Vol 1 Chapter 3 - Rest and Motion Kinematics

CHAPTER – 3

1. a) Distance travelled = 50 + 40 + 20 = 110 m

   b) AF = AB – BF = AB – DC = 50 – 20 = 30 M

   His displacement is AD

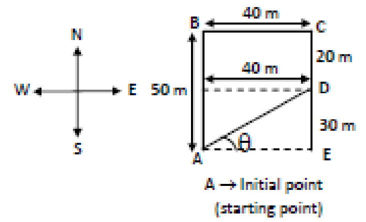
   AD = $\sqrt{AF^2 - DF^2} = \sqrt{30^2 + 40^2} = 50m$

   In ΔAED tan θ = DE/AE = 30/40 = 3/4

   $\Rightarrow \theta = \tan^{-1}(3/4)$

   His displacement from his house to the field is 50 m,

   $\tan^{-1}$ (3/4) north to east.

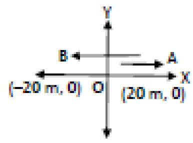


2. O → Starting point origin.

   i) Distance travelled = 20 + 20 + 20 = 60 m

   ii) Displacement is only OB = 20 m in the negative direction.

   Displacement → Distance between final and initial position.



3. a) V_{ave} of plane (Distance/Time) = 260/0.5 = 520 km/hr.

   b) V_{ave} of bus = 320/8 = 40 km/hr.

   c) plane goes in straight path

   velocity = $\vec{V}_{ave}$ = 260/0.5 = 520 km/hr.

   d) Straight path distance between plane to Ranchi is equal to the displacement of bus.

   $\therefore$ Velocity = $\vec{V}_{ave}$ = 260/8 = 32.5 km/hr.

4. a) Total distance covered 12416 – 12352 = 64 km in 2 hours.

   Speed = 64/2 = 32 km/h

   b) As he returns to his house, the displacement is zero.

   Velocity = (displacement/time) = 0 (zero).

5. Initial velocity u = 0 ($\because$ starts from rest)

   Final velocity v = 18 km/hr = 5 sec

   (i.e. max velocity)

   Time interval t = 2 sec.

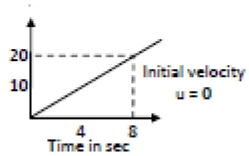
   $\therefore$ Acceleration = $a_{ave} = \frac{v-u}{t} = \frac{5}{2} = 2.5\ m/s^2$.

6. In the interval 8 sec the velocity changes from 0 to 20 m/s.

   Average acceleration = 20/8 = 2.5 m/s^2 $\left(\frac{\text{change in velocity}}{\text{time}}\right)$

   Distance travelled S = ut + 1/2 at^2

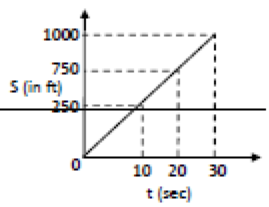
   $\Rightarrow 0 + 1/2(2.5)8^2 = 80$ m.



7. In 1st 10 sec $S_1 = ut + 1/2\ at^2 \Rightarrow 0 + (1/2 \times 5 \times 10^2) = 250$ ft.

   At 10 sec v = u + at = 0 + 5 × 10 = 50 ft/sec.

   $\therefore$ From 10 to 20 sec (Δt = 20 – 10 = 10 sec) it moves with uniform velocity 50 ft/sec,



Distance $S_2 = 50 \times 10 = 500$ ft

Between 20 sec to 30 sec acceleration is constant i.e. -5 ft/s^2. At 20 sec velocity is 50 ft/sec.

$t = 30 - 20 = 10$ s

$S_3 = ut + 1/2\ at^2$

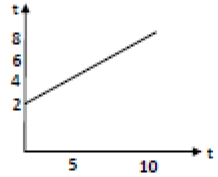
$= 50 \times 10 + (1/2)(-5)(10)^2 = 250$ m

Total distance travelled is 30 sec $= S_1 + S_2 + S_3 = 250 + 500 + 250 = 1000$ ft.

8. a) Initial velocity u = 2 m/s.

final velocity v = 8 m/s

time = 10 sec,



acceleration $= \dfrac{v-u}{ta} = \dfrac{8-2}{10} = 0.6$ m/s^2

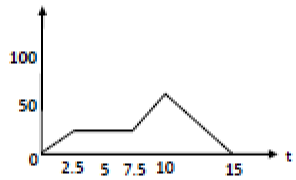
b) $v^2 - u^2 = 2aS$

$\Rightarrow$ Distance $S = \dfrac{v^2-u^2}{2a} = \dfrac{8^2-2^2}{2\times0.6} = 50$ m.

c) Displacement is same as distance travelled.

Displacement = 50 m.

9. a) Displacement in 0 to 10 sec is 1000 m.



(slope of the graph at t = 2 sec)

time = 10 sec.

$V_{ave} = s/t = 100/10 = 10$ m/s.

b) At 2 sec it is moving with uniform velocity 50/2.5 = 20 m/s.

at 2 sec. $V_{inst} = 20$ m/s.

At 5 sec it is at rest.

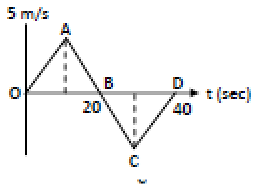
V_{inst} = zero.

At 8 sec it is moving with uniform velocity 20 m/s

$V_{inst} = 20$ m/s

At 12 sec velocity is negative as it move towards initial position. $V_{inst} = -20$ m/s.

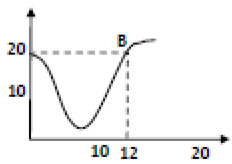
10. Distance in first 40 sec is, Δ OAB + ΔBCD



$= \frac{1}{2} \times 5 \times 20 + \frac{1}{2} \times 5 \times 20 = 100$ m.

Average velocity is 0 as the displacement is zero.

11. Consider the point B, at t = 12 sec



At t = 0 ; s = 20 m

and t = 12 sec s = 20 m

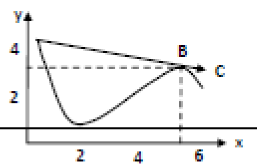
So for time interval 0 to 12 sec

Change in displacement is zero.

So, average velocity = displacement/ time = 0

$\therefore$ The time is 12 sec.

12. At position B instantaneous velocity has direction along $\overrightarrow{BC}$. For average velocity between A and B.



V_{ave} = displacement / time $= (\overrightarrow{AB}/t)$ t = time

We can see that $\overrightarrow{AB}$ is along $\overrightarrow{BC}$ i.e. they are in same direction.

The point is B (5m, 3m).

13. $u = 4$ m/s, $a = 1.2$ m/s^2, $t = 5$ sec

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

$= 4(5) + 1/2\,(1.2)5^2 = 35$ m.

14. Initial velocity $u = 43.2$ km/hr $= 12$ m/s

$u = 12$ m/s, $v = 0$

$a = -6$ m/s^2 (deceleration)

Distance $S = \frac{v^2 - u^2}{2(-6)} = 12$ m

15. Initial velocity $u = 0$

Acceleration $a = 2$ m/s^2. Let final velocity be v (before applying breaks)

$t = 30$ sec

$v = u + at \Rightarrow 0 + 2 \times 30 = 60$ m/s

a) $S_1 = ut + \frac{1}{2}at^2 = 900$ m

when breaks are applied $u' = 60$ m/s

$v' = 0$, $t = 60$ sec (1 min)

Declaration $a' = (v - u)/t = = (0 - 60)/60 = -1$ m/s^2.

$S_2 = \frac{v'^2 - u'^2}{2a'} = 1800$ m

Total $S = S_1 + S_2 = 1800 + 900 = 2700$ m $= 2.7$ km.

b) The maximum speed attained by train $v = 60$ m/s

c) Half the maximum speed $= 60/2 = 30$ m/s

Distance $S = \frac{v^2 - u^2}{2a} = \frac{30^2 - 0^2}{2 \times 2} = 225$ m from starting point

When it accelerates the distance travelled is 900 m. Then again declarates and attain 30 m/s.

$\therefore$ $u = 60$ m/s, $v = 30$ m/s, $a = -1$ m/s^2

Distance $= \frac{v^2 - u^2}{2a} = \frac{30^2 - 60^2}{2(-1)} = 1350$ m

Position is $900 + 1350 = 2250 = 2.25$ km from starting point.

16. $u = 16$ m/s (initial), $v = 0$, $s = 0.4$ m.

Deceleration $a = \frac{v^2 - u^2}{2s} = -320$ m/s^2.

Time $= t = \frac{v - u}{a} = \frac{0 - 16}{-320} = 0.05$ sec.

17. $u = 350$ m/s, $s = 5$ cm $= 0.05$ m, $v = 0$

Deceleration $= a = \frac{v^2 - u^2}{2s} = \frac{0 - (350)^2}{2 \times 0.05} = -12.2 \times 10^5$ m/s^2.

Deceleration is 12.2×10^5 m/s^2.

18. $u = 0$, $v = 18$ km/hr = 5 m/s, $t = 5$ sec

$$a = \frac{v-u}{t} = \frac{5-0}{5} = 1 \text{ m/s}^2.$$

$$s = ut + \frac{1}{2}at^2 = 12.5 \text{ m}$$

a) Average velocity $V_{ave} = (12.5)/5 = 2.5$ m/s.

b) Distance travelled is 12.5 m.

19. In reaction time the body moves with the speed 54 km/hr = 15 m/sec (constant speed)

Distance travelled in this time is $S_1 = 15 \times 0.2 = 3$ m.

When brakes are applied,

$u = 15$ m/s, $v = 0$, $a = -6$ m/s^2 (deceleration)

$$S_2 = \frac{v^2 - u^2}{2a} = \frac{0 - 15^2}{2(-6)} = 18.75 \text{ m}$$

Total distance $s = s_1 + s_2 = 3 + 18.75 = 21.75 = 22$ m.

20.

	Driver X Reaction time 0.25	Driver Y Reaction time 0.35
A (deceleration on hard braking = 6 m/s^2)	Speed = 54 km/h Braking distance a= 19 m Total stopping distance b = 22 m	Speed = 72 km/h Braking distance c = 33 m Total stopping distance d = 39 m.
B (deceleration on hard braking = 7.5 m/s^2)	Speed = 54 km/h Braking distance e = 15 m Total stopping distance f = 18 m	Speed = 72 km/h Braking distance g = 27 m Total stopping distance h = 33 m.

$$a = \frac{0^2 - 15^2}{2(-6)} = 19 \text{ m}$$

So, b = 0.2 × 15 + 19 = 33 m

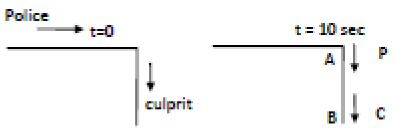
Similarly other can be calculated.

Braking distance : Distance travelled when brakes are applied.

Total stopping distance = Braking distance + distance travelled in reaction time.

21. V_P = 90 km/h = 25 m/s.

V_C = 72 km/h = 20 m/s.



In 10 sec culprit reaches at point B from A.

Distance converted by culprit S = vt = 20 × 10 = 200 m.

At time t = 10 sec the police jeep is 200 m behind the culprit.

Time = s/v = 200 / 5 = 40 s. (Relative velocity is considered).

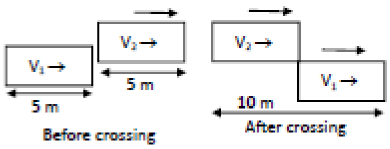
In 40 s the police jeep will move from A to a distance S, where

S = vt = 25 × 40 = 1000 m = 1.0 km away.

∴ The jeep will catch up with the bike, 1 km far from the turning.

22. v_1 = 60 km/hr = 16.6 m/s.

v_2 = 42 km/h = 11.6 m/s.



Relative velocity between the cars = (16.6 – 11.6) = 5 m/s.

Distance to be travelled by first car is 5 + t = 10 m.

Time = t = s/v = 0/5 = 2 sec to cross the 2^{nd} car.

In 2 sec the 1^{st} car moved = 16.6 × 2 = 33.2 m

H also covered its own length 5 m.

∴ Total road distance used for the overtake = 33.2 + 5 = 38 m.