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MOTION

- Motion is a change of position it can be described in terms of the distance moved or the displacement.
- When a body does not change its position, with respect to its surroundings, it is said to be at rest. When a body changes its position, with respect to its surroundings, it is said to be in motion.
- The motion of an object could be uniform or non-uniform depending on whether its velocity is constant or changing.
- **Uniform motion:** An object is said to be in uniform motion if it covers equal distances in equal intervals of time howsoever big or small these time intervals may be.
- **Non-uniform motion:** An object is said to be in non-uniform motion if it covers unequal distances in equal intervals of time.

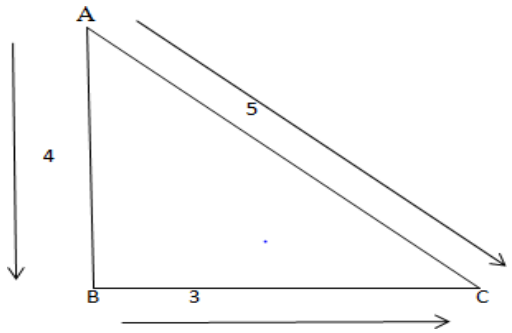
Scalar and Vector

SCALAR	VECTOR
A scalar is a quantity with magnitude only.	A vector is a quantity with the magnitude as well as direction.
Examples are Length, Area, Distance, Speed, Mass, Density, Pressure, etc.	Examples are Displacement, Velocity, Acceleration, momentum, Force.

Distance and Displacement

- **Distance:** The actual length of the path travelled by a moving body irrespective of the direction is called the distance travelled by the body. It is measured in metre in SI system. It is a scalar quantity having magnitude only.
- **Displacement:** It is defined as the change in position of a moving body in a particular direction. It is a vector quantity having both magnitude and direction. It is also measured in metre in SI system.

DISTANCE	DISPLACEMENT
Distance of the object can be defined as the complete path travelled by on object during its motion.	Displacement of the object can be defined as the overall motion of the object or minimum distance between the starting point of the object and the final position of the object.
Distance is a scalar quantity.	Displacement is a vector quantity.
Distance of the any object does not depend on the direction of its motion.	Displacement of the any object depends on the direction of its motion.



- **Distance** refers to how much ground an object has covered during its motion (A ⟶ B ⟶ C)
  Distance = 4 + 3 = 7
- **Displacement** to refers to 'how far out of place an object is' (A⟶C)
  Displacement = 5
- **Distance** gives the complete information about the path travelled by the object.
- **Displacement** does not give the complete information about the path travelled by the object.

Speed, Velocity and Acceleration

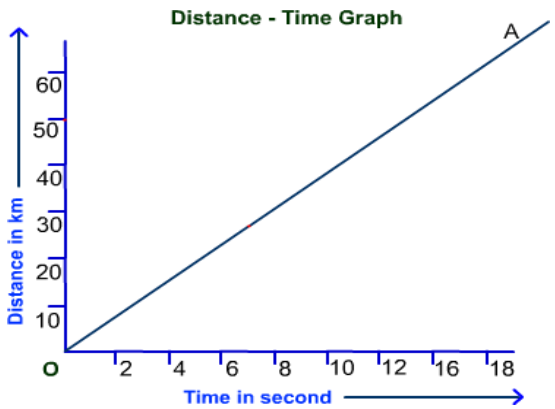
- **Speed:** Speed is the rate of change of distance or the distance travelled in unit time.
  Speed = Distance travelled / Time
  Speed is a scalar quantity and its unit is m/s
- **Velocity:** Velocity is the rate of change of displacement. It is the displacement in unit time.
  Velocity = Displacement / Time
  Velocity is a vector quantity and its unit is m/s
- During **uniform motion** of an object along a straight line, the velocity remains constant with time. In this case, the change in velocity of the object for any time interval is zero.
- During **non-uniform motion**, velocity varies with time. It has different values at different instants and at different points of the path. Thus, the change in velocity of the object during any time interval is not zero. This phenomenon is called acceleration.
- **Acceleration:** Acceleration of an object is the change in velocity per unit time.
  Unit of acceleration is m/s^2
- Acceleration is vector quantity:
  Acceleration = Change in velocity/Time
  Acceleration = (Final velocity – Initial velocity)/Time
  $a = (v - u) / t$

From the above equation:

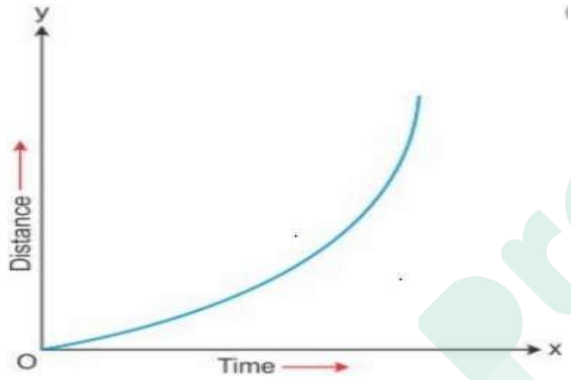
- If $v > u$, i.e., if final velocity is greater than initial velocity, the velocity increases with time and the value of acceleration is positive.
- If $v < u$, i.e., if final velocity is less than initial velocity, the velocity decreases with time and the value of acceleration is negative. It is called negative acceleration. Negative acceleration is called retardation or deceleration.

Graphical Representation of Motion

The distance – time graph for Uniform motion

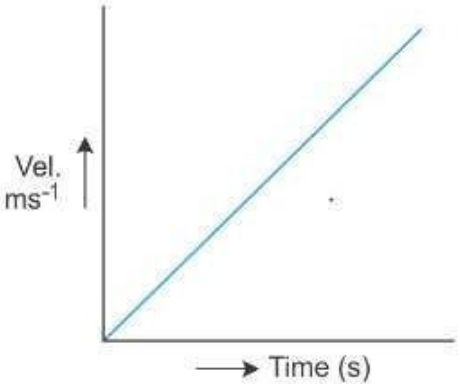


The distance time graph for non-uniform motion



Velocity-time graph for a body having uniform acceleration

- The nature of the graph shows that velocity changes by equal amounts in equal intervals of time. Thus, for all uniformly accelerated motion, the velocity-time graph is a straight line.
- In the case of non-uniformly accelerated motion, velocity-time graphs can have any shape.



Equations of Motion

When an object moves along a straight line with uniform acceleration, it is possible to relate its velocity, acceleration during motion and the distance covered by it in a certain time interval by a set of equations known as the equations of motion. Such equations are:

$v = u + at$

$s = ut + \frac{1}{2} at^2$

$2as = v^2 - u^2$

Where, u - is the initial velocity

v - is the initial velocity

a - Acceleration

s - Displacement

t - Time of motion

Motion Of Freely Falling Body

- When all objects are dropped in the absence of air medium (vacuum), all would have reached the ground at the same time.
- In air medium, air offers some resistance to the motion of freely falling objects. But it is negligibly small when compared to the gravitational pull. Hence, they reach the ground at the same time.
- All objects experiences acceleration during free fall. This acceleration experienced by an object is independent of mass. This means that all objects hollow or solid, big or small, should fall at the same rate.
- The equation of motion for a freely falling body can be obtained by replacing 'a' in equations with g, the acceleration due to gravity. For a freely falling body which is initially at rest, u = 0. Thus, we get the following equations.

  $v = gt$

  $s = \frac{1}{2} gt^2$

  $v^2 = 2gh$
- When we throw an object vertically upwards, it moves against the acceleration due to gravity. Hence, 'a' is taken to be –g and when moving downwards 'a' is taken as +g.

Uniform Circular Motion

- If an object moves in a circular path with uniform speed, its motion is called uniform circular motion.
- There are many more familiar examples of objects moving under uniform circular motion, such as the motion of the moon and the earth, a satellite in a circular orbit around the earth, a cyclist on a circular track at constant speed and so on.

Important points

- The state of motion of an object is described by its speed and the direction of motion. The state of rest is considered to be the state of zero speed. An object may be at rest or in motion, both are its states of motion.
- When a body is thrown vertically upwards in space, at the highest point, the body has zero velocity but it has acceleration due to the gravity.