🏃 Chapter 7: Motion – Complete Notes (NCERT based)

◆ 1. What is Motion?

Motion is the change in position of an object with respect to time. It is relative – an object may be in motion for one observer but at rest for another.

- **Example 1:** Passengers in a moving bus see roadside trees moving backwards, but for a person outside, the bus is moving.
- **Example 2:** We feel the Earth is at rest, but it rotates and orbits the Sun. An astronaut sees Earth's motion.

> ***Activity 7.1 (NCERT):*** *Discuss whether the walls of your classroom are at rest or in motion. (Think: relative to Earth? relative to Sun?)*

> ***Activity 7.2:*** *Have you ever experienced that the train you are sitting in appears to move while it is at rest? Share your experience.*

◆ 2. Describing Motion – Reference Point

To describe the position of an object we need a reference point (origin). For example: "School is 2 km north of the railway station" – the railway station is the reference point.

Motion along a straight line: The simplest type. Consider an object moving from O (reference) to A, then back to B and C. (Fig. 7.1)

O ----- B ----- C ----- A

(O = 0, A = 60 km, C = 35 km from O, B somewhere in between)

◆ 3. Distance and Displacement

- **Distance:** Actual path length covered (scalar).
- **Displacement:** Shortest distance from initial to final position (vector).
- SI unit: metre (m) for both.
- Distance ≥ |displacement|. Displacement can be zero even when distance > 0 (e.g., round trip).
- Example: From O to A (60 km) and back to C (35 km from O): distance = 95 km, displacement = 35 km.

> **Question 1 (NCERT):** An object has moved through a distance. Can it have zero displacement? If yes, support with an example.
> ✅ *Yes, if the object returns to its starting point (e.g., a circular lap).*

> ***Activity 7.3:*** *Walk from one corner of a basketball court to the opposite corner along the sides. Measure distance and displacement – they will differ.*

> ***Activity 7.4 (Odometer):*** *A car driven from Bhubaneshwar to New Delhi shows 1850 km on odometer. The displacement (straight line) will be less – check a road map.*

◆ 4. Uniform and Non-Uniform Motion

- **Uniform motion:** Covers equal distances in equal intervals of time (straight line path).
- **Non-uniform motion:** Covers unequal distances in equal intervals of time.

Table 7.1 (NCERT): Motion of objects A and B

Time	Distance (A) in m	Distance (B) in m
9:30 am	10	12

9:45 am	20	19
10:00 am	30	23
10:15 am	40	35
10:30 am	50	37
10:45 am	60	41
11:00 am	70	44

A moves uniformly (10 m every 15 min), B moves non-uniformly.

◆ 5. Speed and Velocity

- **Speed** = distance/time (scalar). SI unit: m/s.
- **Velocity** = displacement/time (vector). SI unit: m/s.
- **Average speed** = total distance / total time.
- **Average velocity** = total displacement / total time. For uniform acceleration, average velocity = (u + v)/2.
- **Instantaneous speed/velocity** = speed/velocity at a particular instant.

Example 7.1: Object travels 16 m in 4 s, then another 16 m in 2 s. Average speed = (32 m)/(6 s) = 5.33 m/s.

Example 7.2: Odometer reads 2000 km at start, 2400 km after 8 h. Average speed = 400 km/8 h = 50 km/h = 13.9 m/s.

Example 7.3: Usha swims 180 m in a 90 m pool (to other end and back) in 1 min. Average speed = 3 m/s, average velocity = 0 (displacement zero).

> ***Activity 7.6:*** *Measure time to walk from home to bus stop. Estimate distance using average walking speed ≈ 4 km/h.*

> ***Think & Act (lightning):*** *Time between lightning and thunder gives distance. Speed of sound = 346 m/s.*

◆ 6. Acceleration

Acceleration = change in velocity / time taken. $a = (v - u)/t$. SI unit: m/s^2.

- **Positive acceleration** → velocity increases.
- **Negative acceleration (deceleration)** → velocity decreases.
- **Uniform acceleration** → velocity changes by equal amounts in equal time intervals (e.g., free fall).
- **Non-uniform acceleration** → velocity changes at non-uniform rate.

> **Example 7.4:** Rahul starts from rest, reaches 6 m/s in 30 s → $a = 0.2$ m/s^2. Then brakes reduce speed to 4 m/s in 5 s → $a = -0.4$ m/s^2.

> ***Activity 7.8:*** *Identify everyday examples of acceleration in direction of motion, against motion, uniform, non-uniform.*

◆ 7. Graphical Representation of Motion

Distance–Time Graphs (time on x-axis, distance on y-axis)

- Uniform speed → straight line (slope = speed).
- Non-uniform speed → curve.
- Object at rest → line parallel to time axis.

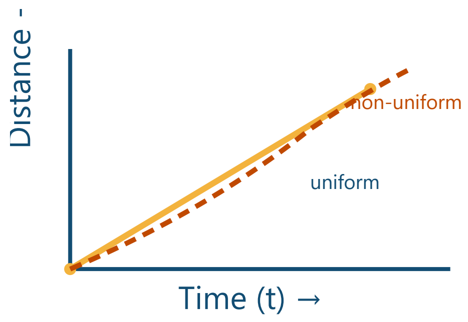
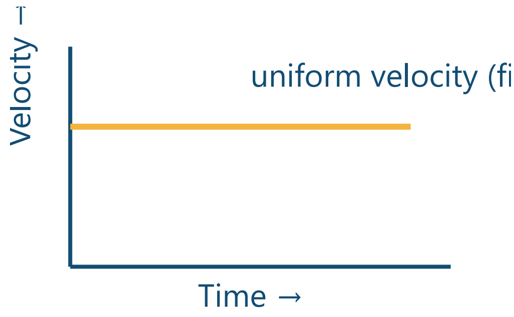


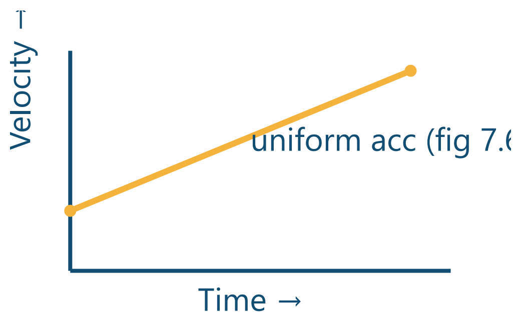
Fig 7.3 & 7.4: Distance–time graphs

Velocity–Time Graphs (time on x-axis, velocity on y-axis)

- Uniform velocity → straight line parallel to time axis (slope = 0). Area under graph = displacement.
- Uniform acceleration → straight line with slope = acceleration.
- Non-uniform acceleration → curved line.



Uniform velocity – area gives displacement



Uniform acceleration – slope = a, area = displacement

Table 7.2 (NCERT): Car with non-uniform speed

Time (s)	0	2	4	6	8	10	12	14	16
Distance (m)	0	1	4	9	16	25	36	49	64

Table 7.3: Velocity of a car at regular instants (uniform acceleration)

Time (s)	0	5	10	15	20	25	30
Velocity (m/s)	0	2.5	5.0	7.5	10.0	12.5	15.0

Activity 7.9: *Plot distance–time graph for train from Table 7.4 (stations A, B, C with times). Interpret uniform motion between stations.*

Activity 7.10: *Plot distance–time graph for Feroz and Sania (Table 7.5) – see who is faster.*

◆ 8. Equations of Motion (Uniform Acceleration)

1. $v = u + at$ (velocity–time relation)

2. $s = ut + \frac{1}{2}at^2$ (position–time relation)

3. $v^2 = u^2 + 2as$ (position–velocity relation)

where u = initial velocity, v = final velocity, a = uniform acceleration, t = time, s = displacement.

Example 7.5: Train starts from rest, attains 72 km/h (20 m/s) in 5 min (300 s). a = (20-0)/300 = 1/15 m/s^2. Distance s = $v^2/2a$ = 400 / (2/15) = 3000 m = 3 km.

Example 7.6: Car accelerates from 18 km/h (5 m/s) to 36 km/h (10 m/s) in 5 s. $a = (10-5)/5 = 1\ m/s^2$. $s = 5\times5 + ½\times1\times25 = 25 + 12.5 = 37.5$ m.

Example 7.7: Brakes produce $a = -6\ m/s^2$, car stops in 2 s. u = ? $v=0 \Rightarrow 0 = u + (-6)\times2 \Rightarrow u = 12$ m/s. $s = 12\times2 + ½\times(-6)\times4 = 24 -12 = 12$ m.

◆ 9. Uniform Circular Motion

When an object moves in a circular path with constant speed, its velocity changes due to change in direction → accelerated motion.

- Circumference = $2\pi r$
- Speed $v = (2\pi r)/t$, where t is time for one round.

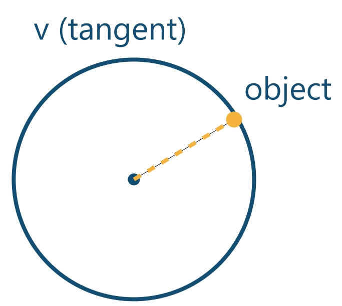


Fig 7.9: Circular motion – velocity tangential

Activity 7.11: *Tie a stone to a thread and rotate in circle. Release – stone flies off tangentially. Shows direction changes at every point.*

Examples: Athlete on circular track, moon around earth, satellite in orbit.

◆ Summary – Key Points

- Motion is change of position; described by distance or displacement.

- Uniform motion → constant velocity; non-uniform → changing velocity.
- Speed = distance/time; velocity = displacement/time (vector).
- Acceleration = (v-u)/t. Positive if velocity increases, negative if decreases.
- Graphs: distance–time (slope = speed), velocity–time (slope = acceleration, area = displacement).
- Equations of motion for uniform acceleration: $v = u+at$, $s = ut+\frac{1}{2}at^2$, $v^2 = u^2+2as$.
- Uniform circular motion – constant speed, changing velocity (direction).

◆ Practice Questions (NCERT Exercises)

1. An athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and displacement at the end of 2 min 20 s?

2. Joseph jogs from A to B (300 m) in 2 min 30 s, then back to C (100 m from B) in 1 min. Find average speed and velocity (a) A→B, (b) A→C.

3. Abdul drives to school at 20 km/h and returns at 30 km/h. Average speed for whole trip? (Hint: not 25)

4. Motorboat accelerates from rest at 3 m/s^2 for 8 s. How far does it travel?

5. A driver applies brakes and the car stops in 5 s. The velocity–time graph is given. Find distance travelled (shade area). Which part represents uniform motion?

6. Fig 7.10 shows distance–time graph of three objects A, B, C. Answer questions on speed and acceleration.

7. Ball dropped from 20 m, accelerates uniformly at 10 m/s^2. With what velocity does it strike ground? Time?

8. Speed–time graph for a car (Fig 7.11). Find distance in first 4 s. Which part shows uniform motion?

9. State possible situations: (a) constant acceleration but zero velocity, (b) acceleration with uniform speed, (c) acceleration perpendicular to direction.

10. Artificial satellite in circular orbit radius 42250 km, takes 24 h. Find speed.