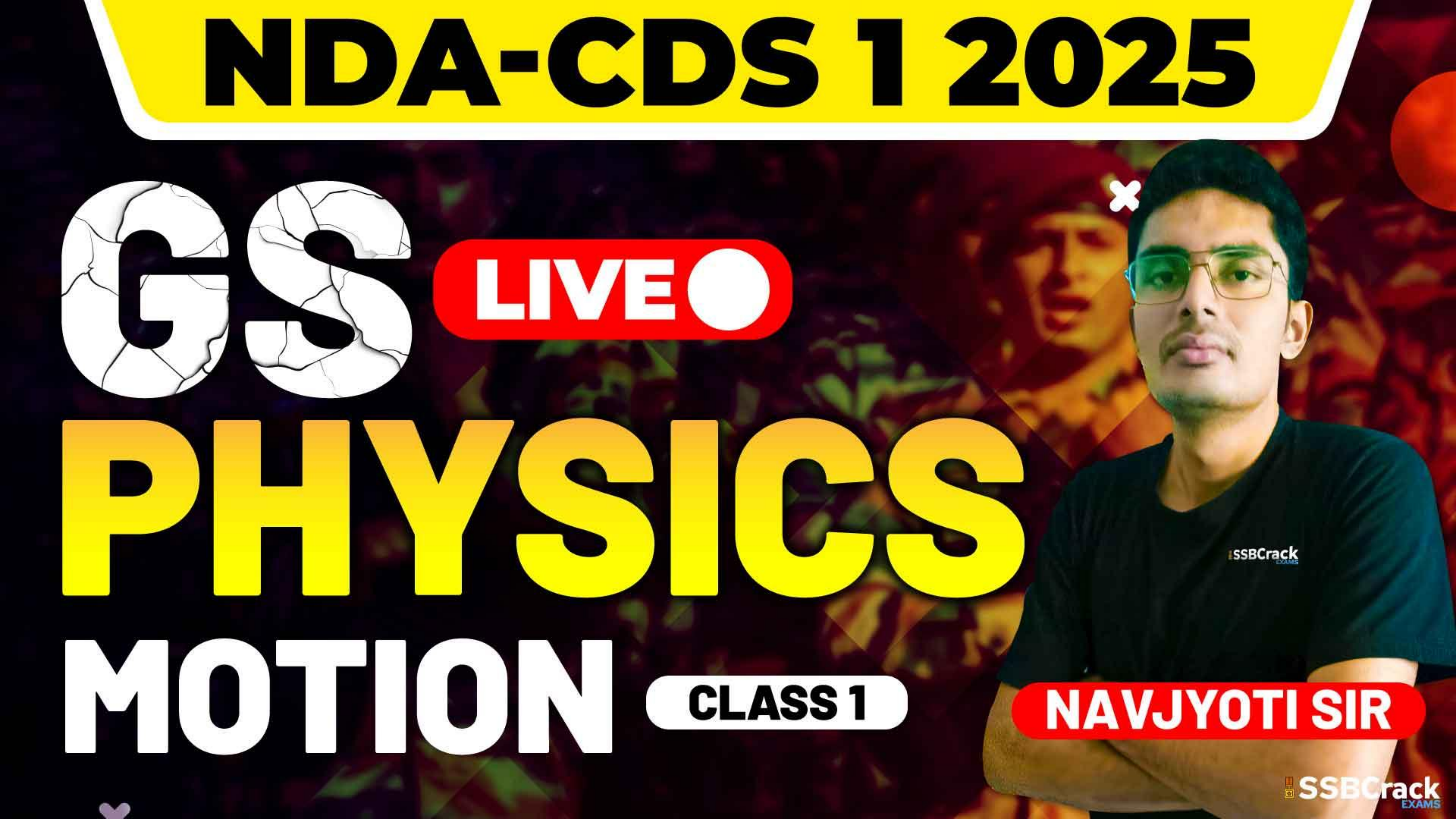
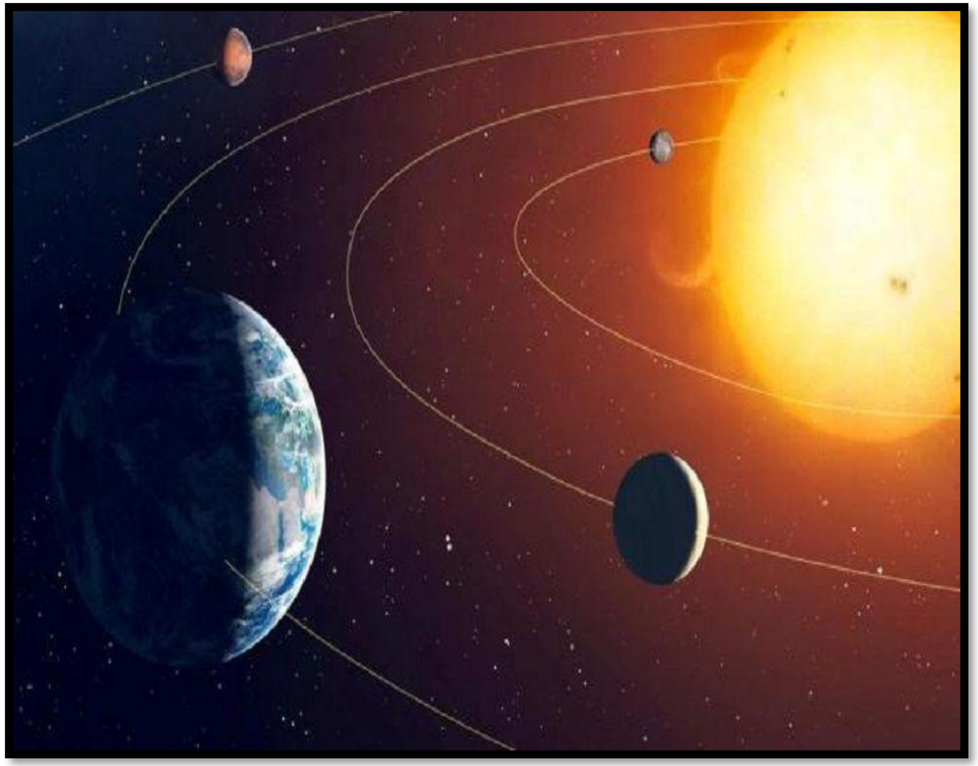

NDA-CDS 1 2025
GS
LIVE
PHYSICS
MOTION
CLASS 1
NAVJYOTI SIR
SSBCrack
EXAMS

MOTION



WHAT WILL WE STUDY ?

- Scalar and Vectors
- Terms associated with Motion of a body
- Graphs describing Motion
- Projectile Motion
- Uniform Circular Motion

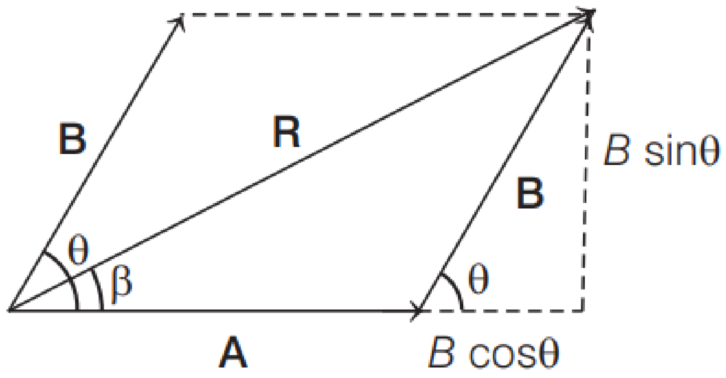
SSBCrack EXAMS

SCALARS AND VECTORS

- Scalars : Those physical quantities which require only magnitude but no direction for their complete representation are called scalars. (number unit) 40 km
  Example - Distance, Speed, work, mass, density etc.
- Scalars can be added, subtracted, multiplied or divided by simple algebraic laws.
  same units; same/different unit
- Vectors : Those physical quantities which require magnitude as well as direction for their complete representation.
- Examples are – Displacement , Velocity, Acceleration, Force etc.
- Vectors have other laws for addition , subtraction and multiplication.

VECTOR ADDITION

If two vectors acting at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram draw from a point, then their resultant is represented in magnitude and direction by the diagonal of the parallelogram drawn from the same point.

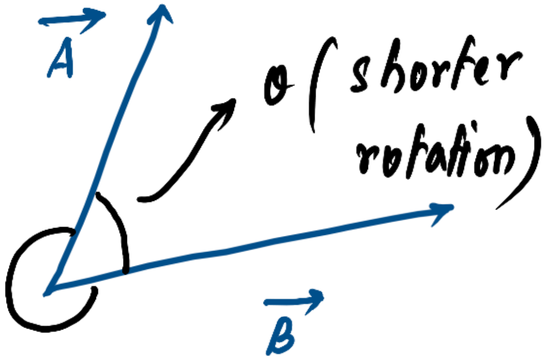


Resultant of vectors **A** and **B** is given by

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

If the resultant vector **R** subtends an angle β with vector **A**, then

$$\tan\beta = \frac{B\sin\theta}{A + B\cos\theta}$$

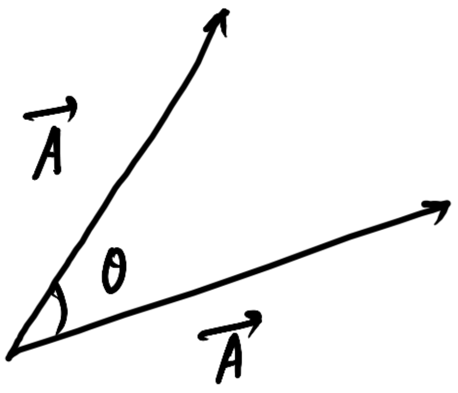


$\theta = 0^\circ \quad R = A + B$

$\theta = 90^\circ \quad R = \sqrt{A^2 + B^2}$

$\theta = 180^\circ \quad R = A - B$

Two same vectors, $\vec{A}$ at angle θ,



$$R = \sqrt{A^2 + A^2 + 2A \cdot A\cos\theta}$$

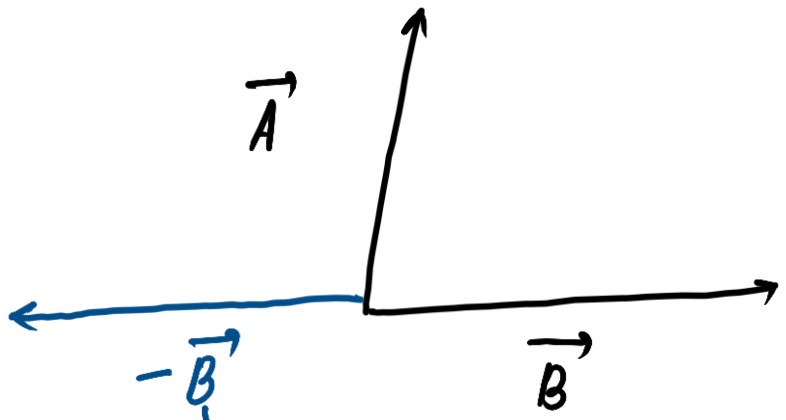
$$R = \sqrt{2A^2 + 2A^2\cos\theta}$$

$$R^2 = 2A^2(1+\cos\theta)$$

$$1+\cos\theta = 2\cos^2\frac{\theta}{2}$$

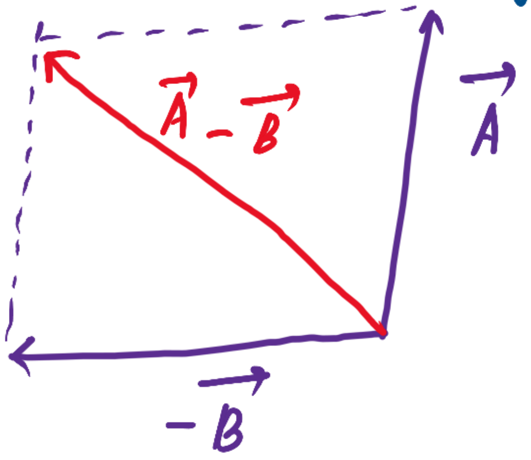
$$R^2 = 2A^2\left(2\cos^2\frac{\theta}{2}\right) = 4A^2\cos^2\frac{\theta}{2}$$

$$R = 2A\cos\frac{\theta}{2}$$



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

(same magnitude as $\vec{B}$; just opposite direction)

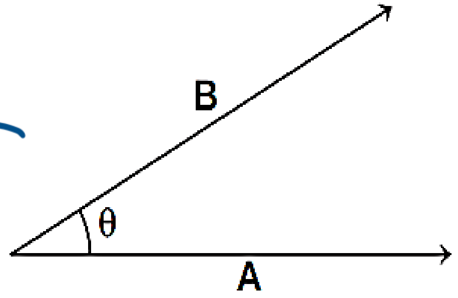


SSBCrack EXAMS

VECTOR MULTIPLICATION

Scalar or Dot Product of Two Vectors

The scalar product of two vectors is equal to the product of their magnitudes and the cosine of the smaller angle between them. It is denoted by · (dot).



Work done = $\vec{F} \cdot \vec{s}$

$$\mathbf{A} \cdot \mathbf{B} = AB \cos\theta$$

The scalar or dot product of two vectors is a scalar.

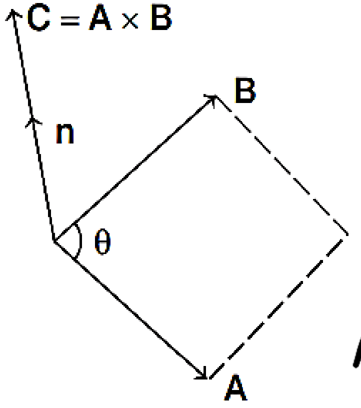
Only magnitude

Vector or Cross Product of Two Vectors

The vector product of two vectors is equal to the product of their magnitudes and the sine of the smaller angle between them. It is denoted by × (cross).

$$\mathbf{A} \times \mathbf{B} = AB \sin\theta \, \hat{\mathbf{n}}$$

(gives a vector)



Torque = $\vec{r} \times \vec{F}$

magnitude + direction

RESOLUTION OF VECTORS

If any vector **A** subtends an angle θ with X-axis, then its

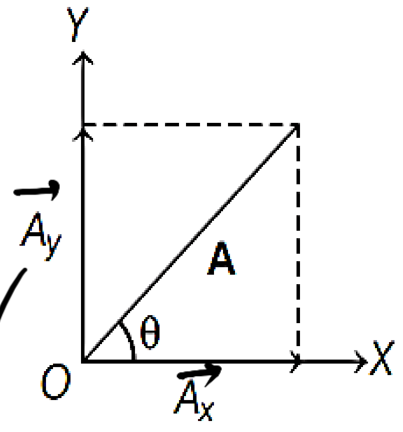
horizontal component, $A_x = A\cos\theta$ ✓

Vertical component, $A_y = A\sin\theta$ ✓

Magnitude of vector, $A = \sqrt{A_x^2 + A_y^2}$

$$\tan\theta = \frac{A_y}{A_x}$$

$$\text{Angle, } \theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$



components

angle between $\vec{A_x}$ and $\vec{A_y}$ = 90°

$$A^2 = A_x^2 + A_y^2 + 2A_xA_y\cos 90^\circ$$

Terms Associated with Motion

- Distance
- Displacement
- Speed
- Velocity
- Average Speed and Velocity
- Acceleration

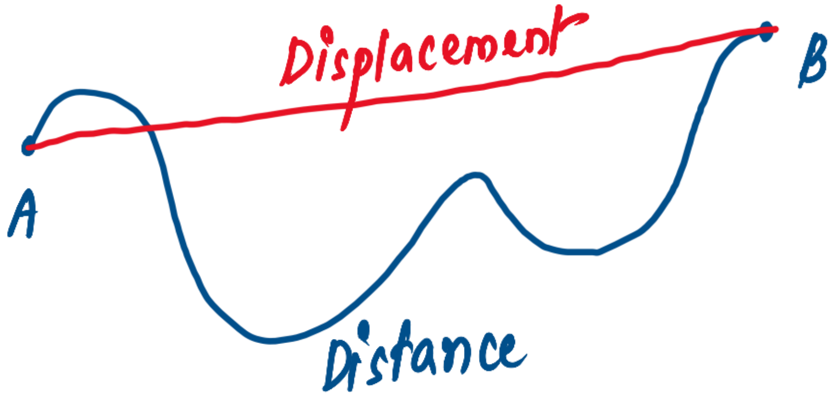
1. **DISTANCE :** The length of the actual path covered by an object.

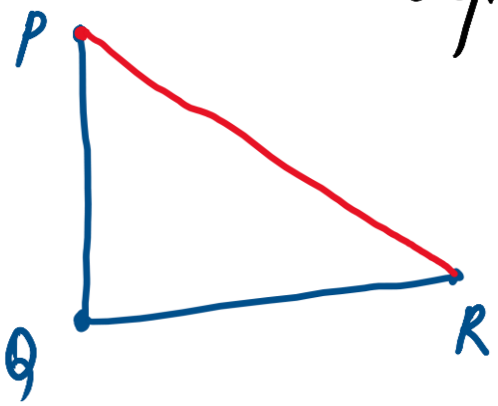
- It is a scalar quantity and it can never be zero or negative during the motion of an object. Its SI unit is metre.

2. **DISPLACEMENT :** The shortest distance between the initial and final positions of any object during motion.

- The displacement of an object in a given time can be positive, zero or negative.
- It is a vector quantity. Its SI unit is metre.

Displacement $\leq$ Distance





3. SPEED :

$$\text{Speed } (v) = \frac{\text{Distance travelled } (s)}{\text{Time taken } (t)}$$

- Its SI unit is m/s. It is a scalar quantity.

4. VELOCITY :

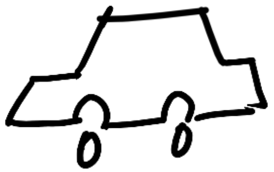
$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time taken}}$$

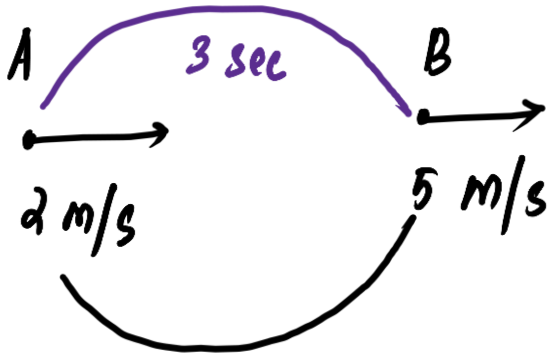
- The velocity of an object can be positive, zero or negative.
- It is a vector quantity. Its SI unit is m/s.

5. ACCELERATION :

$$\text{Acceleration } (a) = \frac{\text{Change in velocity } (\Delta v)}{\text{Time interval } (\Delta t)} = \frac{\text{final velocity} - \text{initial velocity}}{\text{Time taken for the change}}$$

- It is a vector quantity as well. Its SI unit is m/s^2 .
- Acceleration can be positive, zero or negative. Positive acceleration means velocity increasing with time, zero acceleration means velocity is uniform while negative acceleration (retardation/deceleration) means velocity is decreasing with time.

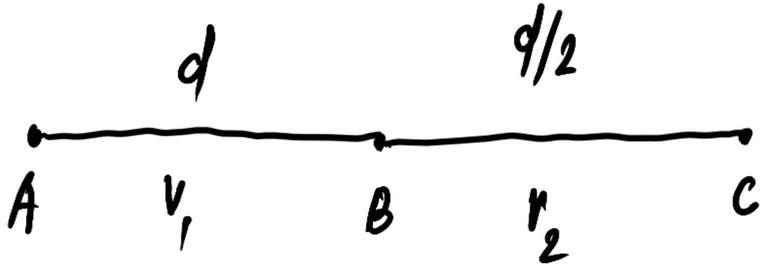




$$a = \frac{5-2}{3} \frac{m/s}{s} = 1\ m/s^2$$

- **UNIFORM SPEED** : If an object covers equal distances in equal intervals
- of time. $(a = 0)$
- **NON-UNIFORM OR VARIABLE SPEED** : If an object covers unequal distances
- in equal intervals of time and vice-versa. $(a \neq 0)$
- **AVERAGE SPEED** :

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$



$$\text{Avg. speed} = \frac{d + d/2}{\frac{d}{v_1} + \frac{d/2}{v_2}} = \frac{3d/2}{d\left(\frac{2v_2 + v_1}{2v_1 v_2}\right)}$$

- **INSTANTANEOUS SPEED :**

$$\text{Instantaneous speed} = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$$

- **Uniform , Average and Instantaneous velocity will have the same formula , replacing distance with displacement.**

- **AVERAGE ACCELERATION:**

If a particle is accelerated for a time t_1 with acceleration a_1 and for a time t_2 with acceleration a_2 , then average acceleration ,

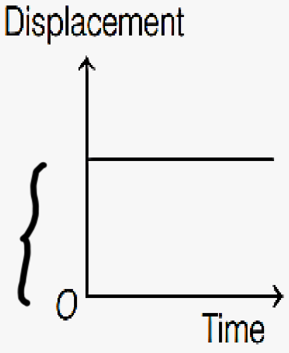
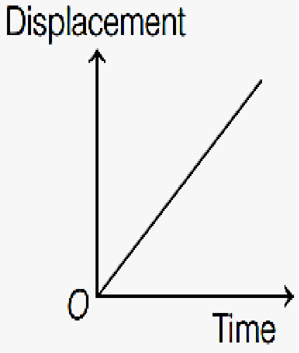
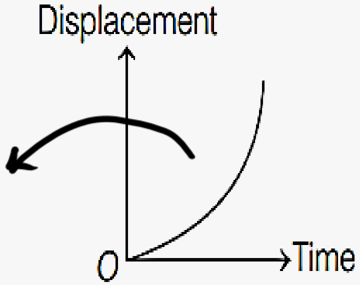
$$a_{av} = \frac{a_1 t_1 + a_2 t_2}{t_1 + t_2}$$

overall change in velocity / Total time

- **INSTANTANEOUS ACCELERATION:**

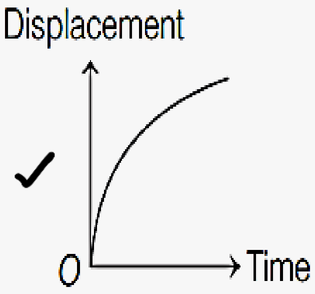
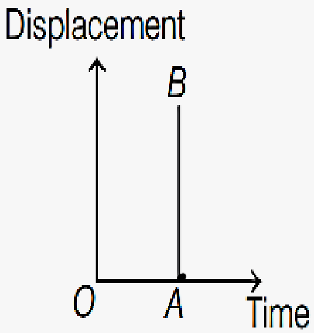
$$a_{inst} = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

DISTANCE -TIME GRAPHS

Condition	Graph
For a stationary body	
Body moving with a constant velocity	
Body moving with a constant acceleration exponential	

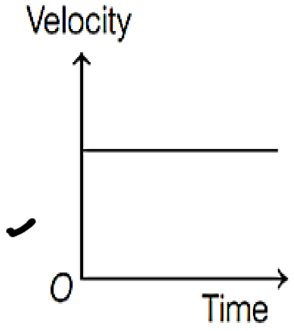
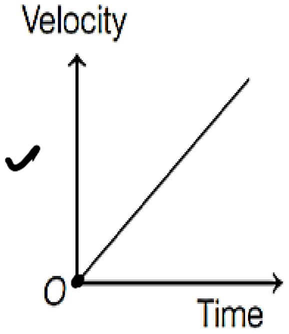
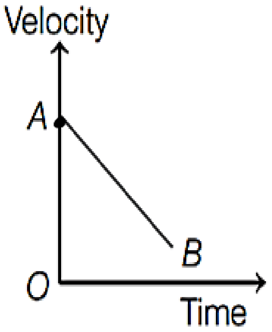
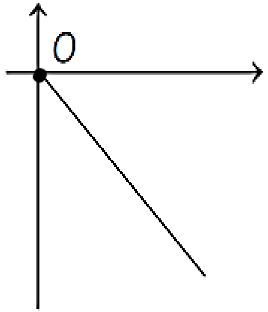
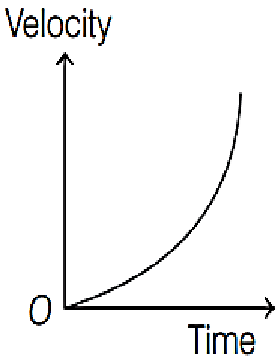
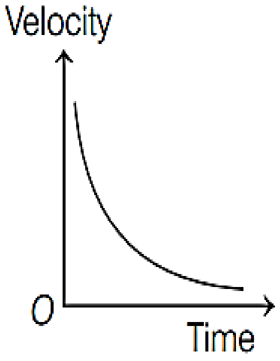
$$\frac{\text{change in } y\text{-coordinate}}{\text{" " } x\text{-coordinate}}$$

Slope gives speed/velocity.

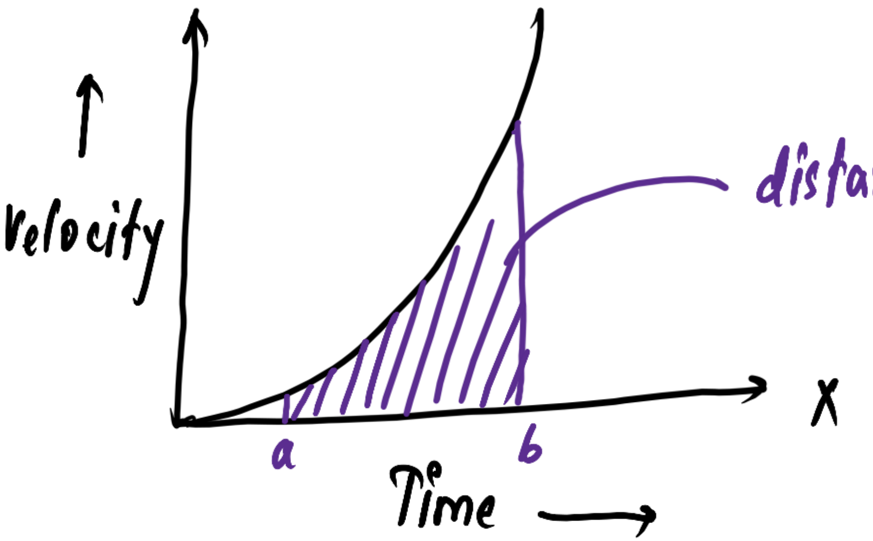
Body moving with a constant retardation	
Body moving with infinite velocity. But such motion of a body is never possible.	

VELOCITY -TIME GRAPHS

Slope gives acceleration. Area gives distance covered.

Condition	Graph
Moving with a constant velocity	
Moving with a constant acceleration having zero initial velocity	
Body moving with a constant retardation and its initial velocity is not zero	
Moving with a constant retardation with zero initial velocity	
Moving with increasing acceleration	
Moving with decreasing acceleration	

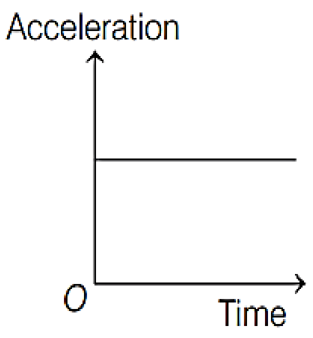
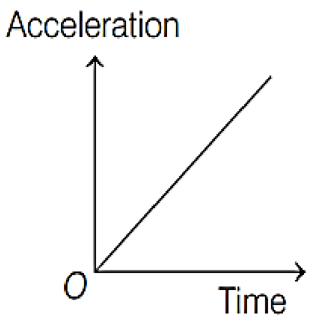
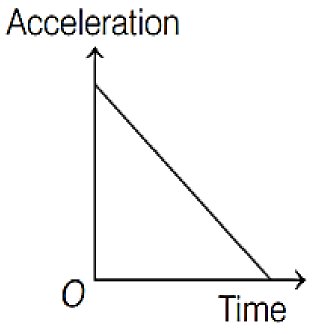
slope = constant ⇒ straight line



distance covered between time 'a' and 'b'.

area under the curve for v-t graph = Total distance covered

ACCELERATION -TIME GRAPHS

Condition	Graph
When object is moving with constant acceleration	
When object is moving with constant increasing acceleration	
When object is moving with constant decreasing acceleration	

EQUATIONS OF UNIFORMLY ACCELERATED MOTION

If a body starts with velocity (u) and after time t its velocity changes to v, if the uniform acceleration is a and the distance travelled in time t is s, then the following relations are obtained, which are called equations of uniformly accelerated motion.

(i) $v = u + at$ ✓ (ii) $s = ut + \frac{1}{2}at^2$ ✓

(iii) $v^2 = u^2 + 2as$ ✓

(iv) Distance travelled in nth second.

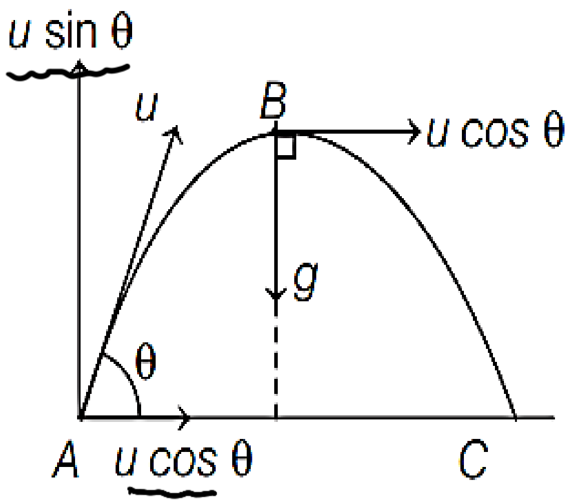
$$s_n = u + \frac{a}{2}(2n - 1)$$

- For free fall under gravity , use a = g (Accleration due to gravity),
- For a body thrown upwards , use a = - g

PROJECTILE MOTION

- **When any object is thrown from horizontal at an angle θ, then it moves on a parabolic path , the object is called projectile and its motion is called projectile motion.**

If any object is thrown with velocity u, making an angle θ, from horizontal, then



PROJECTILE MOTION

Time of flight It is defined as the total time for which the projectile remains in air.

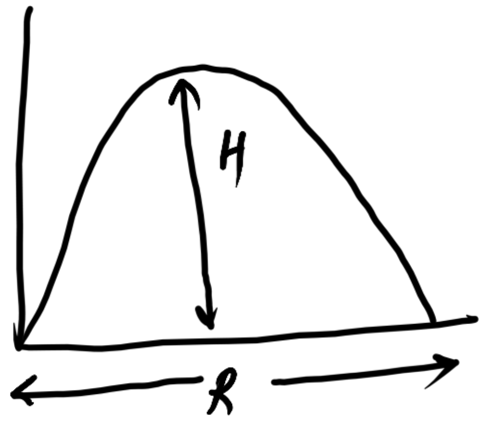
$$T = \frac{2u \sin\theta}{g}$$ ✓

Maximum height It is defined as the maximum vertical height covered by projectile.

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

Horizontal range It is defined as the maximum distance covered in horizontal distance.

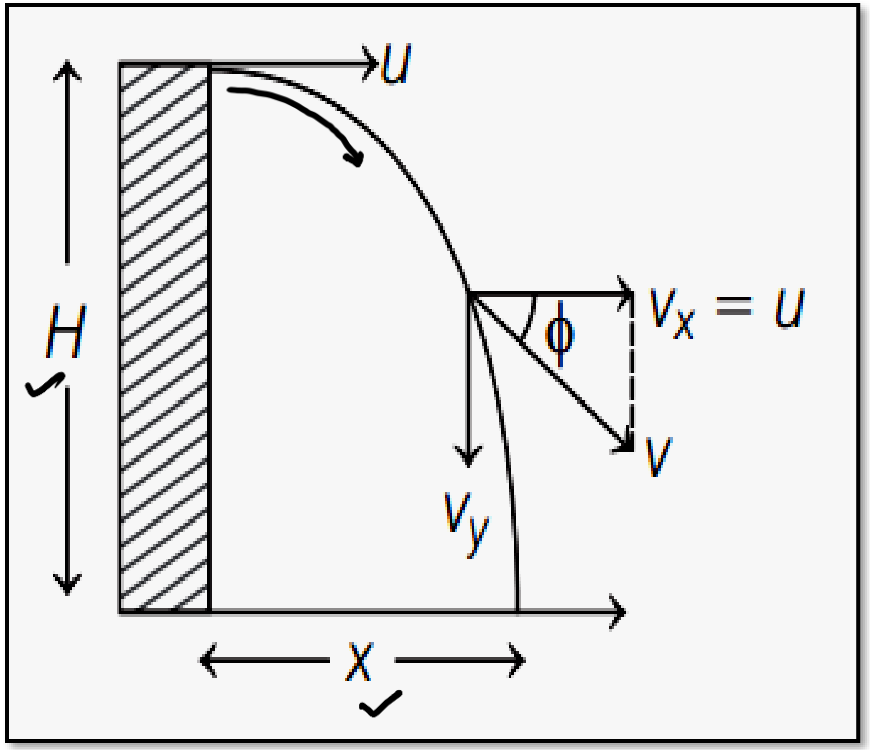
$$R = \frac{u^2 \sin 2\theta}{g}$$



$\sin 2\theta = 1$

$2\theta = 90^\circ \Rightarrow \theta = 45^\circ$

PROJECTILE PROJECTED FROM SOME HEIGHT

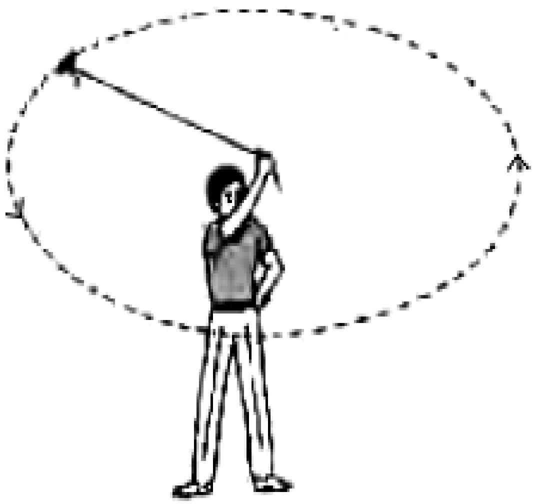


Time of flight, $T = \sqrt{\frac{2H}{g}}$

Horizontal range, $x = uT = u\sqrt{\frac{2H}{g}}$

UNIFORM CIRCULAR MOTION (UCM)

- **If the magnitude of the velocity of the particle in circular motion remains constant, then it is called uniform circular motion.**



TERMS ASSOCIATED

1. **Angular Displacement :**

$$\text{Angular displacement } (\Delta\theta) = \frac{\Delta s}{r}$$

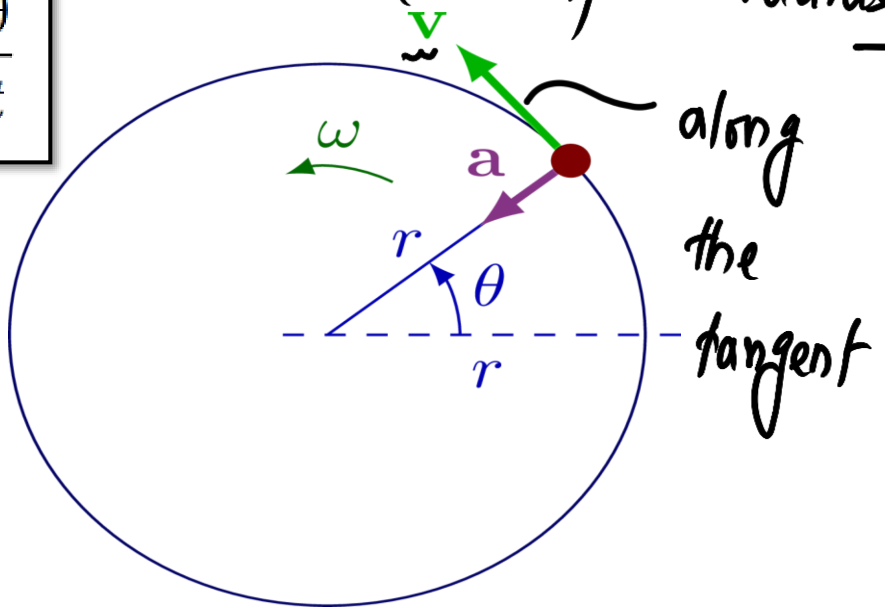
Its SI unit is radian(rad).

angle (radian) = arc length / radius

2. **Angular Velocity :**

$$\text{Angular velocity } (\omega) = \frac{\Delta\theta}{\Delta t}$$

Its Unit is rad/s.



TERMS ASSOCIATED

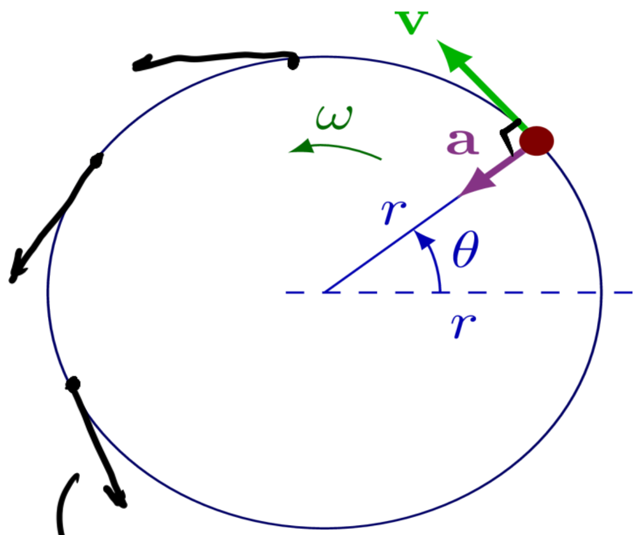
3. <u>Centripetal Acceleration :</u> In circular motion, an acceleration acts on the body, whose direction is always towards the centre of the path. This acceleration is called centripetal acceleration.

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

$(s = r\theta)$

$v = r\omega$

$$a = \frac{r^2\omega^2}{r} = r\omega^2$$

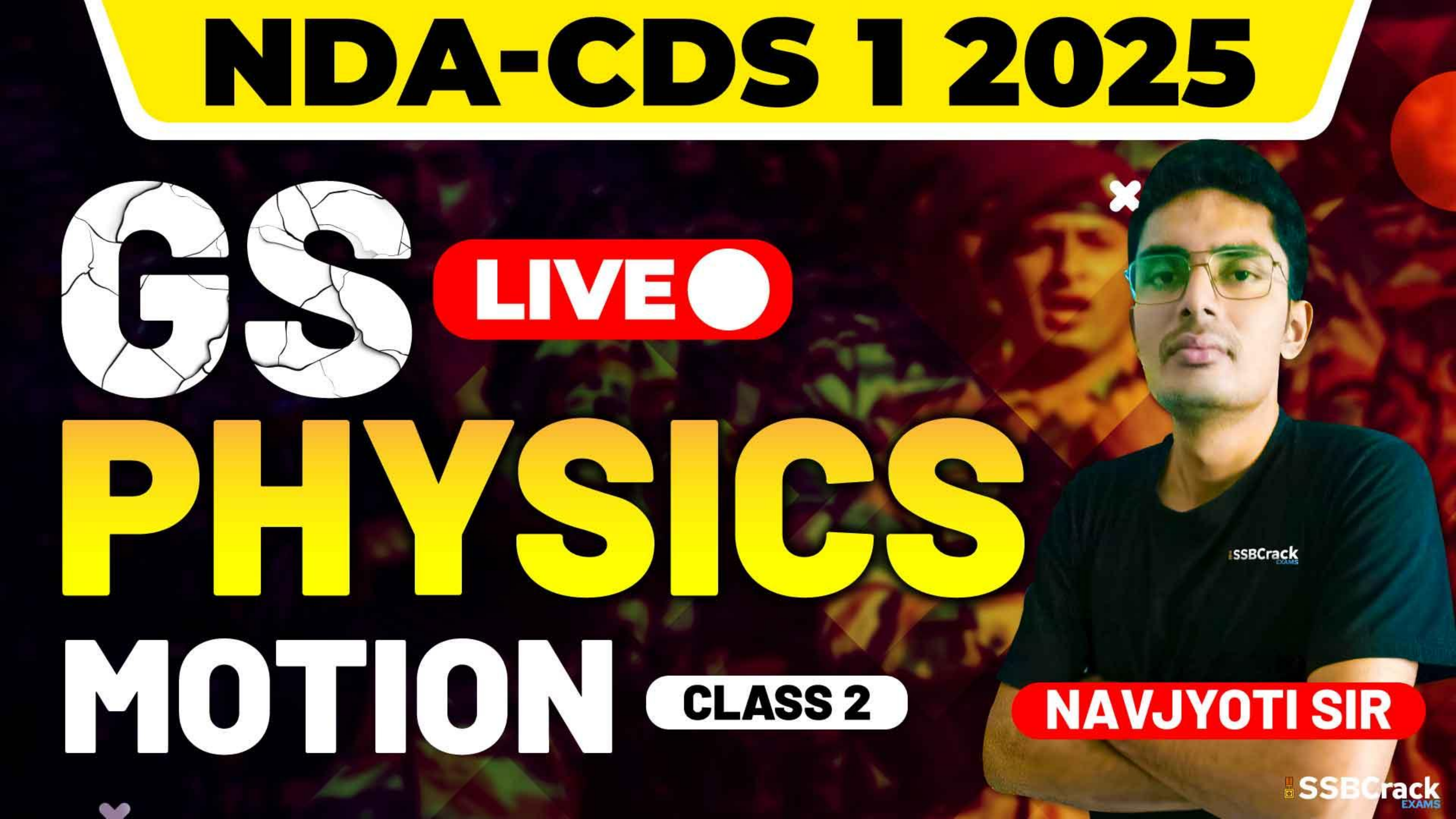


direction of $\vec{v}$ is changing at every point.

So, velocity is not constant for UCM, and so is acceleration.

SUMMARY

- Scalars and Vectors
- Motion and Terms associated
- Graphs showing motion (s – t , v - t , a - t)
- Equations for Uniformly accelerated motion
- Projectile Motion and Formulas
- Uniform Circular Motion and Terms Associated


NDA-CDS 1 2025
GS
LIVE
PHYSICS
MOTION
CLASS 2
SSBCrack
NAVJYOTI SIR
SSBCrack EXAMS