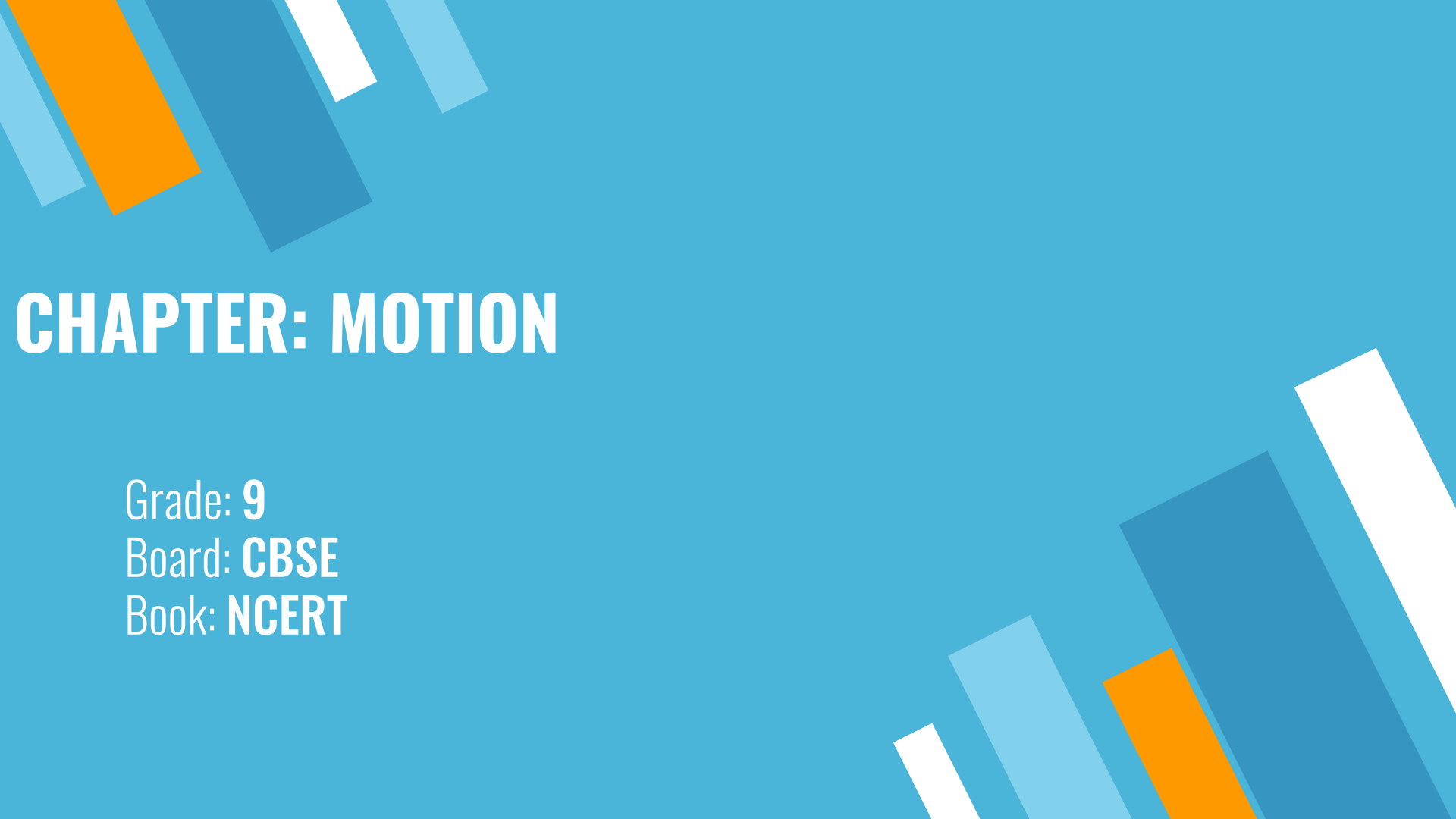


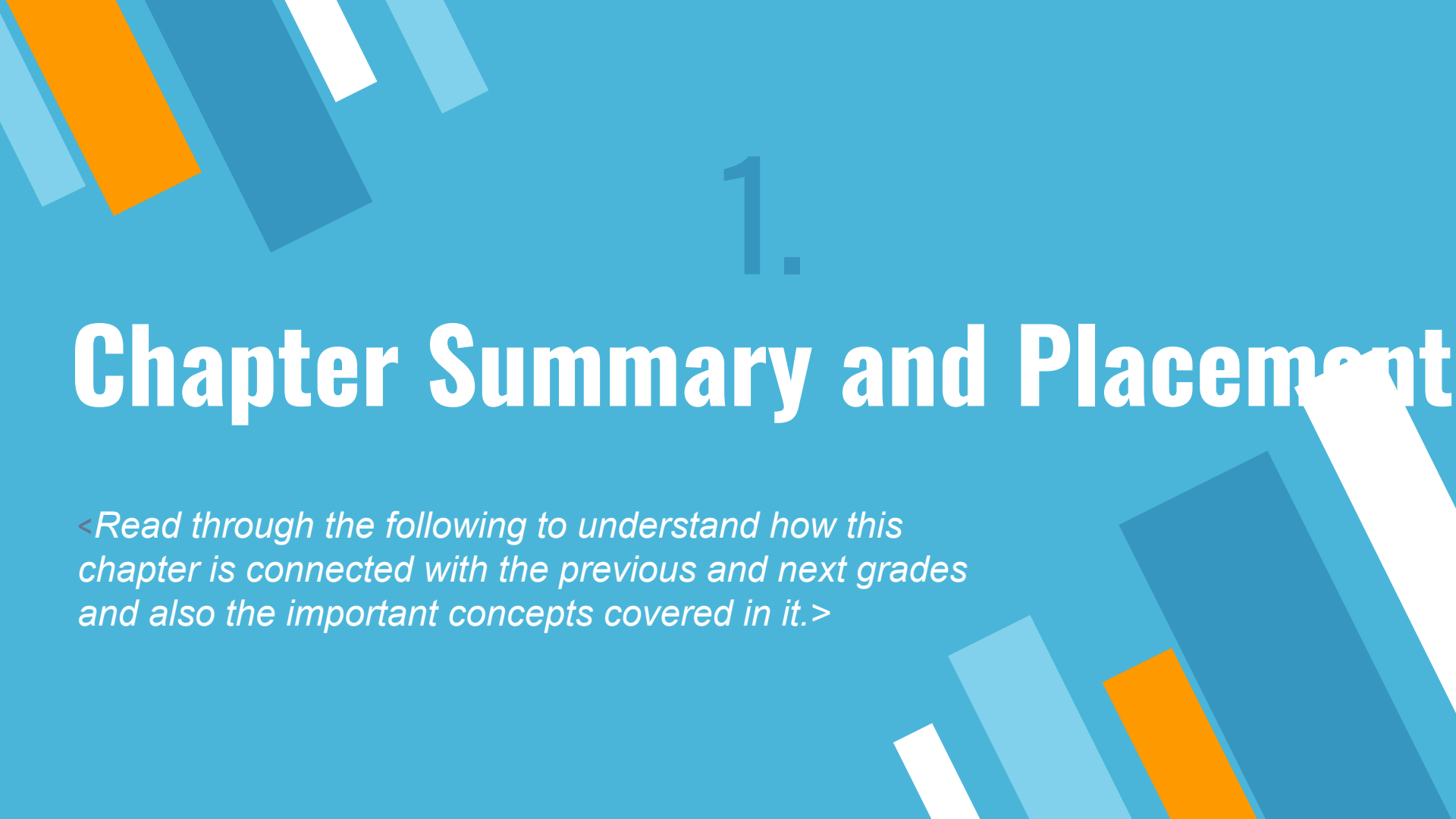


CHAPTER: MOTION

Grade: 9

Board: **CBSE**

Book: **NCERT**



1.

Chapter Summary and Placement

<Read through the following to understand how this chapter is connected with the previous and next grades and also the important concepts covered in it.>

- 
- 
1. Many objects move around us like vehicles, birds, animals, persons etc. All of these are taken as examples in this chapter to introduce the concepts of motion, types of motion, distance, displacement, speed, velocity, acceleration etc.
 2. This chapter further explains the graphical representations for different motions of the body and equations of motion.
 3. Since the central idea of the chapter is about moving bodies/objects, so the different images of objects, graphical representations and tables are used.



2.

LEARNING OUTCOMES

<On completion of the chapter, students will be able to:>



- 
- 
1. Define Motion
 2. Define the location/position of a body
 3. Define Distance and Displacement
 4. Explain Uniform and Non-uniform motion
 5. Understand the terms - speed, average speed and velocity
 6. Explain acceleration of a body
 7. Understand Distance-Time Graphs, Velocity-Time Graphs
 8. Deduce equations of motion by graphical method
 9. Explain Uniform Circular Motion



3. KEYWORDS

Definitions of some terms used in the chapter:





Motion: Change of position

Distance: Total path travelled by a body

Displacement: Shortest distance between initial and final positions of a body in a particular direction

Speed: Distance travelled per unit time

Velocity: Displacement travelled per unit time





3. TEACHING PLAN

Follow this section for getting ideas on teaching the content covered in the chapter. The subtopic given in the first column with the matching learning outcome can be explained using instructions and resources listed subsequently



Subtopic and Learning Objective #1

Describing Motion

1. Define Motion
2. Define the location/position of a body
3. Define Distance and Displacement
4. Explain Uniform and Non-uniform motion

Teacher Activity

1. Give students the example of their coming to school from home by being in motion. (Define motion.)
2. Then take the example persons sitting in a moving train. Persons inside the train are at rest for each other, but they are moving for people/objects outside the train. Similarly, the objects (tree/house) outside the train are moving for persons sitting inside while the same objects are at rest for persons outside the moving train. Refer Resource 1. (Motion is defined by a reference point.)
3. Ask the students as to what is their position in class or what is the position of their home. (To describe the position/location of an object, there is need to define a reference point/origin.)
4. Give examples of the motion of car/bike on a straight path. (Define motion along a straight line.) Refer Resource 1.
5. Define distance (total path travelled by the body) and displacement (shortest distance travelled by the body between initial and final positions.) by giving examples.

6. Perform Activity 1 to have a better understanding of distance and displacement. Differentiate between the two and refer Resource 1.
7. Show Resource 1 to students and give them explanation about uniform (Equal distances travelled in equal interval of time) and non-uniform motion (Unequal distances travelled in equal interval of time).

Check for understanding:

- a. What do you mean by motion
- b. State three examples of non-uniform motion

Resources Suggested

Pen and paper, Blackboard, Resource 1

Resource 1:



Motion requires reference



Motion along straight line

Distance	Displacement
The total path travelled by the body.	The shortest distance travelled by the body between its final and initial positions.
It can never be 0 for a moving body.	It can be 0 for a moving body.

Uniform Motion

Distance travelled (m)	5	5	5	5
Time taken (s)	1	1	1	1

Non-Uniform Motion

Distance travelled (m)	5	3	2	4
Time taken (s)	1	1	1	1

Activity 1

Name of the activity – Walk and Learn

Type of activity – Group

Use it for – clearing the meaning of term distance and displacement

Materials – pen and paper, five to six 1m ropes (you can take more if required), chalk,

Procedure –

1. Take the students to an open field/ground. Ask five students to stand at one place (somewhere in the middle) in the ground which is marked on the ground with a chalk as A.
2. Ask one student to take a round of the field and come back to the same position from where he started.
3. Ask second student to travel 20 steps in north direction, the position marked as B.
4. Ask third student to travel 50 steps in the east direction, the position marked as C.
5. Ask fourth student to travel 100 steps in west direction of the field, the position marked as D.
6. Ask the fifth student to travel 10 steps in south direction of the field, the position marked as E.
7. After this ask 5 students to measure the distance/displacement travelled by each of them.
8. After obtaining the data, ask every student to fill the observation table with the help of the data collected in the activity..

Conclude the concept of distance and displacement to all the students.

S.No.	Name of the student	Initial Position	Final Position	Calculation
1		A		Distance - Displacement -
2		A		Distance - Displacement -
3		A		Distance - Displacement -
4		A		Distance - Displacement -
5		A		Distance - Displacement -

Subtopic and Learning Objective #2

Measuring the Rate of Motion, Rate of change of velocity

1. Understand the terms - speed, average speed and velocity
2. Explain acceleration of a body

Teacher Activity

1. Tell students that they must have seen vehicles on road, some move fast others are slow. Show Resource 2.
2. To measure how fast an object moves is speed. Define speed. (Distance travelled by unit time; $\text{Speed} = \text{Distance} / \text{Time}$; It has only magnitude). Tell the unit of speed (m/s; km/h). In a journey of a vehicle, it may or may not have a uniform speed, which is why the concept of average speed arises. Define average speed. ($\text{Average speed} = \text{Total distance} / \text{Total time}$)
3. The rate of motion of an object can be described with both magnitude and direction. (velocity). Define velocity and average velocity (as the velocity may be uniform or non-uniform). Differentiate between speed and velocity as shown in Resource 2.
4. Like speed, velocity may also change (Both magnitude or/and direction). So, to express the change in velocity, there is a new term introduced (acceleration). Define acceleration (Rate of change of velocity; $\text{Acc} = \text{Change in velocity} / \text{Time}$). State the example of accelerator and breaks of a vehicle we all use to change its velocity. Unit of acc (m/s²)

5. Show the table in Resource 2 and clear the concept of uniform acceleration (Velocity increases/decreases by equal amounts in equal intervals of time.) and non-uniform acceleration (Velocity increases/decreases by unequal amounts in equal intervals of time.).

Check your Understanding

- a. A bus applies brakes and its speed decreases from 120 km/h to 50 km/h in 10 seconds. Find the acceleration of bus.
- b. Kriti runs along a racing track which is 2 km long and comes back along the same path. Find:
- The distance travelled
 - The displacement of the journey
 - Average speed
 - Average velocity

Resources Suggested

Pen and paper, Blackboard, Resource 2

Resource 2:



S.
No.

SPEED

VELOCITY

1.

It is the distance covered by the body per unit time

It is the displacement of the body
▶ per unit time

2.

Speed is a Scalar Quantity

Velocity is a Vector Quantity

3.

The average speed of a moving body can never be zero.

The average velocity of a moving body can be zero. (when Displacement = 0)

4.

Speed gives an idea about rapidity of motion of body.

Velocity gives an idea about rapidity as well as Position of body in motion.

5.

Speed of a moving body can never be negative.

Velocity of a moving body can be positive, negative or zero.
(depending on point of reference)

PG

Physics Galaxy
Videos

Uniform Motion

Initial Velocity (m/s)	0	4	8	12
Final velocity	4	8	12	16
Time taken (s)	0-1	1-2	2-3	3-4

Non-uniform Motion

Initial Velocity (m/s)	0	4	6	8
Final velocity (m/s)	4	6	8	13
Time taken (s)	0-1	1-2	2-3	3-4

Subtopic and Learning Objective #3

Graphical Representation of Motion; Equations of Motion by Graphical Method

1. Understand Distance-Time Graphs, Velocity-Time Graphs
2. Deduce equations of motion by graphical method

Teacher Activity

1. The motion of an object can be represented through line graphs. (Mention about Distance-Time; Velocity-Time)
2. Show Resource 3 (different D-T graphs; Distance in Y-axis and Time in X-axis) and explain each of them how speed can be calculated from each of them (by calculating slope). (Also explain how motion can be deduced from all these kind of graphs.
3. Then show Resource 3 (different V-T graphs; Velocity in Y-axis and Time in X-axis) and explain each of them how acceleration can be calculated from each of them (by calculating slope). (Area of the graph gives displacement of the body) Also explain how motion can be deduced from all these kind of graphs.
4. As we calculate the acceleration from the V-T graph, deduce the first equation of motion ($v = u + at$). Refer Resource 3.
5. As we calculate the distance travelled by the object from the V-T graph, deduce the second equation of motion ($S = ut + \frac{1}{2}at^2$). Refer Resource 3.

6. As we calculate the distance travelled by the object from the V-T graph, deduce the second equation of motion ($S = ut + \frac{1}{2}at^2$). Refer Resource 3.
7. While calculating the distance travelled by the object from the V-T graph, deduce the third equation of motion ($v^2 = u^2 + 2as$). Refer Resource 3.

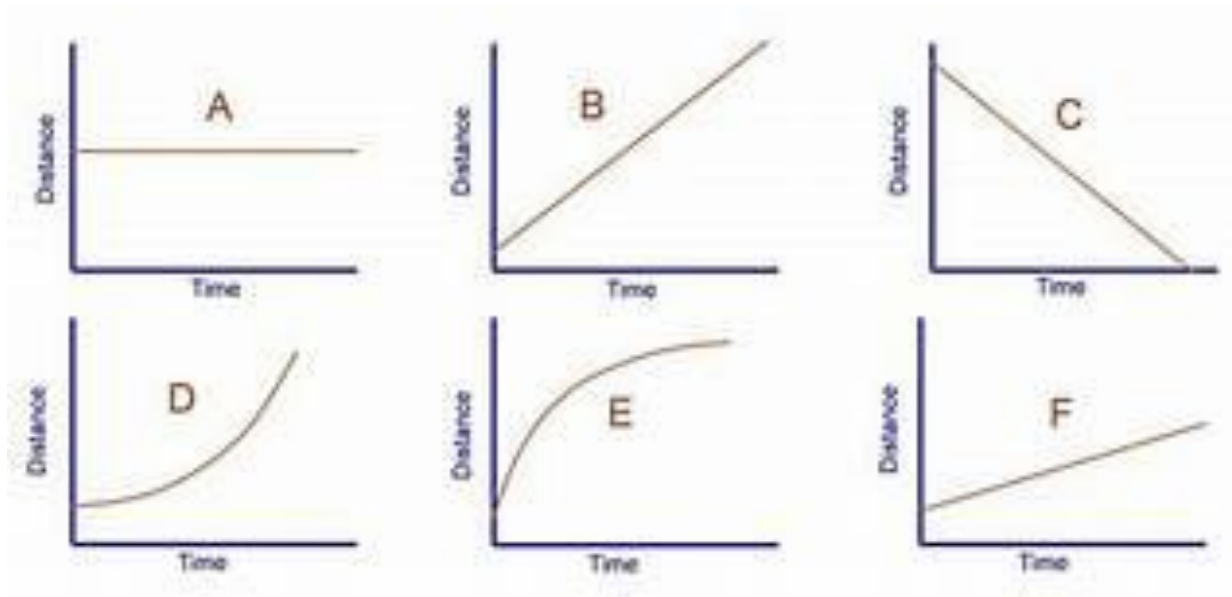
Check for understanding:

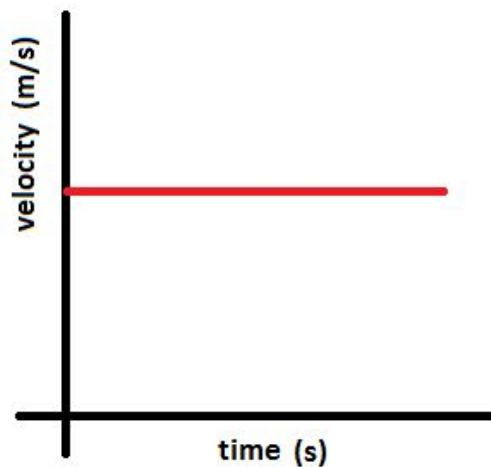
- a. Can you calculate displacement from a Velocity-Time graph? If so, then explain how?
- b. A motor bike accelerates uniformly from 10 km/h to 20 km/h in 20 seconds. Calculate the (i) acceleration (ii) the distance covered by the car in time.

Resources Suggested

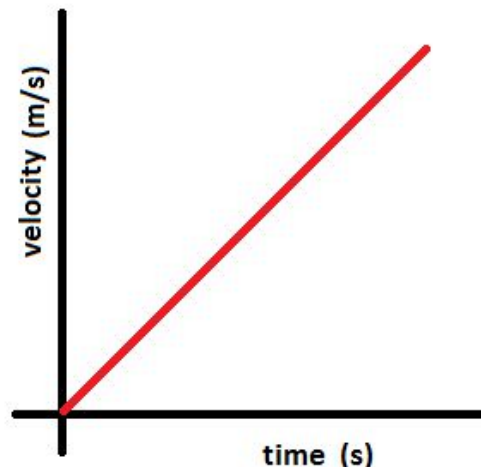
Pen and paper, Blackboard, Resource 3

Resource 3:

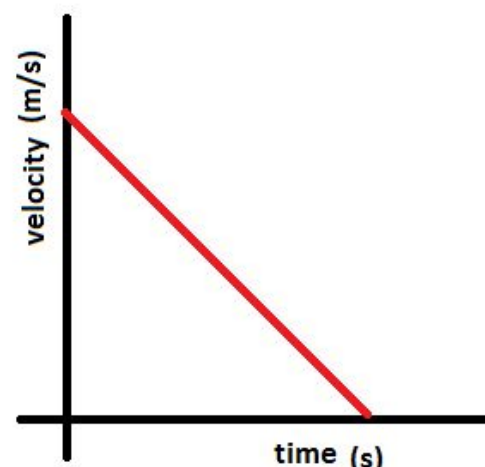




a) Velocity time graph for Uniform Motion.

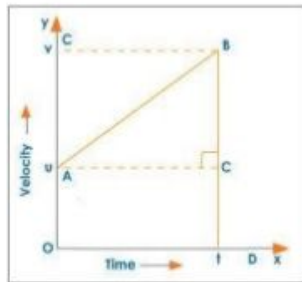


b) Velocity time graph for uniformly accelerated motion



c) Velocity time graph for uniformly retarded motion

Derivation of first equation of motion



Slope of the v - t graph gives the acceleration of the moving object.

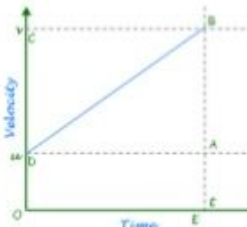
Thus, acceleration = slope = $At \frac{BC}{AC} = \frac{v - u}{t - 0}$

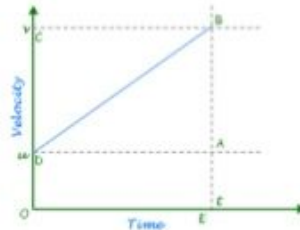
$$a = \frac{v - u}{t}$$

$$v - u = at$$

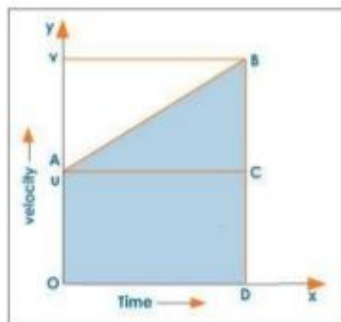
$$v = u + at$$

SECOND EQUATION OF MOTION

- Distance = area of trapezium [shown in graph]
 - Distance or $s = \frac{1}{2} (OD + BE) \times h$
 - $s = \frac{1}{2} (u + v) \times t$
 - $s = \frac{1}{2} (u + u + at) \times t$ [$v = u + at$ by 1st equation motion]
 - $s = \frac{1}{2} (2u + at) \times t$
 - $s = \frac{2ut}{2} + \frac{at^2}{2}$
 - $s = ut + \frac{1}{2} at^2$
- 



Derivation of third equation of motion



Graphical Derivation of Third Equation
S = area of the trapezium OABD.

$$\begin{aligned} &= \frac{1}{2} (b_1 + b_2) h \\ &= \frac{1}{2} (OA + BD) AC \\ &= \frac{1}{2} (u + v) t \quad \dots (1) \end{aligned}$$

But we know that $a = \frac{v - u}{t}$ Or $t = \frac{v - u}{a}$

Substituting the value of t in equation (1) we $v^2 - u^2 = 2aS$

As,

$$2aS = (v + u)(v - u)$$

$$(v + u)(v - u) = 2aS \text{ [using the identity } a^2 - b^2 = (a+b)(a-b)\text{]}$$

$$v^2 - u^2 = 2aS$$

Subtopic and Learning Objective #4

Graphical Representation of Motion; Equations of Motion by Graphical Method

1. Explain Uniform Circular Motion

Teacher Activity

1. Make students recall that the change in velocity is called acceleration. Since velocity consists of both magnitude and direction, so its change can be the change in either of the two or both.
2. State examples of both the cases. (1. Change in magnitude but not direction - Car moving in straight line. 2. Change in both magnitude and direction - Vehicle moving in traffic.)
3. Ask students if they can state the example where there is no change in magnitude of velocity, but its direction continuously changes.
4. Then introduce Uniform Circular Motion. There may be other such examples as shown in Resource 4.
5. Conclude in uniform circular motion: Constant magnitude of velocity, Change in direction of velocity continuously.

Check your Understanding

- a. State two examples of uniform circular motion.
- b. What is the change in speed in a uniform circular motion?

Resources Suggested

Pen and paper, Blackboard, Resource 4

Resource 4:

Uniform Circular Motion



<http://www.physicsclassroom.com/mmedia/circmot/circmotTOC.html>



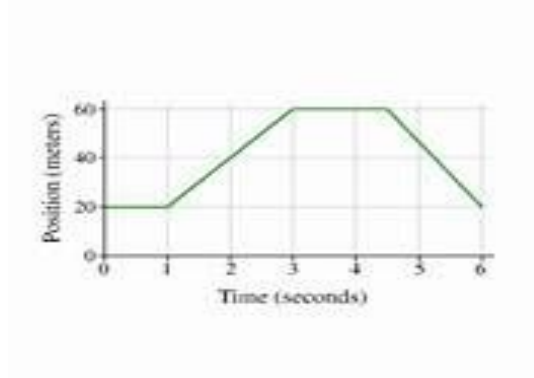


4. WORKSHEETS

Print or copy the worksheet questions on the blackboard and ask the students to attempt them. They can be given as homework or a class test as well.

Worksheet 1

1. Give two points of differences between speed and velocity.
2. When can displacement of a body be 0?
3. Look at the graph below and calculate/find:



- a) the speed for first second
- b) the change in velocity for second and third second
- c) The time when the body was at rest
- d) The time when the body started coming back to its initial position

4. A body has a uniform acceleration of 8 m/s^2 . If its initial velocity is 0, find the distance travelled by the body in 20 seconds.
5. Give two real examples of uniform circular motion.

Worksheet 2

Use it like: checking students understanding in class, oral test

Multiple choice questions:

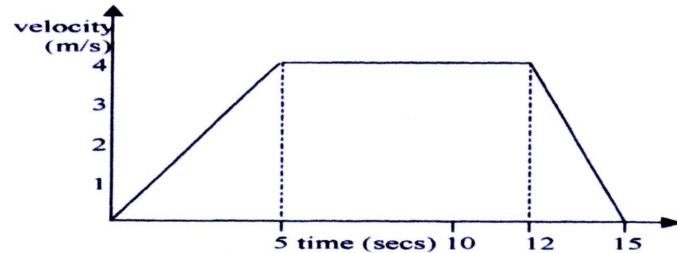
1. Which of the following describes the change in position?
 - a) Motion
 - b) Speed
 - c) Velocity
 - d) Acceleration

2. Can the equations of motion be used in a condition of variable acceleration?
 - a. Yes
 - b. No

3. A car moving in traffic is an example of

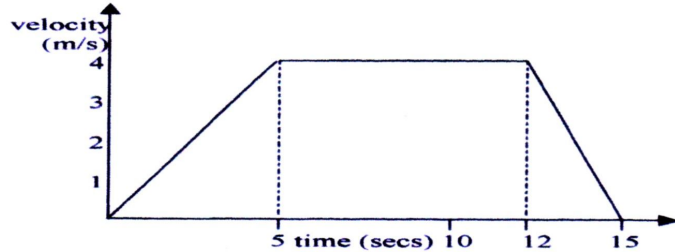
- a. Uniform motion
- b. Uniformly accelerated motion
- c. Uniform circular motion
- d. Non-uniform motion

4. Look at the graph below and describe the type of motion during first 5 seconds.



- a. Uniform motion
- b. Uniformly accelerated motion
- c. Non-uniform motion
- d. Body is at rest

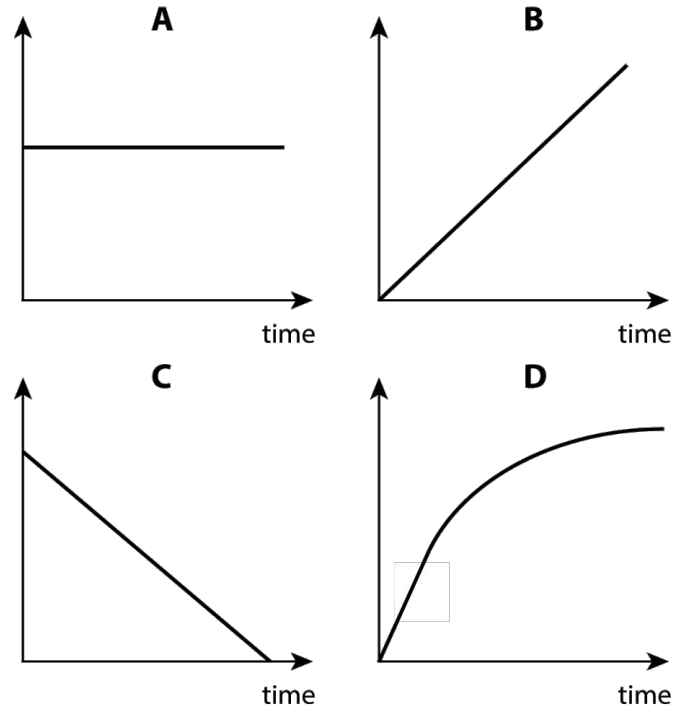
5. What is the displacement covered in the duration of 5-12 seconds by the body whose V-T graph is shown below?



- a. 14 m
b. 28 m
c. 21 m
d. 0
6. Which of the following conditions is possible?
- a. An object with a constant acceleration and displacement 0.
b. An object with a constant velocity and displacement 0.
c. An object with a constant speed and displacement 0.
d. An object with a uniform motion and distance 0.

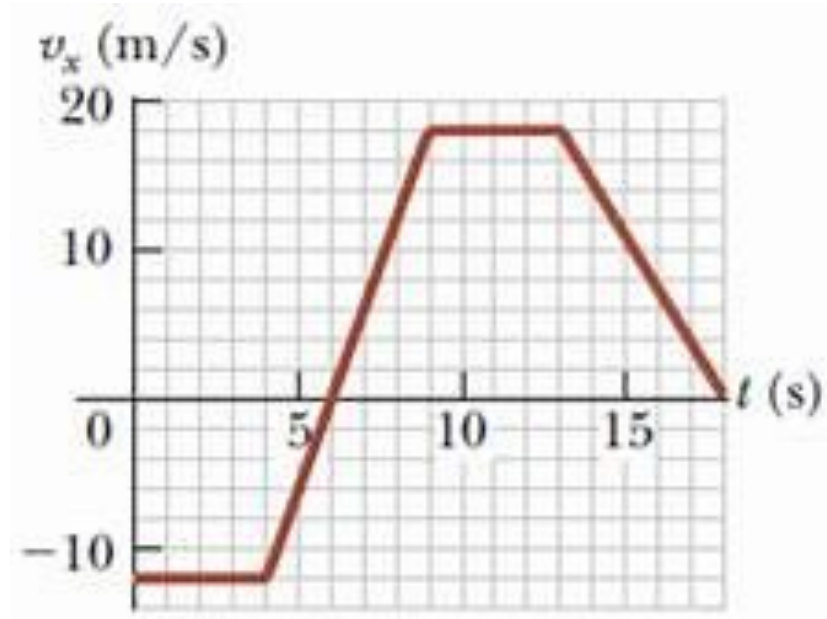
7. Given below are four different D-T graphs for four different moving objects. Which of the following options show the body is moving with a uniform speed?

- a) Graph A and Graph D
- b) Graph B and Graph C
- c) Graph C only
- d) Graph D only



8. See the V-T graph below and tell as to when is the object changing direction

- a) At time = 2 seconds
- b) At time = 5 seconds
- c) At time = 6 seconds
- d) At time = 15 seconds



9. Which of the following is true for uniform circular motion?
- a) Uniform speed
 - b) Same direction
 - c) Uniform velocity
 - d) Displacement is non-zero
10. State whether the following statement is true or false
We can obtain the displacement from a V-T graph by calculating its area.
- a. True
 - b. False

Worksheet 3

Ask the students to see the time difference in the two clocks and calculate the distance and displacement covered by the minute needle in each of the following case, assuming the radius of the clock is 10 cm. (Take $\pi = 3.14$)



1



2

b)



I (12:00 noon)



II (6:10 pm)



5. SOLUTIONS

This section gives you sample answers for activities and questions listed above.



Worksheet 1

1. The differences between speed and velocity are as follows:

Speed	Velocity
1. It has only magnitude.	1. It has both magnitude and direction.
2. It can never be 0.	2. It can be 0.

2. When the initial and final position of a body is same, then the displacement can be 0.
3.
 - (a) The speed for first second = $20 / 1 = 20 \text{ m/s}$
 - (b) Change in velocity for 2nd second = $40 - 20 / 1 = 20 \text{ m/s}^2$
 - (c) Change in velocity for 3rd second = $60 - 40 / 1 = 20 \text{ m/s}^2$
 - (d) The time when the body was at rest = 3 to 4.5 seconds
 - (e) The time when the body started de-accelerating = after 4.5 seconds

4. Given

Initial velocity (u) = 0

Time = 20 sec

Acceleration (a) = 8 m/s²

By the second equation of motion,

$$S = ut + \frac{1}{2} (at)^2$$

$$= 0 + \frac{1}{2} \times 8 \times (20)^2$$

$$= 1600 \text{ m}$$

5. Motion of moon and earth, Movement of a satellite in a circular orbit around Earth.

Worksheet 2

1. a) Motion
2. b) No
3. d) Non-uniform motion
4. b) Uniformly accelerated motion
5. b) 28 m
6. c) An object with a constant speed and displacement 0.
7. b) Graph B and Graph C
8. c) At time = 6 seconds
9. a) Uniform speed
10. a) True

Worksheet 3

- a) By seeing image “I” and image “II”, the minute needle has travelled 3 hours and 40 minutes.

$$\begin{aligned}\text{Total distance travelled} &= (\text{Area of circle} \times 3) + (40 \times \text{Area of circle}) / 60 \\ &= (3 \times \pi r^2) + (40 \times \pi r^2) / 60 \\ &= 3 \times 3.14 \times 0.1 \times 0.1 + 40 \times 3.14 \times 0.1 \times 0.1 / 60 \\ &= 0.0942 + 0.020933 \\ &= 0.115133 \text{ m}\end{aligned}$$

For calculating displacement, three full rounds make it to be 0 and for the last round of 40 minutes, the displacement = $(40 \times \text{Area of circle}) / 60$

$$\begin{aligned}&= 40 \times 3.14 \times 0.1 \times 0.1 / 60 \\ &= 0.020933\text{m}\end{aligned}$$

b) By seeing image “I” and image “II”, the minute needle has travelled 6 hours and 10 minutes.

$$\begin{aligned}\text{Total distance travelled} &= (\text{Area of circle} \times 6) + (10 \times \text{Area of circle}) / 60 \\ &= (6 \times \pi r^2) + (10 \times \pi r^2) / 60 \\ &= 6 \times 3.14 \times 0.1 \times 0.1 + 10 \times 3.14 \times 0.1 \times 0.1 / 60 \\ &= 0.1884 + 0.00523 \\ &= 0.19363 \text{ m}\end{aligned}$$

For calculating displacement, six full rounds make it to be 0 and for the last round of 10 minutes, the displacement = $(10 \times \text{Area of circle}) / 60$

$$\begin{aligned}&= 10 \times 3.14 \times 0.1 \times 0.1 / 60 \\ &= 0.00523 \text{ m}\end{aligned}$$



6. EXTRA RESOURCES

Carry out the following suggested activities/ tasks if you have the time and resources to do them



1. Video Links:

Show the following videos to the students on computer/ tablet/ screen:

a) Equations of Motion

<https://www.youtube.com/watch?v=xViRvJxTu6k>

b) Uniform and Non-uniform motion

<https://www.youtube.com/watch?v=VFfF3F-G9Uk>

2. Extension Activity 2:

Purpose: The students can be asked to make a model of the activity and depict the distance and displacement travelled in it. This will enhance their clarity of the concepts of motion.

3. Extension involving more concepts:

How about making different D-T and V-T graphs in a model/project.

Purpose: Better understanding of graphical representation of motion.

Ask students to make graphs (both D-T and V-T) in a project and also measure the various physical quantities. They can also be asked to derive the equations of motion consequently the way they have learnt in the teaching plan.