PROBLEMS

2.1 A train moves with a uniform velocity of 36 kmh-1 for 10 s. Find the distance travelled by it.
(100 m)

Solution: Velocity = V = 36 kmh^{-1} = 36 x 1000/ 60 x 60 = 36000/ 3600 = 10 ms^{-1}

Time t = 10 s

Distance = S =?

$S = Vt$

$S = 10 \times 10 = 100$ m

2.2 A train starts from rest. It moves through 1 km in 100 s with uniform acceleration. What will be its speed at the end of 100 s.? (20 ms^{-1})

Solution: Initial velocity $V_i = 0$ ms^{-1}

Distance S = 1 km = 1000 m

Time = 100 s

Final velocity V_f =?

$S = V_i \times t + 1/2 \times a \times t2$

$1000 = 0 \times 100 + 1/2 \times a \times (100)^2$

$1000 = 1/2 \times 10000a$

$1000 = 5000a$

$a = 1000/5000 = 0.2$ ms^{-2}

Now using 1st equation of motion

$V_f = V_i + at$

$V_f = 0 + 0.2 \times 100$

$V_f = 20\ ms^{-1}$

2.3 A car has a velocity of 10 ms^{-1}. It accelerates at 0.2 ms^{-2} for half minute. Find the distance travelled during this time and the final velocity of the car. (390 m, 16 ms^{-1})

Solution: Initial velocity = $V_i = 10\ ms^{-1}$

Acceleration $a = 0.2\ ms^{-2}$

Time $t = 0.5\ min = 0.5 \times 60 = 30\ s$

(I) Distance S =?

(II) Final velocity V_f =?

$S = V_i \times t + 1/2 \times a \times t^2$

$S = 10 \times 30 + 1/2 \times 0.2 \times (30)^2$

$S = 300 + 1/2 \times 0.2 \times 90$

$S = 300 + 1/2 \times 2/10 \times 90$

$S = 300 + 90$

$S = 390\ m$

(II) Using 1st equation of motion

$V_f = V_i + at$

$V_f = 10 + 0.2 \times 30$

$V_f = 10 + 6$

$V_f = 16\ ms^{-1}$

2.4 A tennis ball is hit vertically upward with a velocity of 30 ms^{-1}, it takes 3 s to reach the highest point. Calculate the maximum height reached by the ball. How long it will take to return to ground? (45 m, 6 s)

Solution: Initial velocity = $V_i = 30\ ms^{-1}$

Acceleration due to gravity g = -10 ms^{-2}

Time to reach maximum height = t = 3 s

Final velocity V_f = 0 ms^{-1}

(I) Maximum height attained by the ball S =?

(II) Time taken to return to ground t =?

$S = V_i x t + 1/2 x g x t^2$

$S = 30 \times 3 + 1/2 \times (-10) \times (3)^2$

$S = 90 - 5 \times 9$

$S = 90 - 45$

$S = 45$ m

Total time = time to reach maximum height + time to return to the ground

= 3 s + 3 s = 6 s

2.5 A car moves with uniform velocity of 40 ms^{-1} for 5 s. It comes to rest in the next 10 s with uniform deceleration.

Find:

(I) deceleration
(II) total distance travelled by the car.

(-4 ms^{-2}, 400 m)

Solution: Initial velocity = Vi = 40 ms^{-1}

Time = t = 5 s

Final velocity = Vf = 0 ms^{-1}

Time = 10 s

(I) deceleration a =?

(II) total distance S =?

$V_f = V_i + at$

Or $at = V_f - V_i$

$a = V_f - V_i/t$

$a = 0 - 40/10$

$a = -4\ ms^{-2}$

Total distance travelled = $S = S_1 + S_2$

By using this relation

$S_1 = V_f$

$S_1 = 40 \times 5$

$S_1 = 200\ m$ ..... (i)

Now by using 3rd equation of motion

$2aS_2 = V_f^2 - V_i^2$

$S_2 = V_f^2 - V_i^2/2a$

$S_2 = (0)2 - (40)2/2 \times (-4)$

$S_2 = -1600/-8$

$S_2 = 200\ m$ ..... (ii)

From (i) and (ii) we get;

$S = S_1 + S_2$

Or $S = 200\ m + 200\ m$

$S = 400\ m$

2.6 A train starts from rest with an acceleration of 0.5 ms^{-2}. Find its speed in kmh^{-1}, when it has moved through 100 m. (36 kmh^{-1})

Solution: Initial velocity $V_i = 0\ ms^{-1}$

Acceleration $a = 0.5\ ms^{-2}$

Distance $S = 100\ m$

Final velocity V_f =?

$2aS = Vf^2 - V_i^2$

$2 \times 0.5 \times 100 = Vf^2 - 0$

Or , $100 = Vf^2$

Or $Vf^2 = 100\ ms^{-1}$.....(I)

Speed in kmh^{-1}:

From (I) we get;

$V_f = 10 \times 3600/1000 = 36\ kmh^{-1}$

2.7 A train starting from rest, accelerates uniformly and attains a velocity 48 kmh^{-1} in 2 minutes. It travels at this speed for 5 minutes. Finally, it moves with uniform retardation and is stopped after 3 minutes. Find the total distance travelled by the train.

Solution: Case – I: (6000 m)

Initial velocity = $V_i = 0ms^{-1}$

Time = t = 2 minutes = 2x 60 = 120 s

Final velocity = $V_f = 48\ kmh^{-1} = 48 \times 1000/3600 = 13.333\ ms^{-1}$

$S_1 = V_{av} \times t$

$S_1 = (V_f + V_i)/2 \times t$

$S_1 = 13.333 + 0/2 \times 120$

$S_1 = 6.6665 \times 120$

S_1 = 799.99 m = 800 m

Case – II:

Uniform velocity = V_f = 13.333 ms^{-1}

Time = t = 5 minutes = 5 x 60 = 300 s

S_2 = v x t

S_2 = 13.333 x 300

S_2 = 3999.9 = 4000 m

Case – III:

Initial velocity = V_f = 13.333 ms^{-1}

Final velocity = V_i = 0 ms^{-1}

Time = t = 3 minutes = 3 x 60 = 180 s

$S_3 = V_{av} \times t$

$S_3 = (V_f + V_i)/2 \times 180$

S_3 = 13.333 + 0/2 x 180

S_3 = 6.6665 x 180

S_3 = 1199.97 = 1200 m

Total distance = $S = S_1 + S_2 + S_3$

S = 800 + 4000 + 1200

S = 6000 m

ClassNotes

2.8 A cricket ball is hit vertically upwards and returns to ground 6 s later. Calculate

(i) Maximum height reached by the ball

(ii) initial velocity of the ball (45m, 30 ms-1)

Solution: Acceleration due to gravity = g = -10 ms^{-1} (for upward motion)

Time to reach maximum height (one sided time) = t = 6/2 = 3 s

Velocity at maximum height = V_f = 0 ms^{-1}

(i) Maximum height reached by the ball S = h =?
(ii) Maximum initial velocity of the ball = V_i =?

Since, $V_f = V_i + gxt$

$V_i = V_f - gxt$

$V_i = 0 - (-10) \times 3$

$V_i = 30\ ms^{-1}$

Now using 3rd equation of motion

$2aS = V_{f2} - V_{i2}$

$S = V_{f2} - V_{i2}/2a$

$S = (0)2 - (30)2/2 \times (-10)$

$S = -90/-20$

$S = 45$ m

2.9 When brakes are applied, the speed of a train decreases from 96 kmh-1 to 48 kmh-1 in 800 m. How much further will the train move before coming to rest? (Assuming the retardation to be constant).
(266.66 m)

Solution: Initial velocity = V_i = 96 kmh^{-1} = 96 x 1000/3600 = 96000/3600 ms^{-1}

Final velocity = Vf = 48 kmh^{-1} = 48 x 1000/3600 = 48000/3600 ms^{-1}

Distance = S = 800 m

Further Distance = S_1 =?

First of all, we will find the value of acceleration a

$2aS = V_f^2 - V_i^2$

$2 \times a \times 800 = (48000/3600)^2 - (96000/3600)^2$

$1600a = (48000/3600)^2 - ((2 \times 48000)/3600)^2$ (96000 = 2 x 48000)

$1600a = (48000/3600)^2 ((1)^2 - (2)^2)$ (taking (48000/36000) as common)

$1600a = (48000/3600)^2 (1 - 4)$

$1600a = (48000/3600)^2 (-3)$

$a = (48000/3600)^2 \times 3/1600$

now, we will find the value of further distance S^2:

$V_f = 0$, S_2 =?

$2aS = V_f^2 - V_i^2$

$-2 (48000/36000)^2 \times 3/1600 \times S_1 = (0)^2 - (48000/36000)^2$

$S_1 = (48000/36000)^2 \times (48000/36000)^2 \times 1600/3 \times 2$

$S_1 = 1600/6$

$S_2 = 266.66m$

2.10 In the above problem, find the time taken by the train to stop after the application of brakes.
(80 s)

Solution: by taking the data from problem 2.9:

Initial velocity = V_i = 96 kmh^{-1} = 96 x 1000/3600 = 96000/3600 ms^{-1}

Final velocity = V_f = 0 ms^{-1}

a = -(48000/3600)^2 x 3/1600 ms^{-2}

time = t =?

Or $V_f = V_i + at$

Or $at = V_f - V_i$

$t = V_f - V_i/a$

t = 0 - (48000/3600)/-((48000/3600) x 1/1600

t = - 96000/3600 x (3600/48000)^2 x 1600/3

t = 2 x 48000/3600 x (3600/48000 x 3600/48000) x 1600/3

t = 2 x 3600/3 x 3

t = 2 x 40 = 80 s

ClassNotes