EXAM DRILL

CHAPTER 8

Motion

ANSWERS

1. Speed is a scalar quantity, and velocity and acceleration are vector quantity.

2. The given graph shows non-uniform retardation first and then non-uniform acceleration.

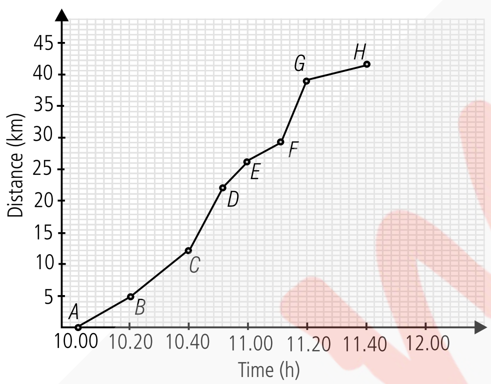
3(i) *A* is travelling slowest.

3(ii) All three objects do not cover equal distance.

3(iii) As is clear from the figure, *B* passes *A* at *D*. At this time, *C* is at *E*, which corresponds to 7 km. Hence when *B* crosses *A*, then *C* is at 7 km from the origin.

3(iv) *C* passes A at a distance of 11 km.

4.



4(i) Figure represents the distance-time graph of the car. Time is taken along *X*-axis and distance is taken along *Y*-axis.

4(ii) As the slope of distance-time graph represents speed, therefore, the line with maximum slope will represent maximum speed. As is clear from figure. Line *CD* represents maximum speed between 10.40 am to 10.50 am.

4(iii) (b) : Total distance travelled from 10.05 am to 11.40 am, $s = 42$ km. Total time taken,

$t = 11.40 - 10.05 = 1$ h 35 m

$$= \frac{95}{60}\text{h}$$

Average speed, $v_{av} = \frac{\text{total distance}}{\text{total time}}$

$$= \frac{42\,\text{km}}{95/60\,\text{h}} = 26.5\,\text{km/h}$$

4(iv) (a) : Between 11.25 am and 11.40 am,

distance travelled = 42 – 38 = 4 km

time taken = 11.40 – 11.25 = 15 min

$$= \frac{15}{60}\text{h} = 0.25\,\text{h}$$

$$\text{speed} = \frac{\text{distance}}{\text{time}} = \frac{4\,\text{km}}{0.25\,\text{h}} = 16\,\text{km/h}$$

5. (c) : When velocity time graph is parallel to time axis, *i.e.*, velocity = constant, so, acceleration of body is zero.

OR

(d) : When acceleration is uniform, velocity time graph is a straight line at an angle as shown in option. (d).

6. (d) : As, $s \propto u^2$. If the speed is two times so distance will be four times, $s = 4 \times 6 = 24$ m.

7. (d) : There is uniform acceleration from rest, so

$$v = \sqrt{2as} = \sqrt{2(9.8\,\text{m/s}^2)(34\,\text{m})} \simeq 26\,\text{m/s}$$

8. (a) : The distance-time graph is a straight line when the body is in uniform motion.

OR

(c) : The displacement is equal to the diameter of the circle.

9. (d) : We know that magnitude of displacement is less than or equals to the distance.

So, the numerical ratio of displacement to distance covered by a moving object is less than 0 are equals to 1.

10. (a) : For the stone thrown upwards,

$$u_1 = u_1,\ v_1 = 0,\ s_1 = h_1,\ a_1 = -g$$

$$v_1^2 - u_1^2 = 2a_1s_1$$

$$\Rightarrow (0)^2 - u_1^2 = 2(-g)h_1$$

$$\Rightarrow h_1 = \frac{u_1^2}{2g}$$

Similarly for the second stone,

$$h_2 = \frac{u_2^2}{2g} \quad \therefore \quad \frac{h_1}{h_2} = \frac{u_1^2}{u_1^2}$$

11. (c) : A body moves with a constant speed along a circular path, then its direction of motion keeps changing continuously. The centripetal force always acts towards the centres.

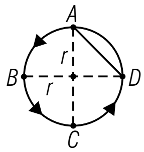
12. **(a) :** Here, diameter = 135 m, radius $(r) = \frac{135}{2}$

Time taken, $t = 5 \times 60 = 300$ s

Speed $v = \frac{2\pi r}{t} = 2 \times \frac{22}{7} \times \frac{135}{2 \times 300} = 1.41$ m/s

OR

(a) : When the particle goes from *A* to *D*, over three quarters of the circle,



Displacement = *AD*

where $AD = \sqrt{r^2 + r^2} = r\sqrt{2}$

13. **(a) :** When a body going vertically upwards reaches at the highest point, then it is momentarily at rest and it then reverses its direction. At the highest point of motion, its velocity is zero but its acceleration is equal to acceleration due to gravity.

14. **(d) :** Speed is the magnitude of velocity, it cannot be zero if velocity is non-zero. As, displacement of the particle can be zero but distance travelled cannot be zero.

15. **(a)** Acceleration of a body is defined as the rate of change of its velocity with time

i.e., Acceleration $= \frac{\text{Change in velocity}}{\text{Time taken}}$

Acceleration $= \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Time taken}}$

Suppose the initial velocity of a body is *u* and it changes to a final velocity *v* in time *t*, then :

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

where a = acceleration of the body

v = final velocity of the body

u = initial velocity of the body

t = time taken for the change in velocity

The S.I. unit of acceleration is meter per second square (m/s^2).

(b) A body has a uniform acceleration if it travels in a straight line and its velocity increase by equal amounts in equal intervals of time. In other words, a body has a uniform acceleration if its velocity changes at a uniform rate. The motion of a freely falling body is an example of uniformly accelerated motion.

OR

Velocity-time graph is a straight line parallel to time axis, so, velocity of the cyclist is constant.

(a) Acceleration = 0

(b) At, $t = 15$ s velocity = 20 m s^{-1} (from the given graph)

(c) Distance covered by the cyclist in 15 s

= Area under *v-t* graph during that time interval

= 20 m $s^{-1} \times 15$ s = 300 m.

16. **(a)** Average speed $= \frac{\text{Total distance travelled}}{\text{Total time taken}}$

$= \frac{40 \text{ m}}{50 \text{ s}} = 0.8$ m/s

(b) Average velocity $= \frac{\text{Displacement}}{\text{Time taken}} = \frac{0}{50 \text{ s}} = 0$

17. The importance of graphical study of the uniform motion of an object in one dimension are following :

(i) The position-time graph of the uniform motion lies in the fact that its slope gives velocity of the object.

(ii) Velocity-time graph of uniform motion helps us to measure the displacement by an object in a given time as the area enclosed by velocity-time graph with time axis.

(iii) In be graph for the given internal of time, the positive area below time axis give negative displacement.

(iv) The slope of velocity-time graph gives the acceleration of the object.

18. Let the object be moving with initial velocity *u* m s^{-1} and uniform acceleration *a* m s^{-2}.

∴ The distance travelled by the moving object in *t* s is,

$s = ut + \frac{1}{2}at^2$

Now, distance travelled in 4 s,

$s_4 = u \times 4 + \frac{1}{2} a \times 4^2 = 4u + 8a$

Distance travelled in 5 s,

$s_5 = u \times 5 + \frac{1}{2} a \times 5^2 = 5u + \frac{25}{2} a$

∴ Distance travelled in the interval between 4^{th} and 5^{th} second

$= \left(5u + \frac{25}{2}a\right) - (4u + 8a) = \left(u + \frac{9}{2}a\right)$ m

OR

(a) Distance travelled by an object in a given time is equal to the area which the velocity-time graph encloses with the time axis for the given interval of time. Finding that area under velocity-time graph, travelled distance will be determined.

(b) The slope of velocity-time graph represents acceleration.

19. **(a)** The distance travelled by a body in a given interval of time is equal to total area enclosed by velocity-time graph, without considering sign. It means, even if the body is moving with negative velocity, the area of velocity-time graph is to be taken positive for the measurement of distance travelled by the body.

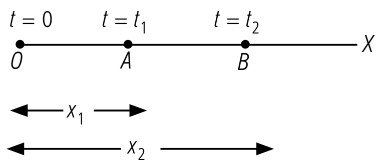
(b) Displacement of a body in a given interval of time is equal to total area enclosed by velocity-time graph, during the given interval of time, which is to be added with proper sign.

20. Acceleration $= \dfrac{\text{Change in velocity}}{\text{Time taken}}$

Acceleration is a vector quantity. It be positive, negative or zero.

Consider an object, moving with a uniform acceleration 'a' along a straight line OX with origin at O. Let the object reach at points A and B at instants t_1 and t_2. Let x_1 and x_2 be the displacements of the ojbect at time t_1 and t_2 respectively and u_1 and u_2 be the velocities of the object at position A and B respectively,

$$\text{Acceleration of the object} = \frac{\text{Change in velocity}}{\text{Time taken}}$$



$$\therefore \quad a = \frac{v_2 - v_1}{t_2 - t_1} \quad \text{...(i)}$$

or $\quad v_2 - v_1 = a(t_2 - t_1)$ or $v_2 = v_1 + a(t_2 - t_1) \quad$ ...(ii)

Let the origin of time axis be taken at O and u be the velocity of the object at A. v be the velocity of the object at B after time t. Then $v_1 = u$; $t_1 = 0$; $v_2 = v$ and $t_2 = t$.

Putting values in (ii), we get $v = u + a\,t$ ...(iii)

The equation (iii) shows the required velocity-time relations for body moving under constant acceleration.

21. There are three equations of motion for uniformly accelerated bodies which are :

(i) $v = u + at$

It gives the velocity acquired by a body in time t.

(ii) $s = ut + \dfrac{1}{2}at^2$

This equation gives the distance travelled by a body in time t.

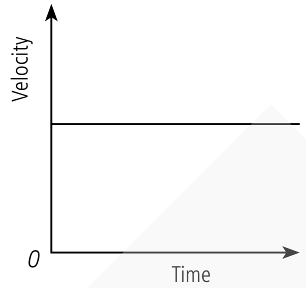
(iii) $v^2 = u^2 + as$

It gives the velocity acquired by a body in travelling a distance s.

Where, v = final velocity of the body
u = initial velocity of the body
a = acceleration
t = time taken
s = distance travelled by the body.

OR

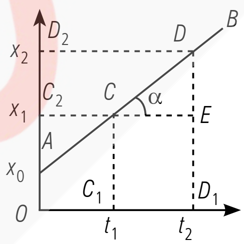
The velocity-time graph for part of a train journey is a horizontal straight line which is as shown in figure.



(a) From the figure we can say that, the train has a uniform velocity.

(b) As velocity is uniform the train has zero acceleration.

22. The position-time graph of an object in a uniform motion in one dimension is a straight line AB, inclined to time axis as shown in figure. Here, the position coordinates of the object at the instants $t = 0$, t_1 and t_2 respectively are x_0, x_1, and x_2. Let C and D be the two points on the position-time graph corresponding to instants t_1 and t_2. Draw CC_1, CC_2, DD_1 and DD_2, perpendiculars on time axis and position axis, as shown in figure.



Then, $t_2 - t_1 = OD_1 - OC_1 = C_1D_1 = CE$

and $x_2 - x_1 = OD_2 - OC_2 = C_2D_2 = ED$

$\therefore$ Velocity of the object, $v = \dfrac{x_2 - x_1}{t_2 - t_1} = \dfrac{ED}{CE} = \tan\alpha$ = slope of position-time graph.

Thus, velocity of an object in uniform motion is equal to the slope of position-time graph with time axis. Hence, the importance of the position-time graph of uniform motion lies in the fact that its slope gives us velocity of the object.

23. The motion of a freely falling body is an example of uniformly accelerated motion, as due to the gravitational pull of the earth the body covers equal amount of velocity in equal intervals of time.

24. Circumference $= 2\pi r$

Circumference of $\dfrac{3}{4}$circle $= \dfrac{3}{4} \times 2\pi r$

$$= \frac{3}{4} \times 2 \times \frac{22}{7} \times 400 = 1885.71\,\text{m}$$

25. We have, circumference of the cycle track $= 2\pi r = 314$ m

So, radius of the circular track

$$r = \frac{\text{Circumference}}{2\pi} = \frac{314\ \text{m}}{2 \times \pi} = 50\ \text{m}$$

(a) The distance moved by the cyclist is equal to the arc *AB*. The arc *AB* is half of the circumference. So,

Distance along the arc $AB = \frac{2\pi r}{2} = \frac{314}{2}\text{ m} = 157\text{ m}$

So, distance moved by the cyclist = 157 m

(b) As per convention, the displacement of a body moving from north to south is considered negative. Therefore,

Displacement of the cyclist = $-AB$ = – Diameter of the circle

$= -2r = -r \times 50\text{ m} = -100\text{ m}$

(c) The velocity of cyclist moving along a circular track with a velocity of constant magnitude changes due to change in the direction of motion.

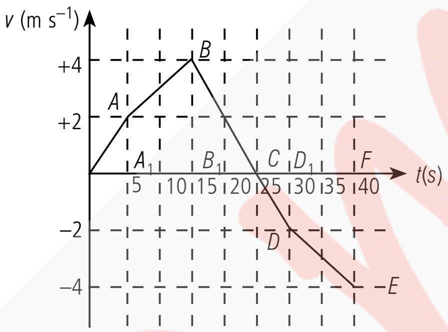
Average magnitude of velocity of the cyclist = 15.7 m/s

(d) We know, acceleration of a body having uniform circular motion= $\frac{v^2}{r}$

So, acceleration of the cyclist $= \frac{(15.7\text{ m/s})^2}{50\text{ m}}\text{m/s}^2$

$= \frac{15.7 \times 15.7}{50} = 4.93\text{ m/s}^2$

OR



(a) Distance travelled by body in time 5 to 15 seconds = Area $A_1ABB_1 = \frac{(2+4)\times 10}{2} = 30\text{ m}$

Distance travelled by body in time 15 to 25 seconds = Area $BB_1C = \frac{4 \times 10}{2} = 20\text{ m}$

Distance travelled by body in time 25 to 30 seconds = Area $CDD_1 = \frac{5 \times 2}{2} = 5\text{ m}$

Distance travelled by body in time 30 to 40 seconds = Area $D_1DEF = \frac{(2+4)\times 10}{2} = 30\text{ m}$

∴ Total distance travelled = 30 + 20 + 5 + 30 = 85 m.

(b) Here, the area CDD_1 and area D_1DEF being below the time axis will show negative displacement.

Hence, total displacement between 5 to 40 seconds

= 30 + 20 – 5 – 30 = 15

(c) Acceleration of the body in time interval 15 to 25 s is the slope of the line *BC*

$= \frac{-BB_1}{CB_1} = \frac{-4}{(25-15)} = \frac{-4}{10} = -0.4\text{ m/s}^{-2}$.

26. An object is said to be in motion if it changes its position with time, with respect to its surroundings. A birds flying in air, a train moving on routs, a man walking on road are some of the examples of motion.

An object is said to be in uniform motion if it covers equal distances in equal intervals of time, howsoever big or small these time intervals may be.

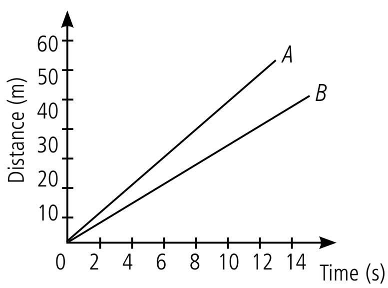
For example, suppose a car covers 60 km in first hour, another 60 km in second hour, again 60 km in the third hour and so on. The motion of the car is uniform. In this example, the car travels a distance of 60 km in each hour. In the stricter sense, the car should travel 30 km in each half hour; 15 km in every 15 minutes; 10 km is every 10 minutes, 5 km is every 5 minutes and 1 km in every one minute.

An object is said to be in non-uniform motion, if it under goes unequal distance in equal interval of time.

If a bus starting from one stop, it proceeds slowly when it passes crowded area of the road. Suppose it manages to travel merely 100 m in 5 minutes due to heavy traffic. When it gets out and the road is clear, it speeds up and is able to travel about 2 km in 5 minutes. We can say the motion of bus is non-uniform. *i.e.* it travels unequal distances in equal intervals of time. Example of non-uniform motion is, a speeding up or a slowing down vehicle.

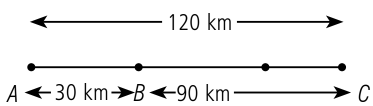
OR

(a) Distance-time graphs of two bodies *A* and *B* with uniform speed is as shown below :



The body *A* is moving faster than body *B* as the slope of distance-time graph for body *A* is more than body *B*.

(b)



Total time taken $(t) = \frac{\text{Total distance travelled}}{\text{Average speed}}$

$= \frac{120\text{ km}}{60\text{ km/h}} = 2\text{ h}$

If t_1 is the time required to cover the first 30 km, then

$$t_1 = \frac{30\text{ km}}{30\text{ km/h}} = 1\text{ h}$$

So, time taken to cover the next 90 km = (2 h – 1 h) = 1 h

Then, speed for covering the next 90 km $= \frac{\text{Distance covered}}{\text{Time taken}}$

$$= \frac{90\text{ km}}{1\text{ h}} = 90\text{ km/h}$$

So, the train should travel at a speed of 90 km/h for the next 90 km distance.

27. **(a)** The train is accelerating. As the horizontal velocity of the coin will remain same as the velocity of the train when it was tossed from the passenger's hand. The coin fall behind the passenger, so the velocity of the train is increasing with time and thus train covers more distance than the coin.

(b) Given : initial velocity, $u = 80$ m/s

final velocity = $v = 0$

time , $t = 8$ s

and mass, $m = 50$ g

$$= \frac{50\text{ kg}}{1000} = 0.05\text{ kg}$$

Acceleration = slope of the velocity time graph

$$= \frac{v-u}{t} = \frac{0-80}{8} = -10\text{ m/s}^2$$

Now, frictional force of the floor on the ball,

$f = ma$

$= 0.05 \times 10 = 0.5$ N

28. **(a)** In the given figure, stone tied to the thread is in circular motion.

(b) Yes, this is an example of accelerated motion. In this given figure a stone moving on a circular path with a constant speed *i.e.*, it covers equal distance on the circumference of the circle in equal interval of time, so the motion is uniform circular motion. The direction of its velocity is changing with time, this indicates the motion is accelerated motion.

(c) A force required to keep the stone move along a circular path with uniform speed is called centripetal force.

(d) The direction of centripetal force is always along the radius and towards the centre of the circular path.

29. **(a)** Type of motion

(i) For motion from *A* to *B* (*AB*)

As *AB* is a straight line with positive slope, so, the body has a uniform acceleration.

(ii) For motion from *B* to *D* (*BD*)

As *BD* is a straight line parallel to *X*-axis (time axis), so it has zero slope, and therefore, the body has zero acceleration, *i.e.*, it is moving with constant velocity.

(iii) For motion from *D* to *E* (*DE*)

As *DE* is a straight-line with negative slope, the body has a uniform retardation (negative acceleration).

(b) Acceleration in the last two hours (Body moves from *D* to *E*) :

Here, $u = 40$ km/h

$v = 0$ km/h

$t = 2$ h

By using the expression, $a = \frac{v-u}{t}$, we get

$$= \frac{0\text{ km/h} - 40\text{ km/h}}{2\text{ h}} = \frac{-40\text{ km/h}}{2\text{ h}} = -20\text{ km/h}^2$$

Thus, the acceleration of the body for the last 2 hours is -20 km/h^2. The negative sign indicates that the body is under retardation in the last 2 hours.

(c) Total distance travelled = Total area under the velocity-time graph

= Area *ABDE*

= Area of ΔABF + Area of rectangle *BDGF* + Area of ΔDGE

Total distance travelled,

$$s = \left(\frac{1}{2} \times AF \times BF\right) + (BF \times BD) + \left(\frac{1}{2} \times GE \times DG\right)$$

$$s = \left(\frac{1}{2} \times 2\text{ h} \times 40\text{ km/h}\right) + (40\text{ km/h} \times 4\text{ h}) + \left(\frac{1}{2} \times 2\text{ h} \times 40\text{ km/h}\right)$$

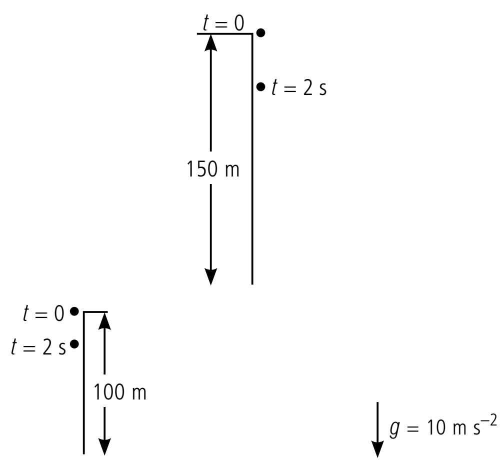
$s = 40$ km + 160 km + 40 km

(d) Average speed $= \frac{\text{Total distance travelled}}{\text{Total time taken}}$

$$= \frac{240\text{ km}}{(2+4+2)\text{ h}} = \frac{240\text{ km}}{8\text{ h}}$$

So, the average speed of the moving body is 30 km/h.

OR



Initially, difference in heights of two objects

= 150 m – 100 m = 50 m

Distance travelled by first object in 2 s,

$$h = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 10 \times 2 \times 2 = 20\text{ m}$$

Distance travelled by the second object in 2 s,

$$h' = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 10 \times 2 \times 2 = 20 \text{ m}$$

Height of first object from ground at $t = 2$ s

= 150 m – 20 m = 130 m

Height of second object from ground at $t = 2$ s

= 100 m – 20 m = 80 m

$\therefore$ Difference in height after $t = 2$ s

= 130 m – 80 m = 50 m.

Difference in heights does not vary with time as long as both the objects are in motion. However, when second object reaches the ground and the first one is still in motion, then it decreases.

30. **(a)** The average velocity $= \frac{x}{t} = \frac{(v + v_1)^2}{2}$

where v = 15 m/s and v_1 is the initial speed.

The average speed $= \frac{x}{t} = \frac{60\text{ m}}{6\text{ s}} = \frac{(15\text{ m/s} + v_1)}{2}$

or 10 m/s $= \frac{(15\text{ m/s} + v_1)}{2}$

or 20 m/s = 15 m/s + v_1

So, v_1 = 5 m/s.

(b) The acceleration $a = \frac{(v - v_1)}{(t - t_1)}$

$$= \frac{(15-5)}{6.0} = \frac{5}{3}\text{m/s}^2 = 1.66 \text{ m/s}^2$$

= (15 m/s – 5 m/s)/(6.0 s) = 5/3 m/s^2

(c) $v_1^2 = v_0^2 + 2a(x_1 - x_0) = (5 \text{ m/s})^2$

i.e., $0 + 2\,(\frac{5}{3}\text{ m/s}^2)\,(x_1 - x_0) = 25 \text{ m}^2/\text{s}^2$ $(\because v_0 = 0)$

or $(\frac{10}{3}\text{m/s}^2)(x_1 - x_0) = 25 \text{ m}^2/\text{s}^2$

or $(x_1 - x_0)$ = 7.5 m.

Total distance = 7.5 + 60 = 67.5 m

Let's check all of this. First we find the time for the object to acquire a velocity v_1 = 5.0 m/s with an acceleration of $\frac{5}{3}$ m/s^2 starting from an initial velocity of zero.

$v = v_0 + at$

or $5.0\text{ m/s} = 0 + \left(\frac{5}{3}\text{m/s}^2\right)t$ or $t = 3$ s.

At t = (6 + 3)s, = 9 s

We have $S = ut + \frac{1}{2}at^2$

i.e., $S = 0 + \left(\frac{1}{2} \times \frac{5}{3}\text{m/s}^2\right) \times (9)^2$ = 67.5 m = 60 m + 7.5 m,

where 60 m is the distance given in the statement of the problem for the object to go from 5 m/s to 15 m/s and 7.5 m is the distance moved from the point where the object was at rest where it was travelling with 5 m/s.