UNIT 2

Motion

INTRODUCTION

- **Origin** is a fixed point with respect to which the position of any object changes.
- **Distance** is the actual length of the path covered by a body during the whole journey, without taking into consideration its direction. It is a scalar quantity.
- **Displacement** is the distance in a particular direction. It is a vector quantity. It must be kept in mind that the distance travelled is always positive. On the other hand, displacement may be positive, negative or zero.
- **Difference between distance and displacement**
  Distance travelled is always greater than or equal to the displacement. On the other hand, displacement is always less than or equal to the distance travelled.
- **Condition under which distance and displacement become same**
  When a body moves along a straight line in a positive direction, then its displacement and the distance travelled are equal and have the same sign.
- **Speed** is the rate of change of distance.
- **Average speed** is defined as the total distance travelled, divided by the total time taken.
- **Initial speed** is that speed with which a body starts its motion in the beginning. It is denoted by u.
  It is zero whenever a body starts from rest.
- **Final speed** is that speed which is acquired by the body after its start. It is denoted by v. When a body finally comes to rest its final speed is zero.
- **Scalar quantities** are those which have *magnitude* only, but, *vector quantities* have both *magnitude* and *direction.* For example, the amount of time and speed are scalar quantities because they have only magnitude, but acceleration and force are vector quantities because they have magnitude and direction. The magnitude of a vector is called modulus of the vector.
- When a body covers unequal distances in equal intervals of time, or its direction changes or both change, its velocity is said to be *variable.*
- When a body travels equal distances in equal intervals of time, however small the intervals of time may be, its velocity is said to be *uniform.*
- The rate of change of *angular displacement* is called *angular velocity.*
- **Acceleration** of a body is defined as the rate of change of velocity. Acceleration has both magnitude and direction, hence it is a vector quantity.
- The rate of change of angular velocity is called ***angular acceleration.***
- **Centripetal acceleration**
  If a body is moving along the circumference of a circle, then the acceleration produced is directed towards the centre of the circle. This acceleration is called *centripetal acceleration.* Force due to

centripetal acceleration, acting towards the centre, is called *the centripetal force.*

- **Retardation**
  When the final speed of a body is less than its initial speed, the body is said to be retarding. Retardation can also be expressed as acceleration with a minus sign.
- **Uniform speed**
  Whenever a body covers equal distances in equal intervals of time, however small these intervals of time may be, then the speed is said to be uniform.
- **Uniform acceleration**
  If velocity increases by equal amounts in equal intervals of time in a straight line, however small the intervals of time may be, the body is said to have uniform acceleration.
- **Graphs and their uses**
  Graphs provide much more information than observations recorded in tabular form. From the graphs one can find out even those values which are not given in the data. The position of the moving body can be easily located at any instant of time. One can also come to know whether the body is moving with uniform speed or not. To plot a graph, always take the independent quantity on the x-axis and the dependent on the y-axis.
- **Slope of the graphs**
  (i) The slope of the distance-time graph gives the speed of the moving body.
  (ii) The distance travelled by a body can be obtained by determining the area under the speed-time graph.
  (iii) The slope of the velocity-time graph gives the acceleration of the moving body.
  (iv) By plotting the distance-time graph of two bodies, one can find out when and where the two bodies cross each other.

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct choice amongst the following:

1. Unit of acceleration is
   (a) m/s (b) ms
   (c) m/s^2 (d) none of these
2. A body goes from A to B with a velocity of 20 m/s and comes back from B to A with a velocity of 30 m/s. The average velocity of the body during the whole journey is
   (a) zero (b) 25 m/s
   (c) 24 m/s (d) none of these
3. A body covers half the distance with a speed of 20 m/s and the other half with a speed of 30 m/s. The average velocity of the body during the whole journey is
   (a) zero (b) 24 m/s
   (c) 25 m/s (d) none of these
4. In the equation of motion, $S = ut + 1/2\ at^2$, S stands for
   (a) distance in t seconds
   (b) maximum height reached
   (c) distance in the t^{th} second
   (d) none of these
5. Choose the wrong statement.
   (a) retardation is a vector quantity
   (b) acceleration due to gravity is a vector quantity
   (c) average speed is a vector quantity
   (d) displacement is a vector quantity
6. In the equation of motion, $x = at + bt^2$, the units of a and b are respectively
   (a) m/s^2, m/s (b) m/s, m/s^2
   (c) m/s, m/s (d) none of these
7. A body is thrown up with an initial velocity u and covers a maximum height of h, then h is equal to
   (a) $\frac{u^2}{2g}$ (b) $\frac{u}{2g}$
   (c) $2ug$ (d) none of these
8. The second's hand of a watch is 2 cm long. The speed of the tip of this hand is
   (a) 0.21 cm/s (b) 2.1 cm/s
   (c) 21.0 cm/s (d) none of these
9. A body is thrown vertically upwards and rises to a height of 10 m. The velocity with which the body was thrown upwards is ($g = 9.8\ m/s^2$)
   (a) 10 m/s (b) 20 m/s
   (c) 14 m/s (d) none of these
10. In question number nine the time taken by the body to reach the highest point is

(a) 1.43 s (b) 4.1 s
(c) 1.24 s (d) none of these

11. If the time-displacement graph of a particle is parallel to the time-axis, the velocity of the particle is
(a) infinity
(b) unity
(c) equal to acceleration of the body
(d) zero

12. Velocity-time graph *AB* (Fig. 2.1) shows that the body has
(a) a uniform acceleration
(b) a non-uniform retardation
(c) uniform speed
(d) initial velocity *OA* and is moving with uniform retardation

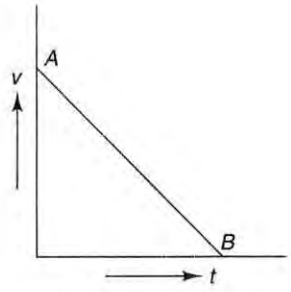

Fig. 2.1

13. Velocity-time graph *AB* (Fig. 2.2) shows that the body has
(a) uniform acceleration
(b) uniform retardation
(c) uniform velocity throughout its motion and has zero initial velocity
(d) none of these

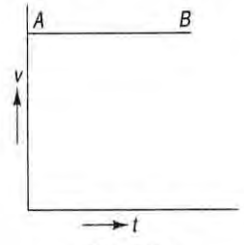

Fig. 2.2

14. The distance travelled by a freely falling body is proportional to
(a) the mass of the body
(b) the square of the acceleration due to gravity
(c) the square of the time of fall
(d) the time of fall

15. The rate of change of displacement with time is
(a) speed (b) acceleration
(c) retardation (d) velocity

16. A body strikes the floor vertically with a velocity u and rebounds at the same speed. The change in speed would be
(a) u (b) $3u$
(c) $2u$ (d) zero

17. The moon is 4×10^8 m from the earth. A radar signal transmitted from the earth will reach the moon in about
(a) 5.2 s (b) 1.3 s
(c) 2.6 s (d) 0.70 s

18. *A* and *B* are arguing about uniform acceleration. *A* states that acceleration means "the longer you go." *B* states that acceleration means "the further you go." Who is right?
(a) *A* (b) *B*
(c) both (d) none

19. A particle experiences constant acceleration for 20 s after starting from rest. If it travels a distance X_1, in the first 10 s and distance X_2, in the remaining 10 s, then which of the following is true?
(a) $X_1 = 2X_2$ (b) $X_1 = X_2$
(c) $X_1 = 3X_2$ (d) none of these

20. If a trolley starts from rest with an acceleration of 2 m/s^2, the velocity of the body after 4 s would be
(a) 2 m/s (b) 8 m/s
(c) 4 m/s (d) 6 m/s

21. A train passes over a 400 m long bridge. If the speed of the train is 30 m/s and the train takes 20 s to cross the bridge, then the length of the train is
(a) 400m (b) 600m
(c) 800 m (d) 200 m

22. The SI unit for the average velocity is
(a) m/s (b) km/s
(c) cm/s (d) mm/s

23. The SI unit for the resultant velocity is
    (a) m/s (b) km/s
    (c) cm/s (d) min/s
24. A train 50 m long passes over a bridge at a velocity of 30 km/h. If it takes 36 s to cross the bridge, the length of the bridge will be
    (a) 100 m (b) 200 m
    (c) 250 m (d) 300 m
25. The SI unit for angular velocity is
    (a) m/s (b) rad
    (c) rad/s (d) m/rad
26. $N\,kg^{-1}$ is the unit of
    (a) retardation
    (b) acceleration
    (c) rate of change of velocity
    (d) all the above
27. A ball is thrown up with a certain velocity. It attains a height of 40 m and comes back to the thrower. Then the
    (a) total distance covered by it is 40 m
    (b) total displacement covered by it is 80 m
    (c) total displacement is zero
    (d) total distance covered by it is zero
28. The acceleration of a body projected upwards with a certain velocity is
    (a) $9.8\ m/s^2$ (b) $-9.8\ m/s^2$
    (c) zero (d) insufficient data
29. A driver is driving his car along a road as shown in Fig. 2.3. The driver makes sure that the speedometer reads exactly 40 km/h. What happens to the speed of the car from P to Q?
    (a) Speed remains constant
    (b) Speed first increases then decreases
    (c) Speed first decreases then increases
    (d) Nothing can be decided

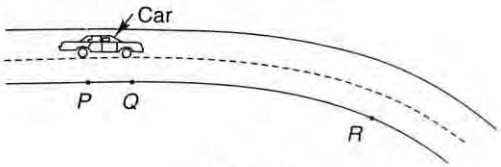

Fig. 2.3

30. In the above question, what happens to the velocity of the car from P to Q?
    (a) Velocity remains constant
    (b) Velocity first increases then decreases
    (c) Velocity first decreases then increases
    (d) Nothing can be decided
31. From Question 29, we can say that
    (a) the average speed is 40 km/h
    (b) the average velocity is 40 km/h
    (c) the average speed is 80 km/h
    (d) the average velocity is 80 km/h
32. A stone tied to a string is whirled in a circle. As it is revolving, the rope suddenly breaks. Then
    (a) the stone flies off tangentially
    (b) the stone moves radially inward
    (c) the stone moves radially outward
    (d) the motion of the stone depends upon its velocity
33. In the following graph (Fig. 2.4) of displacement versus time,
    (a) the body is at rest
    (b) the body has some initial speed
    (c) the body moves with constant speed
    (d) the body moves with constant velocity

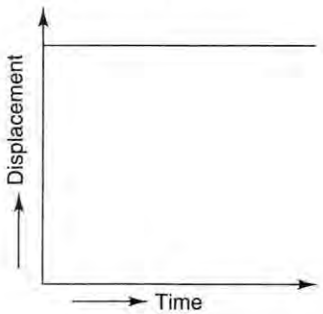

Fig. 2.4

34. Figure 2.5 shows the displacement-time graphs (a) and (b) for a body moving in a straight path drawn on the same scales. Then

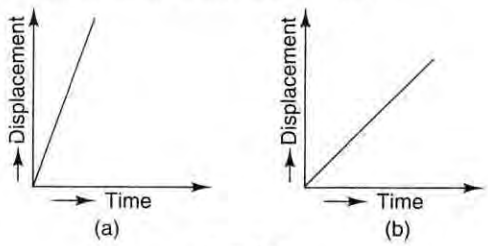

Fig. 2.5

(a) slope of line in (a) is greater than the slope of line in (b)
(b) slope of line in (b) is greater than the slope of line in (a)
(c) slope of line in (a) is equal to the slope of line in (b)
(d) nothing can be said about the slopes

35. It follows from Question 34, that the velocity in case of (b) is
(a) more than the velocity in case of (a)
(b) less than the velocity in case of (a)
(c) equal to the velocity in case of (a)
(d) square of the velocity in case of (a)

36. In Fig. 2.6, *BC* represents a body moving
(a) backward with uniform velocity
(b) forward with uniform velocity
(c) backward with non-uniform velocity
(d) forward with non-uniform velocity

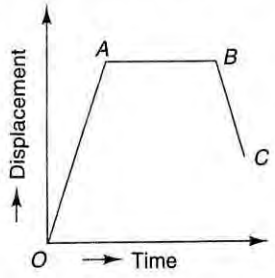

Fig. 2.6

37. In Fig. 2.7, the velocity of the body at A is
(a) zero (b) unity
(c) maximum (d) infinite

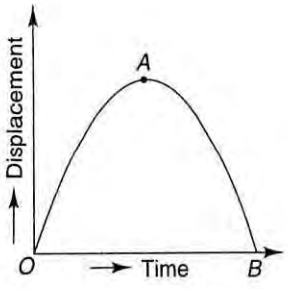

Fig. 2.7

38. In the above question, the velocity
(a) increases between points *O* and *A*
(b) increases between points *A* and *B*
(c) decreases between points *A* and *B*
(d) is zero throughout

39. A body moving along a circular path has
(a) a constant speed
(b) a constant velocity
(c) no tangential velocity
(d) no radial acceleration

40. In Fig. 2.8
(a) retardation is uniform
(b) velocity is decreasing with time
(c) beyond *M*, the body has negative velocity
(d) all the above are incorrect

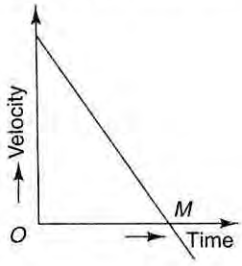

Fig. 2.8

41. A body whose speed in a particular direction is constant
(a) must be accelerating
(b) must be retarding
(c) has a constant velocity
(d) all the above

42. The velocity of a particle increases from u to v in a time t during which it covers a distances S. If the particle has a uniform acceleration, which one of the following equations does not apply to the motion?

(a) $2S = (v + u)t$ (b) $a = \dfrac{v - u}{t}$

(c) $v^2 = u^2 - 2aS$ (d) $S = \left(u + \dfrac{1}{2}at\right)t$

43. A body has an acceleration of $-4\ \text{ms}^{-2}$. What is its retardation?
(a) $-4\ \text{ms}^2$
(b) $4\ \text{ms}^{-2}$
(c) Zero
(d) nothing can be decided

44. A cyclist moves from a certain point X and goes round a circle of radius 'r' and reaches Y, exactly at the other side of the point X, as shown in Fig. 2.9. The displacement of the cyclist would be
(a) πr (b) $2\pi r$
(c) $2r$ (d) $2\pi/r$

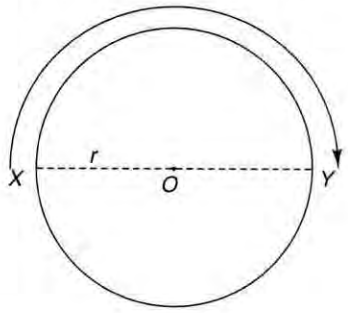

Fig. 2.9

45. In the above problem, the distance covered by the cyclist would be
(a) πr (b) $2\pi r$
(c) $2r$ (d) $2\pi/r$
46. Which of the following relations represents the relationship between the average speed, time and distance correctly?
(a) Average speed = distance × time
(b) Average speed = $\frac{\text{total distance}}{\text{total time}}$
(c) Time = average speed + distance
(d) Distance = average speed – time
47. When a graph between two physical quantities is a straight line, the two quantities are:
(a) both constant
(b) independent of each other
(c) directly proportional
(d) inversely proportional
48. A man walks 8 m towards East and then 6 m towards North. His magnitude of displacement is
(a) 10 m (b) 14 m
(c) 2 m (d) zero
49. Area under a velocity-time graph gives
(a) the time taken by a moving object
(b) the distance travelled by a moving object
(c) the acceleration of moving object
(d) the retardation of a moving object
50. A player completes a circular path of radius r in 40 s. At the end of 2 minutes 20 seconds, displacement will be
(a) $2r$ (b) $2\pi r$
(c) $7\pi r$ (d) zero
51. Which of the following physical quantities is different from others?
(a) speed (b) distance
(c) energy (d) average velocity
52. Which of the following physical quantities is different from others?
(a) displacement (b) velocity
(c) force (d) kinetic energy
53. The speed of a body describing its motion is
(a) direction (b) state
(c) type (d) rapidity
54. The unit for the rate of change of velocity will be
(a) m/s (b) m/s^2
(c) Ns (d) N/s
55. The velocity-time graph for a body with non-uniform motion is a
(a) straight line
(b) straight line parallel to x-axis
(c) straight line parallel to y-axis
(d) curved line
56. The ratio of SI units to CGS units of retardation is
(a) 10^{-2} (b) 10^2
(c) 10 (d) 10^{-1}
57. The physical quantity corresponding to the rate of change of displacement is
(a) speed (b) velocity
(c) acceleration (d) retardation
58. The velocity of a body at rest is always
(a) unity (b) negative
(c) zero (d) infinite
59. When the distance an object travels is directly proportional to the length of time, it is said to travel with
(a) zero velocity
(b) constant speed
(c) constant acceleration
(d) uniform velocity

60. In the following speed-time graph (Fig. 2.10), the shaded portion gives
    (a) distance travelled
    (b) average speed
    (c) average velocity
    (d) displacement travelled

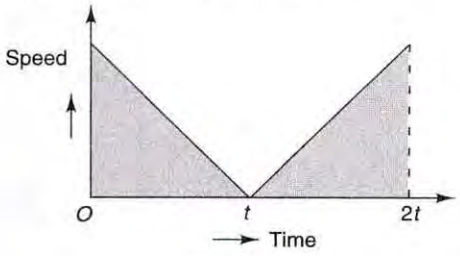

Fig. 2.10

61. A car increases its speed from 20 km/h to 50 *km/h* in 10 seconds. Its acceleration is
    (a) 30 ms^{-2} (b) 3 ms^{-2}
    (c) 18 ms^{-2} (d) none of these

62. If the velocity of a body does not change with time, its acceleration is
    (a) zero (b) infinite
    (c) unity (d) none of these

ANSWERS

1. (c)	2. (a)	3. (b)	4. (a)	5. (c)
6. (b)	7. (a)	8. (a)	9. (c)	10. (a)
11. (d)	12. (d)	13. (d)	14. (c)	15. (d)
16. (d)	17. (b)	18. (c)	19. (d)	20. (b)
21. (d)	22. (a)	23. (a)	24. (c)	25. (c)
26. (d)	27. (c)	28. (b)	29. (a)	30. (a)
31. (a)	32. (a)	33. (a)	34. (a)	35. (b)
36. (a)	37. (a)	38. (b)	39. (a)	40. (d)
41. (c)	42. (c)	43. (b)	44. (c)	45. (a)
46. (b)	47. (c)	48. (a)	49. (b)	50. (a)
51. (d)	52. (d)	53. (d)	54. (b)	55. (d)
56. (b)	57. (b)	58. (c)	59. (b)	60. (a)
61. (d)	62. (a)			