Board – CBSE	Class – 9th	Topic – Motion

1. Motion (Uniform Motion And Non-Uniform Motion, Acceleration and Velocity) :
   - A particle is a point-like object, has mass but is of infinitesimal size.
   - The object's position is its location with respect to a chosen reference point.
   - Motion occurs when an object changes its position. Both **Distance** and **Time** are important in describing motion.
   - Sometimes you know motion has occurred even if you didn't see it happen. (Mail truck)
   - Relative motion: when two objects are moving in a plane (either in the same direction or opposite), each has a relative motion with respect to the second. E.g. a person sitting in a train and watching a tree; in this case, the tree is stable but assumed to be moving with respect to the train.
2. Distance vs Displacement
   - Distance: How far an object has moved. It has only magnitude without direction. (total)
   - Displacement: How far and in what direction an object has moved from its start position. i.e. the direct distance between two points. Speed
3. Speed:

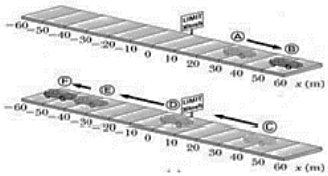
$$Speed = \frac{distance}{time}$$

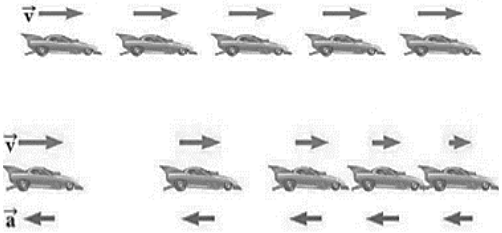
   - Speed = the distance an object travels in a given amount of time
   - SI unit of speed is m/s
4. Types of Speed
   - Constant speed: speed doesn't change (set your car on cruise control)
   - Changing speed: Riding a bike for 5 km. Take off and increase speed, slow down uphill, speed up downhill, stop for a stop sign. The trip took you $15min(.25\ h)$
   - Average speed = $\frac{Total\ distance}{Total\ time}$
   - **Instantaneous speed:** the speed at any given time.

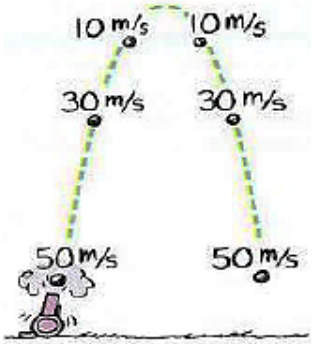
5. Velocity:
   - Velocity: includes speed and direction
   - Suppose two trains go at the same speed in the opposite direction, so they have different velocities.
   - A racecar going around an oval track might have a constant speed but different velocities at each point.
6. Acceleration :
   - Any change in velocity over a period of time is called acceleration.
   - The sign (+ or −) indicates its direction.
   - The sign shows the acceleration, and the - sign shows de-acceleration.
   - Uniform (constant) acceleration equation $a = \frac{v}{t}$
   - Images of the car are equally spaced.
   - The car is moving with constant positive velocity (shown by red arrows maintaining the same size).
   - The acceleration equals zero
   - Images of cars become farther apart as time increase
   - Velocity and acceleration are in the same direction.
   - Acceleration is uniform (Arrows below the car maintain the same length)
   - Velocity is increasing (Arrows above the car are getting longer)
   - This shows positive acceleration and positive velocity

     The instant speed at points of equal elevations is the same.

     The velocities are different because they are in opposite







7. Free Fall & Air Resistance

Galileo Galilei, an Italian physicist and astronomer, formulated laws of motion for objects in free fall -

- A freely falling object is any object moving freely under the influence of gravity alone.
- It does not depend upon the initial motion of the object
- Dropped - released from rest
- Thrown downward
- Thrown upward
- The acceleration of an object in free fall is directed downward, regardless of the initial motion
- The magnitude of free-fall acceleration (gravitational acceleration) is

$g = 9.80\ m/s2$

- g decreases with increasing altitude

- g varies with latitude, height and depth from the earth surface.
- $9.8\ m/s^2$ is the average at the Earth's surface
- The italicized g will be used for the acceleration due to gravity
- Not to be confused with g for grams
- With negligible air resistance, falling objects can be considered freely falling objects of different shapes accelerate differently (stone vs feather)
- Speed both upward and downward
- The path is symmetrical.
- Acceleration is constant.
- The magnitude of the velocities is the same at equal heights.
- Images become closer together as time increases
- Acceleration and velocity are in opposite directions when the ball goes upward.
- Acceleration is uniform (violet arrows maintain the same length)
- Velocity is decreasing in an upward motion (red arrows are getting shorter)
- Positive velocity and negative acceleration
- Velocity becomes zero at maximum height.
- Time duration flight in going upward and coming back is always the same.

8. Equation of motion :

(1) When an object is moving in a straight line-

- $v = v_0 + at$
- $x = x_0 + v_0 t + \frac{1}{2}at^2$
- $v^2 = v_0^2 + 2a(\Delta x)$

Average acceleration describes how fast the velocity is changing with respect to time.

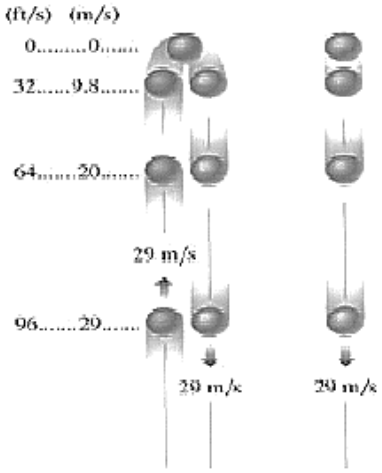
$$a_{ave} = \frac{\Delta v}{\Delta t} = \frac{\Delta\left(\frac{\Delta x}{\Delta t}\right)}{\Delta t}$$

a_{ave} = average acceleration

Δv = change in velocity

Δx = displacement

Δt = elapsed time



(2) When an object is coming vertically downward-

- $v = v_0 + gt$
- $h = v_0 t + \frac{1}{2} g t^2 \, s$
- $v^2 = v_0^2 + 2ah$

(3) When an object is coming vertically upward-

- $v = v_0 - gt$
- $h = v_0 t + \frac{1}{2} g t^2$
- $v^2 = v_0^2 + 2gh$
- The SI unit of velocity is the m/s.
- Average acceleration is + or - depending on direction.

Instantaneous Acceleration

$$a = \lim_{t \to \infty} \left(\frac{\Delta v}{\Delta t} \right)$$

- Instantaneous acceleration is the limit of $\Delta v / \Delta t$ as Δt approaches zero.
- Instantaneous acceleration is zero where the slope is constant

- Instantaneous acceleration is positive where the curve is concave up
- Instantaneous acceleration is negative where the curve is concave down

(4) Uniform Circular Motion

In this kind of motion, the object moves on the circle at a fixed speed. Still, the direction is changed by time, so the velocity of the change so its called acceleration motion. This acceleration is called centrifugal acceleration. It is directed toward the centre.