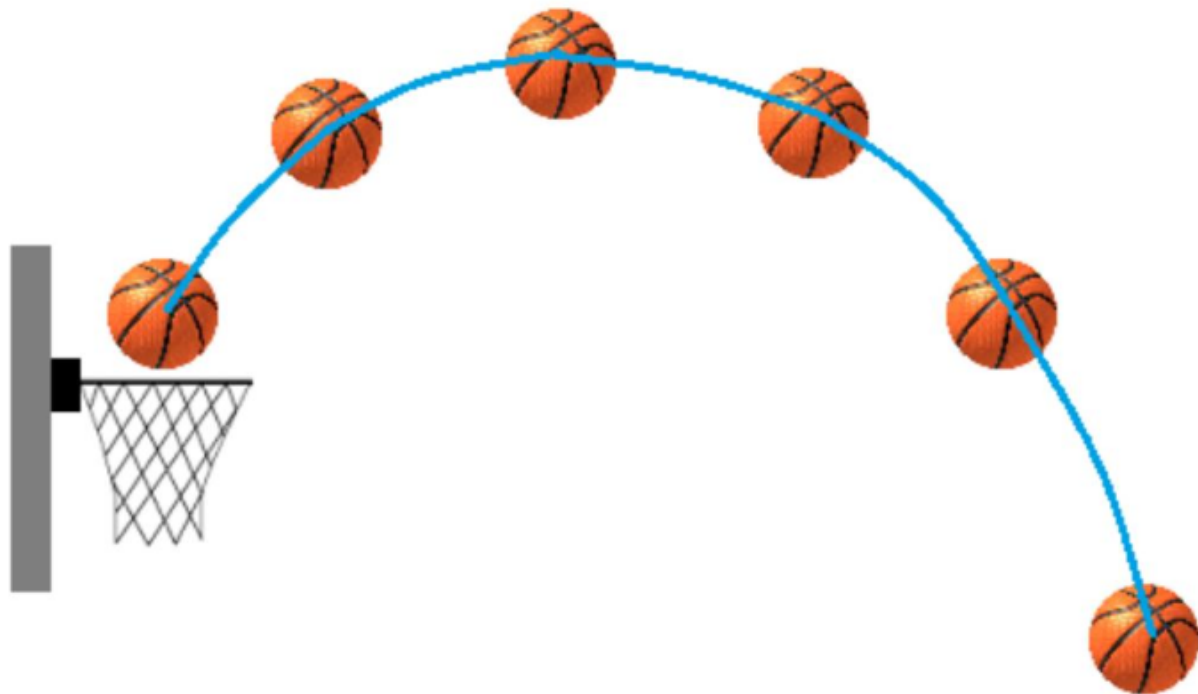
1 Motion Is Two-dimensional (गति द्विविमीय होती है)

The Motion Of A Projectile Takes Place In **Two Dimensions** – **Horizontal (X-axis)** And **Vertical (Y-axis)**.

प्रक्षेप्य गति **दो विमाओं में होती है** – एक क्षैतिज दिशा (X-axis) में और दूसरी ऊर्ध्वाधर दिशा (Y-axis) में।



Projectile motion





⚙ Properties of Projectile Motion (प्रक्षेप्य गति के गुण / विशेषताएँ)

2 Path Is Parabolic (पथ परवल्याकार होता है)

The Trajectory Of A Projectile Is A **Parabola**.

प्रक्षेप्य का पथ (Trajectory) **परवल्याकार (Parabolic)** होता है।

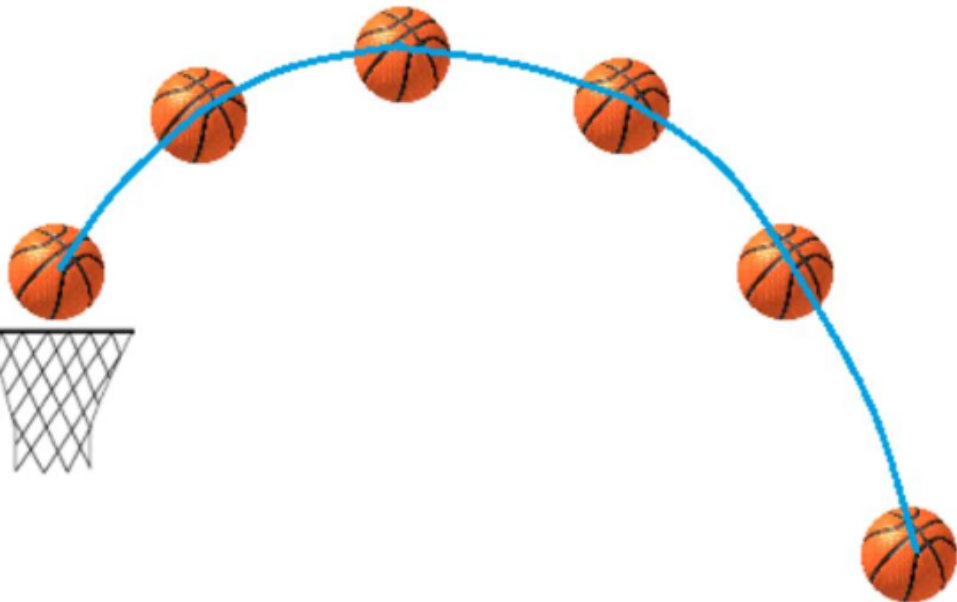
यह इसलिए होता है क्योंकि Horizontal Motion Uniform होती है,

जबकि Vertical Motion Uniformly Accelerated (Under Gravity) होती है।

$$y = x^2 \leftarrow \text{Quadratic}$$

Parabola
परवल्याकार

Projectile motion



$$\Rightarrow y(x) = x \tan \theta - \frac{gx^2}{2u^2 \cos^2 \theta}$$

(यह पाराबोला है।)



⚙ Properties of Projectile Motion (प्रक्षेप्य गति के गुण / विशेषताएँ)

⚡ ③ Horizontal Velocity Constant रहती है (Horizontal Velocity Remains Constant)

The **Horizontal Component ($U \cos \theta$)** Of Velocity Does **Not Change** Throughout The Motion.

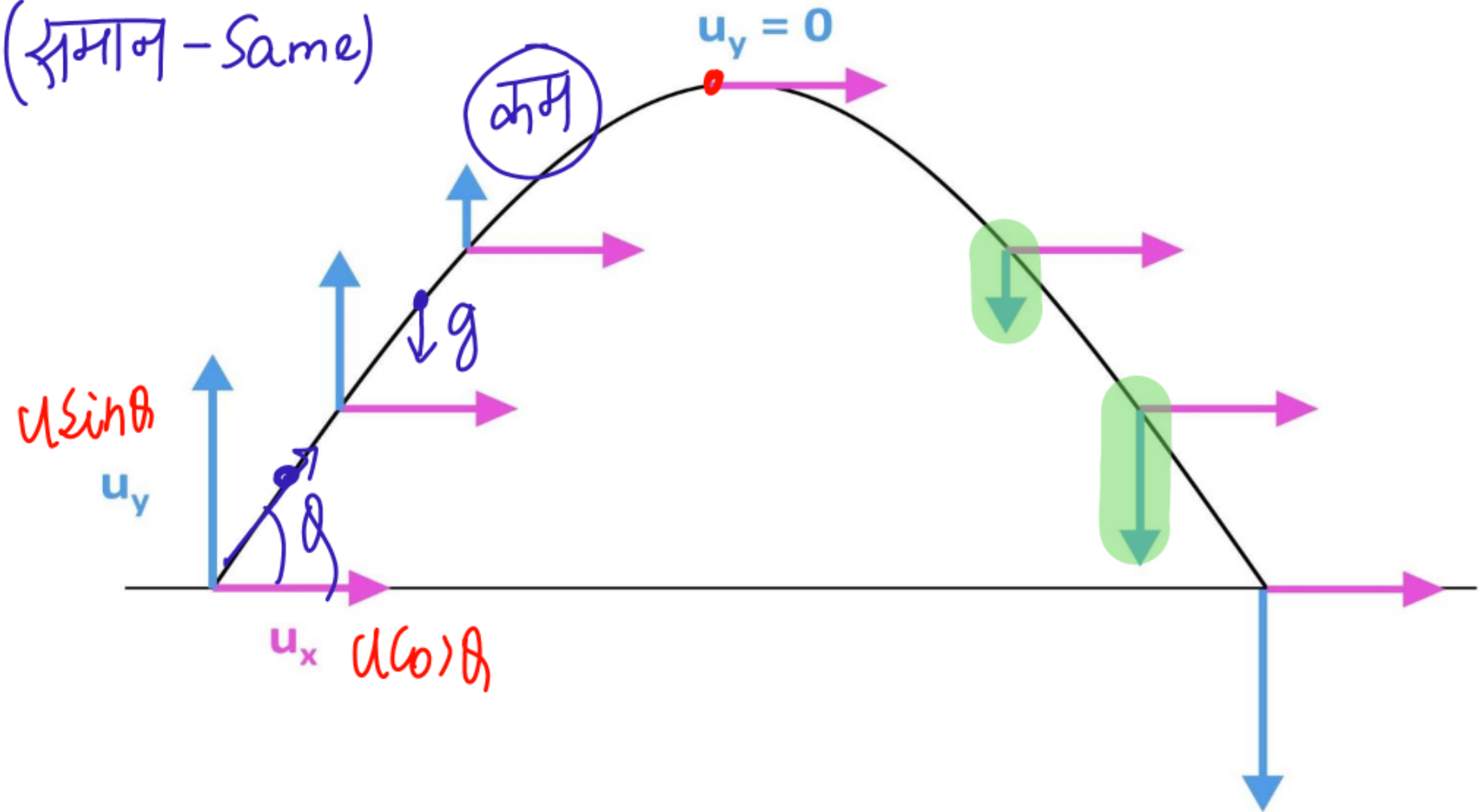
क्षैतिज दिशा में कोई बल नहीं लगता, इसलिए Horizontal Velocity Constant रहती है।

$$U \sin \theta = 0$$

$$\text{Horizontal Velocity} = U \cos \theta \text{ (समान - Same)}$$

$$\text{Vertical Velocity} = U \sin \theta$$

'g' → Vertical Velocity
'कम'





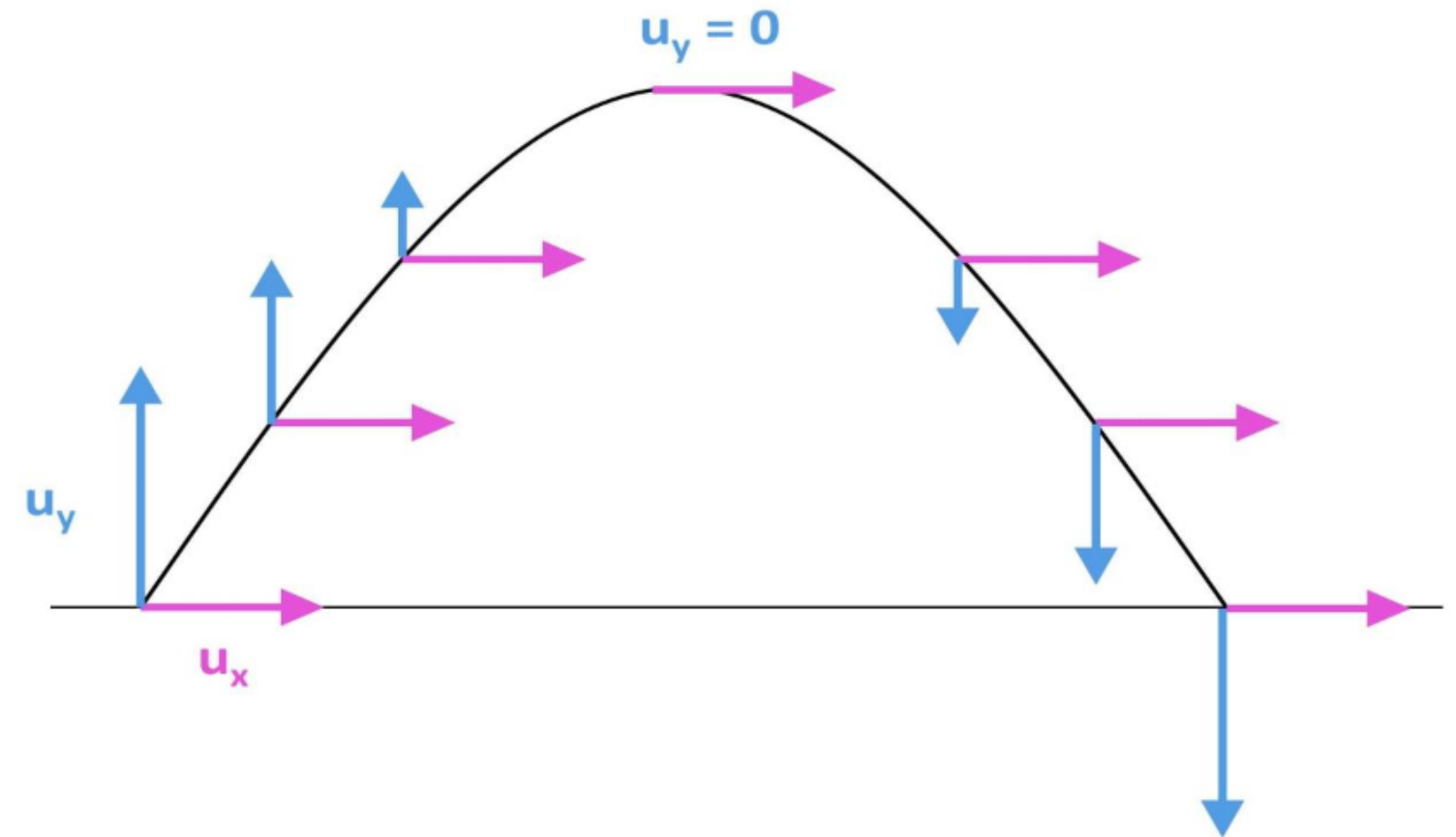
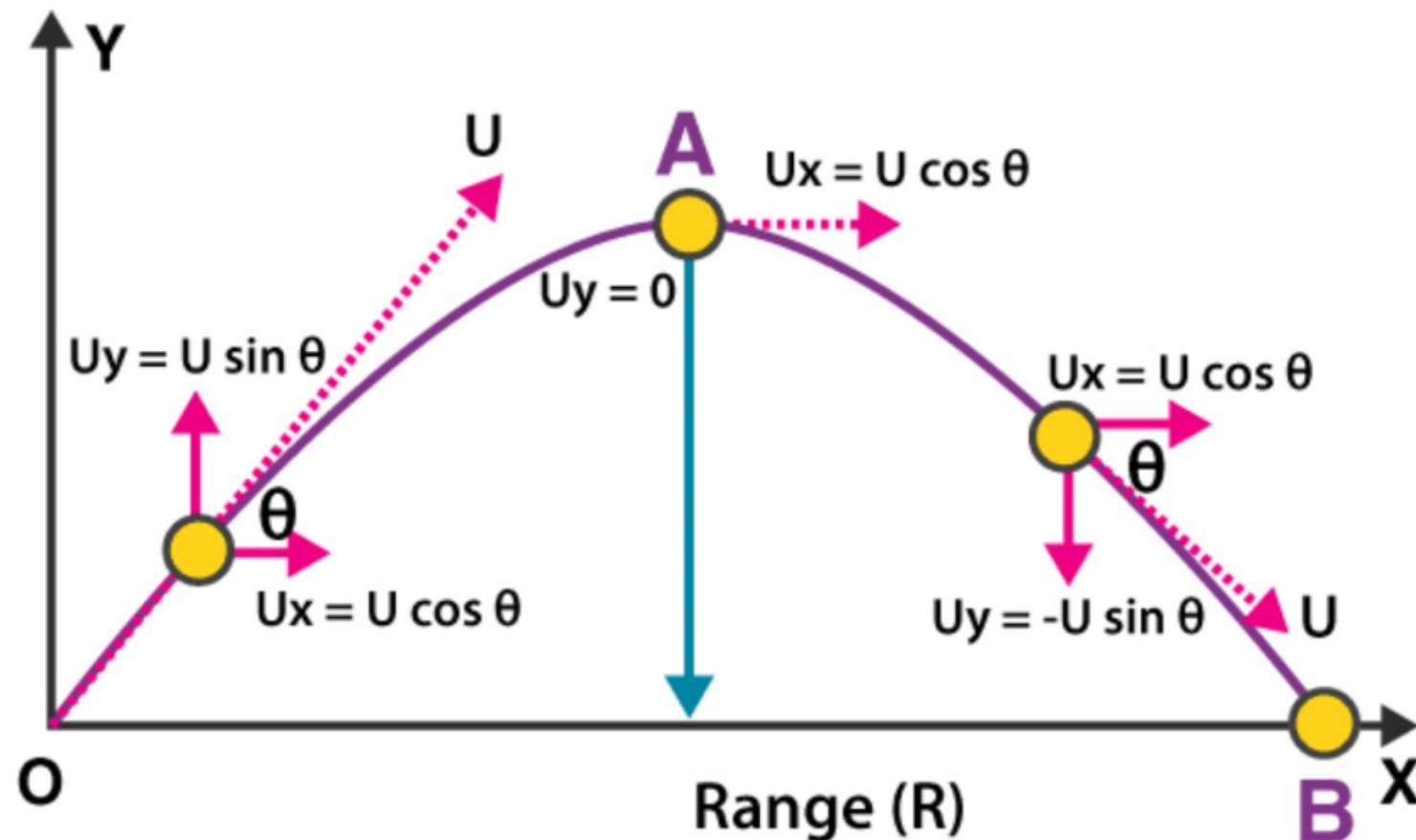
⚙ Properties of Projectile Motion (प्रक्षेप्य गति के गुण / विशेषताएँ)

📌 4 At Maximum Height (अधिकतम ऊँचाई पर)

Vertical velocity (v_y) = 0 होती है।

केवल horizontal velocity ($u \cos \theta$) रह जाती है।

At the highest point, vertical velocity becomes zero, but horizontal velocity remains constant.





Time of Flight (उड़ान का कुल समय)

1 Time of Flight (उड़ान का कुल समय)

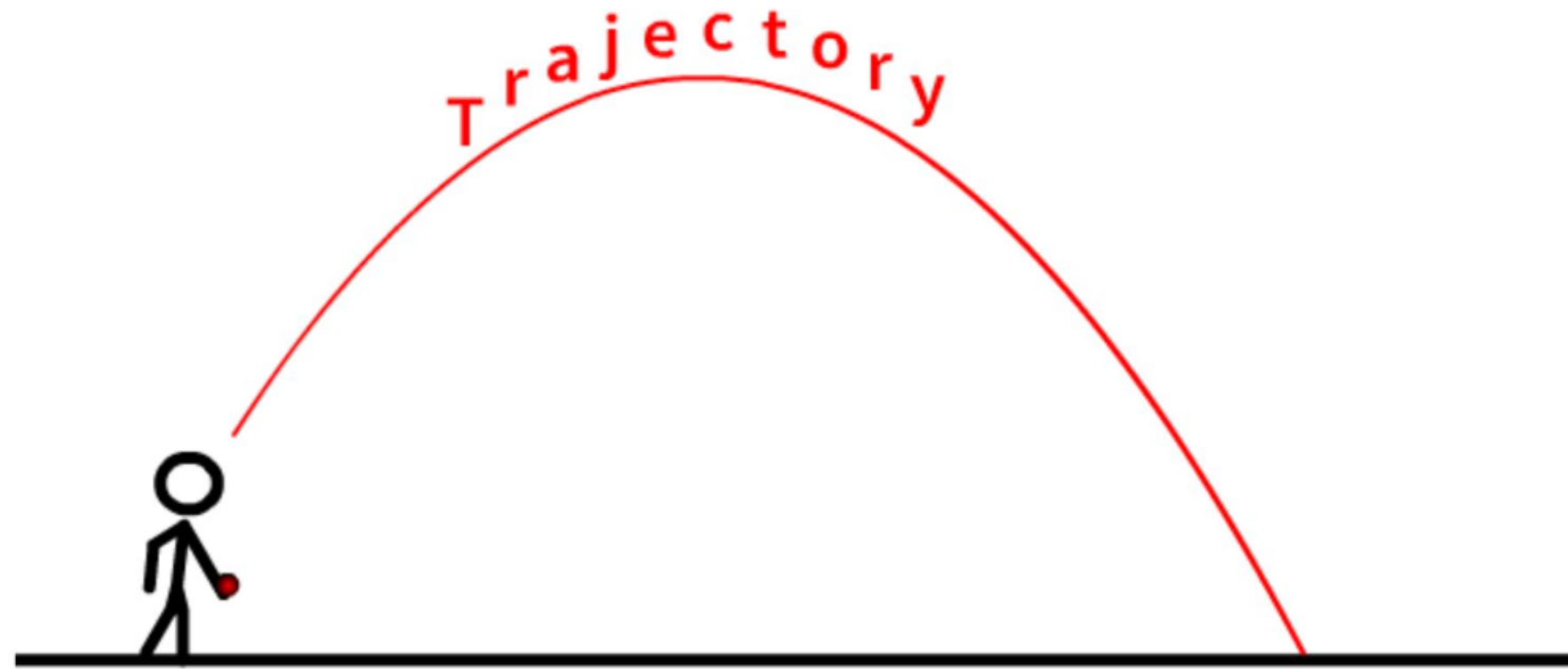
$$T = \frac{2u \sin \theta}{g}$$

♦ जहाँ

u = प्रारंभिक वेग (Initial velocity)

θ = प्रक्षेपण कोण (Angle of projection)

g = गुरुत्व त्वरण (Acceleration due to gravity)





2 Maximum Height (अधिकतम ऊँचाई)

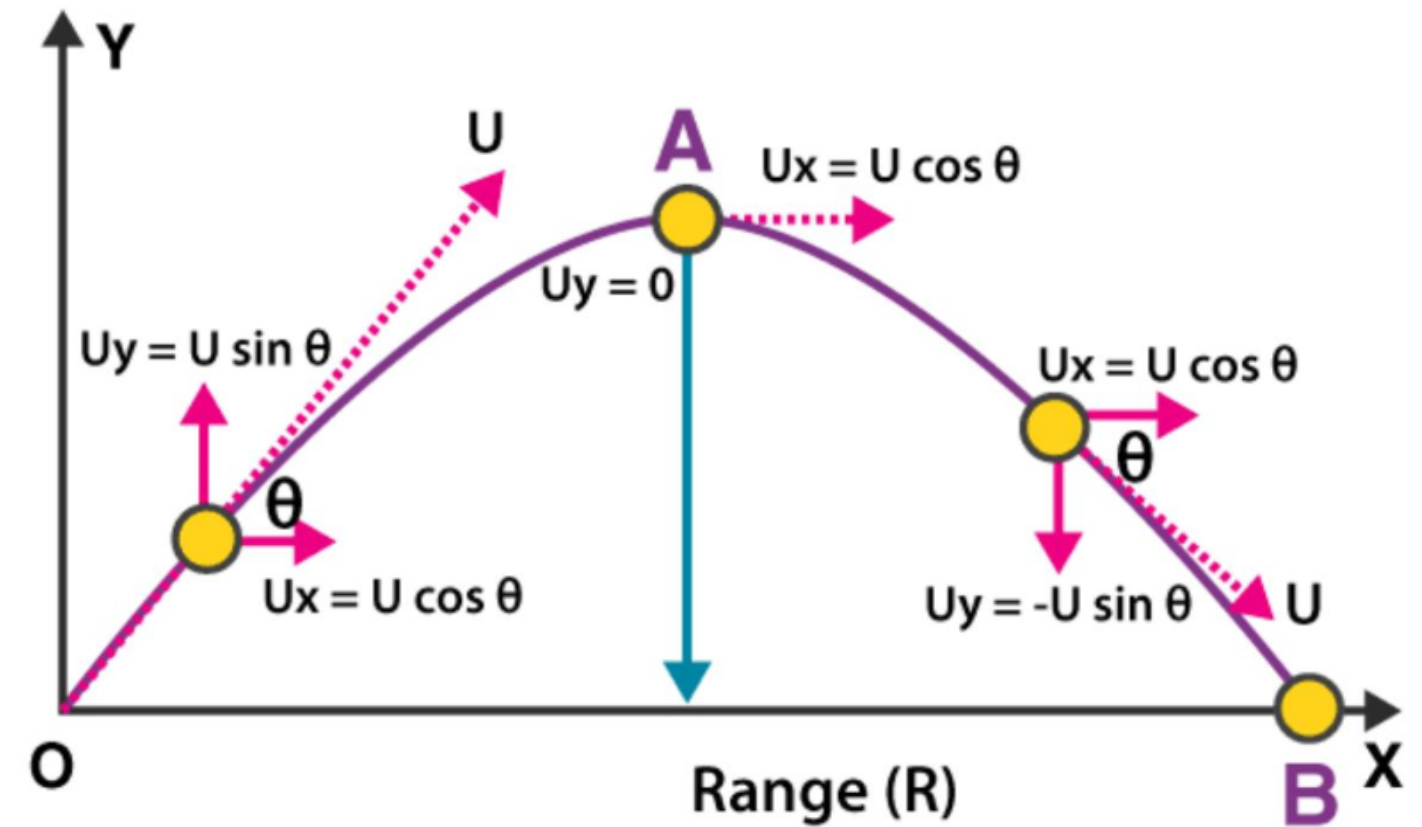
$$H = \frac{u^2 \sin^2 \theta}{2g}$$

3 Horizontal Range (क्षैतिज दूरी)

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

R सर्वाधिक

$$\theta = 45^\circ$$



PROJECTILE MOTION

MOTION IN TWO DIMENSIONS UNDER GRAVITY

IMPORTANT FORMULAS

Time of Flight (T)



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

(Total time in air)

Maximum Height (H)



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

(Vertical rise to highest point)

Range (R)



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

(Horizontal distance covered)

Maximum Range



Occurs at $\theta = 45^\circ$

$$R_{\max} = \frac{u^2}{g}$$

(Maximum possible range)

Where,

u = Initial speed

θ = Angle of projection with horizontal

g = Acceleration due to gravity ($\approx 9.8 \text{ m/s}^2$)

CONDITIONS (For same level projection and landing)



At highest point,
 $v_y = 0$ (vertical velocity)
velocity is horizontal



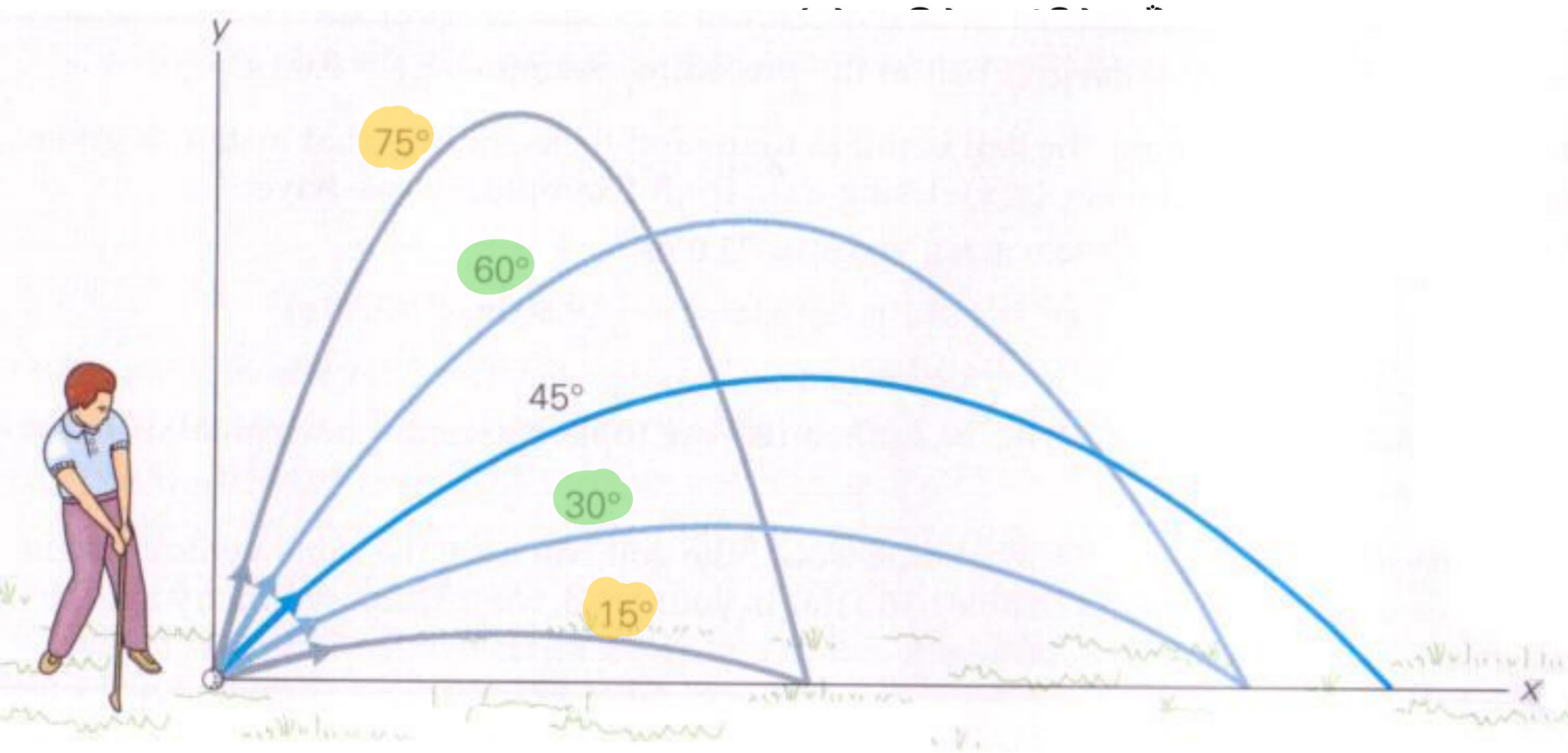
Time of ascent
= Time of descent



Path followed
is a parabola



Horizontal acceleration = 0
Vertical acceleration = $-g$





⚙ Properties of Projectile Motion (प्रक्षेप्य गति के गुण / विशेषताएँ)

🌀 जब दो प्रक्षेप्य समान प्रारंभिक वेग (u) से पूरक कोणों (θ और $90^\circ - \theta$) पर छोड़े जाते हैं — $\alpha + \beta = 90^\circ$

When two projectiles are projected with the same initial velocity (u) at complementary angles (θ and $90^\circ - \theta$)

1 Range समान होती है (Range is same)

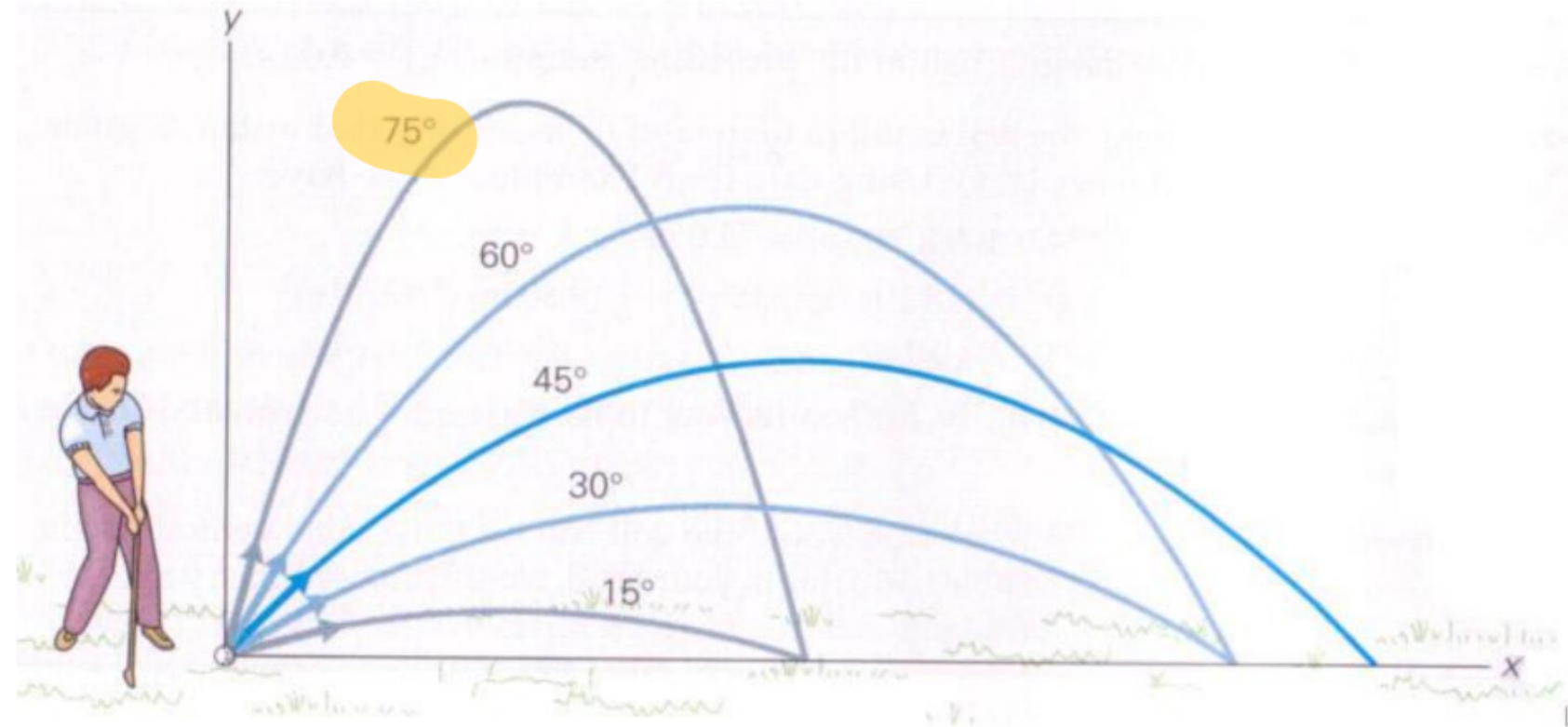
2 Height अलग होती है (Heights are different)

3 Time of Flight अलग होता है (Times of flight are different)

4 Path परवल्याकार होता है (Path is parabolic)

5 दोनों के पथ एक-दूसरे के प्रतिबिंब होते हैं (Both paths are mirror images of each other)

6 अधिक कोण वाला प्रक्षेप्य अधिक ऊँचाई तक जाता है (Projectile with greater angle reaches higher height)





किस कोण से फेंके जाने पर कोई वस्तु सर्वाधिक दूरी तक प्रक्षेपित होती है?

At what angle should a body be projected to cover the maximum horizontal range?



Exam: RRB Group-D



Date: 16 November 2018 (Shift-III)

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

$$\sin 2\theta = 1 \leftarrow \sin 90^\circ$$

$$\sin 2\theta = \sin 90^\circ$$

$$2\theta = 90^\circ$$

$$\theta = 45^\circ$$

(a) 60°

(b) 75°

(c) 30°

(d) 45°



A Body Is Projected At An Angle Of 15° And Covers A Range Of 1.5 Km. If The Same Body Is Projected At 45° , What Will Be Its New Range?

एक कण को 15° कोण पर प्रक्षेपित किया जाता है और वह 1.5 Km की दूरी तय करता है। यदि उसी कण को 45° कोण पर प्रक्षेपित किया जाए, तो उसकी नई दूरी क्या होगी?



Exam: RRB JE 2024

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

$$1.5 = \frac{u^2}{2g}$$

(a) 6 km

(b) 0.75 km

(c) 1.5 km

(d) 3.0 km

$$1.5 = \frac{u^2 \sin(2 \times 15)}{g}$$

$$\frac{u^2}{g} = 3$$

$$1.5 = \frac{u^2 \sin 30}{g}$$

$$R = \frac{u^2 \sin(2 \times 45)}{g}$$

$$R = \frac{u^2}{g} (\sin 90)$$

$$R = \frac{u^2}{g} = 3$$



For projectile motion, the correct relation between maximum height (H) and range (R) is:

$$\sin 2\theta = 2 \sin \theta \cos \theta$$

प्रक्षेप्य गति के लिए अधिकतम ऊँचाई (H) और दूरी (R) के बीच सही संबंध है:

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

$$\frac{H}{R} = \frac{\sin^2 \theta}{2 \sin 2\theta}$$

$$H = 4R \cot \theta$$

$$R = 4H \cot \theta$$

$$R = \frac{H}{4} \cot \theta$$

$$R = 2H \cot \theta$$

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

$$\frac{H}{R} = \frac{\cancel{\sin \theta} \cdot \sin \theta}{2 \cdot 2 \cancel{\sin \theta} \cdot \cos \theta} = \frac{\sin \theta}{4 \cdot \cos \theta}$$

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



THANKS FOR WATCHING