Class 9 Science Chapter 7: Motion (Detailed Notes with Practice Questions and Numericals)

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1. Introduction to Motion

- **Motion**: Change in the position of an object with respect to a reference point.
    - **Examples**: A bird flying in the sky, a car moving on a road, planets revolving around the sun.

Practice Questions:

1. Define motion. Provide two real-life examples.
2. Can an object appear to be in motion to one person and at rest to another? Explain with an example.
3. Explain how you can infer the motion of air without seeing it.

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2. Types of Motion

- **Uniform Motion**: An object covers equal distances in equal intervals of time.
    - **Example**: A car moving at a constant speed of 60 km/h.
    - **Graph**: A straight line in the distance-time graph.
- **Non-Uniform Motion**: An object covers unequal distances in equal intervals of time.
    - **Example**: A car slowing down or speeding up in traffic.
    - **Graph**: A curved line in the distance-time graph.

Practice Questions:

1. Differentiate between uniform and non-uniform motion with examples.
2. Sketch a distance-time graph for both uniform and non-uniform motion.
3. A bus covers 40 km in the first hour and 60 km in the second hour. Is this motion uniform or non-uniform? Justify.

3. Distance and Displacement

- **Distance**: Total path covered by an object, irrespective of direction.
  - **Example**: If a person walks 4 km east and then 3 km west, the distance is 7 km.
- **Displacement**: Shortest distance between the initial and final position, considering direction.
  - **Example**: If a person walks 4 km east and then 3 km west, the displacement is 1 km east.

Practice Questions:

1. Can displacement be zero even if distance is non-zero? Give an example.
2. A farmer walks around the boundary of a square field of side 100 m. What is his displacement after completing one round?
3. Is displacement always less than or equal to the distance? Explain with an example.

Numerical Problems:

1. A cyclist rides 5 km east, then 3 km north, and finally 2 km west. Calculate the total distance traveled and the displacement.
2. A car moves 100 m east, 50 m north, and 100 m west. Calculate its total distance and displacement.

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4. Speed, Velocity, and Average Speed

- **Speed**: The rate at which an object covers distance. Formula:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

  - **SI Unit**: m/s or km/h.
- **Velocity**: Speed with direction. Velocity is a vector quantity.
  - **Example**: A car moving at 60 km/h towards the north.

- **Average Speed**: The total distance covered divided by the total time taken.
  - Formula:

$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

Practice Questions:

1. A car covers 100 km in 2 hours. What is its speed?
2. A person travels 40 km east in 2 hours and then 20 km west in 1 hour. Find the average speed and average velocity.
3. Explain the difference between speed and velocity with examples.

Numerical Problems:

1. A car travels 120 km in 3 hours and another 60 km in 2 hours. Calculate the average speed of the car.
2. A man walks 5 km in 1 hour and another 10 km in 2 hours. What is his average speed?

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5. Acceleration

- **Acceleration**: The rate of change of velocity per unit time.
  Formula:

$$a = \frac{v - u}{t}$$

  Where:

  - a = acceleration,
  - v = final velocity,
  - u = initial velocity,
  - t = time.
  - **SI Unit**: m/s².

Practice Questions:

1. A car accelerates from 0 to 30 m/s in 10 seconds. Calculate its acceleration.
2. A bike reduces its speed from 20 m/s to 5 m/s in 5 seconds. What is its acceleration?
3. Define uniform and non-uniform acceleration with examples.

Numerical Problems:

1. A car accelerates uniformly from 10 m/s to 30 m/s in 5 seconds. Calculate the acceleration and the distance covered during this time.
2. A train starts from rest and accelerates uniformly at 2 m/s^2. How much distance will it cover in 10 seconds?

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6. Graphical Representation of Motion

- **Distance-Time Graph**: Shows the distance covered by an object over time.
  - **For uniform motion**: The graph is a straight line.
  - **For non-uniform motion**: The graph is a curve.
- **Velocity-Time Graph**: Shows the velocity of an object over time.
  - **For uniform velocity**: The graph is a straight line parallel to the time axis.
  - **For accelerated motion**: The graph is a sloped line.

Practice Questions:

1. Sketch a distance-time graph for a car moving with uniform speed.
2. What information can you get from a velocity-time graph?
3. How can you calculate the displacement of an object from a velocity-time graph?

Numerical Problems:

1. A car starts from rest and accelerates uniformly to a velocity of 20 m/s in 10 seconds. Sketch its velocity-time graph and calculate the distance covered.
2. A cyclist starts from rest and reaches a speed of 10 m/s in 5 seconds. Plot the velocity-time graph and find the acceleration.

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7. Equations of Motion

The equations of motion for uniformly accelerated motion are:

1. $v = u + at$
2. $s = ut + \frac{1}{2}at^2$
3. $v^2 = u^2 + 2as$

Where:

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

Practice Questions:

1. A car starts from rest and reaches a speed of 20 m/s in 5 seconds. Find the acceleration and the distance covered.
2. A ball is thrown upwards with an initial velocity of 15 m/s. Calculate the time it takes to reach its highest point.

Numerical Problems:

1. A motorbike accelerates from rest to a velocity of 30 m/s in 10 seconds. Calculate the acceleration and the distance traveled.
2. A car moving with an initial velocity of 15 m/s accelerates uniformly at 3 m/s² for 6 seconds. Find its final velocity and the distance covered.

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8. Uniform Circular Motion

- **Uniform Circular Motion**: Motion along a circular path with constant speed. Although the speed remains constant, the direction of motion changes continuously, leading to acceleration.
- **Formula for speed in circular motion**:

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

  Where:

  - v = speed,
  - r = radius of the circular path,
  - T = time period for one complete revolution.

Practice Questions:

1. Explain how an object moving in a circular path is accelerating even if its speed is constant.
2. Calculate the speed of an object moving in a circular path of radius 5 m, taking 10 seconds to complete one revolution.
3. Give two examples of uniform circular motion.

Numerical Problems:

1. An object moves in a circular path of radius 7 m and takes 14 seconds to complete one revolution. Calculate its speed.
2. A cyclist takes 20 seconds to complete one round of a circular track with a radius of 35 m. Find the speed of the cyclist.

Important Formulas

1. Speed:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

2. Velocity:

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

3. Acceleration:

$$a = \frac{v - u}{t}$$

4. Average Speed:

$$\text{Average Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

5. Equations of Motion:

$$v = u + at, \quad s = ut + \frac{1}{2}at^2, \quad v^2 = u^2 + 2as$$

6. Uniform Circular Motion:

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