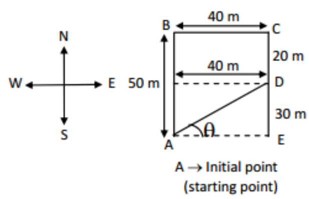
August 7, 2016 by phani

Rest and Motion Kinematics HC Verma Concepts of Physics Solutions

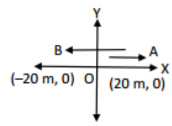
Rest and Motion Kinematics HC Verma Solutions to Concepts Chapter 3

SOLUTIONS TO CONCEPTS
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
   ⇒ θ = $\tan^{-1}$ (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.

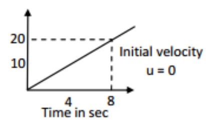


3. a) V_{ave} of plane (Distance/Time) = 260/0.5 = 520 km/hr.
   b) V_{ave} of bus = 320/8 = 40 km/hr.
   c) plane goes in straight path
   velocity = $\vec{V}_{ave}$ = 260/0.5 = 520 km/hr.
   d) Straight path distance between plane to Ranchi is equal to the displacement of bus.
   ∴ Velocity = $\vec{V}_{ave}$ = 260/8 = 32.5 km/hr.

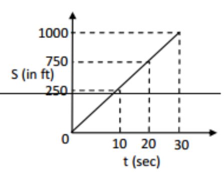
4. a) Total distance covered 12416 – 12352 = 64 km in 2 hours.
   Speed = 64/2 = 32 km/h
   b) As he returns to his house, the displacement is zero.
   Velocity = (displacement/time) = 0 (zero).

5. Initial velocity u = 0 (∴ starts from rest)
   Final velocity v = 18 km/hr = 5 sec
   (i.e. max velocity)
   Time interval t = 2 sec.
   ∴ 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
   ⇒ 0 + 1/2(2.5)8^2 = 80 m.

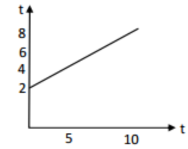


7. In 1st 10 sec S_1 = ut + 1/2 at^2 ⇒ 0 + (1/2 × 5 × 10^2) = 250 ft.
   At 10 sec v = u + at = 0 + 5 × 10 = 50 ft/sec.
   ∴ From 10 to 20 sec (Δt = 20 – 10 = 10 sec) it moves with uniform velocity 50 ft/sec,



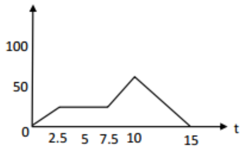
Total distance travelled is 30 sec = $S_1 + S_2 + S_3 = 250 + 500 + 250 = 1000$ ft.

8. a) Initial velocity u = 2 m/s.
final velocity v = 8 m/s
time = 10 sec,
acceleration = $\frac{v-u}{ta} = \frac{8-2}{10} = 0.6\ m/s^2$



b) $v^2 - u^2 = 2aS$
$\Rightarrow$ Distance S = $\frac{v^2-u^2}{2a} = \frac{8^2-2^2}{2\times 0.6} = 50$ m.
c) Displacement is same as distance travelled.
Displacement = 50 m.

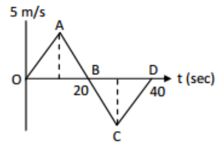
9. a) Displacement in 0 to 10 sec is 1000 m.
time = 10 sec.
$V_{ave} = s/t = 100/10 = 10$ m/s.
b) At 2 sec it is moving with uniform velocity 50/2.5 = 20 m/s.
at 2 sec. $V_{inst} = 20$ m/s.
At 5 sec it is at rest.



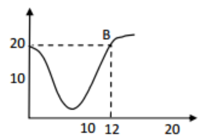
(slope of the graph at t = 2 sec)

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.

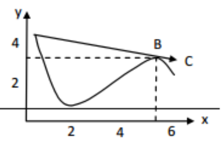
10. Distance in first 40 sec is, Δ OAB + ΔBCD
$= \frac{1}{2}\times 5 \times 20 + \frac{1}{2}\times 5 \times 20 = 100$ m.
Average velocity is 0 as the displacement is zero.



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

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

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

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

$S_2 = \dfrac{v'^2 - u'^2}{2a'} = 1800$ 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 $S = \dfrac{v^2 - u^2}{2a} = \dfrac{30^2 - 0^2}{2 \times 2} = 225$ 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 $= \dfrac{v^2 - u^2}{2a} = \dfrac{30^2 - 60^2}{2(-1)} = 1350$ 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 $a = \dfrac{v^2 - u^2}{2s} = -320\ m/s^2$.

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

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

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

Deceleration is $12.2 \times 10^5\ m/s^2$.

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

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

$s = ut + \dfrac{1}{2}at^2 = 12.5$ 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.

	Total stopping distance b = 22 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.

$a = \dfrac{0^2 - 15^2}{2(-6)} = 19$ 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.

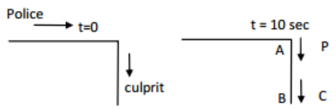
21. V_P = 90 km/h = 25 m/s.

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.

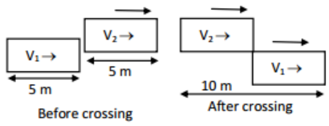
Relative velocity between the cars = (16.6 – 11.6) = 5 m/s.

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

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

In 2 sec the 1st 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.

23. u = 50 m/s, g = –10 m/s^2 when moving upward, v = 0 (at highest point).

a) $S = \dfrac{v^2 - u^2}{2a} = \dfrac{0 - 50^2}{2(-10)} = 125$ m

maximum height reached = 125 m

b) t = (v – u)/a = (0 – 50)/–10 = 5 sec

c) s′ = 125/2 = 62.5 m, u = 50 m/s, a = –10 m/s^2,

$v^2 - u^2 = 2as$

$\Rightarrow v = \sqrt{(u^2 + 2as)} = \sqrt{50^2 + 2(-10)(62.5)} = 35$ m/s.

24. Initially the ball is going upward

u = –7 m/s, s = 60 m, a = g = 10 m/s^2

$s = ut + \frac{1}{2}at^2 \Rightarrow 60 = -7t + 1/2\ 10t^2$

$\Rightarrow 5t^2 - 7t - 60 = 0$

$t = \dfrac{7 \pm \sqrt{49 - 4.5(-60)}}{2 \times 5} = \dfrac{7 \pm 35.34}{10}$

taking positive sign $t = \dfrac{7 + 35.34}{10} = 4.2$ sec ($\therefore t \neq -ve$)

Therefore, the ball will take 4.2 sec to reach the ground.

25. u = 28 m/s, v = 0, a = –g = –9.8 m/s^2

a) $S = \dfrac{v^2 - u^2}{2a} = \dfrac{0^2 - 28^2}{2(9.8)} = 40$ m

b) time $t = \dfrac{v - u}{a} = \dfrac{0 - 28}{-9.8} = 2.85$

t′ = 2.85 – 1 = 1.85

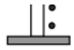
v′ = u + at′ = 28 – (9.8) (1.85) = 9.87 m/s.

∴ The velocity is 9.87 m/s.

c) No it will not change. As after one second velocity becomes zero for any initial velocity and deceleration is g = 9.8 m/s^2 remains same. Fro initial velocity more than 28 m/s max height increases.

For 4[th] ball, t = 2 sec

$S_2 = 0 + 1/2\ gt^2 = 1/2\ (9.8)2^2 = 19.6$ m below the top (u = 0)



For 5[th] ball, t = 1 sec

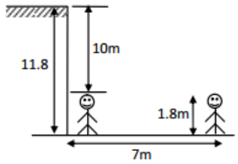
$S_3 = ut + 1/2\ at^2 = 0 + 1/2\ (9.8)t^2 = 4.98$ m below the top.

27. At point B (i.e. over 1.8 m from ground) the kid should be catched.

For kid initial velocity u = 0

Acceleration = 9.8 m/s^2

Distance S = 11.8 – 1.8 = 10 m



$S = ut + \frac{1}{2}at^2 \Rightarrow 10 = 0 + 1/2\ (9.8)t^2$

$\Rightarrow t^2 = 2.04 \Rightarrow t = 1.42.$

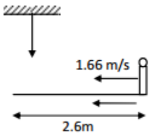
In this time the man has to reach at the bottom of the building.

Velocity s/t = 7/1.42 = 4.9 m/s.

28. Let the true of fall be 't' initial velocity u = 0

Acceleration a = 9.8 m/s^2

Distance S = 12/1 m



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

$\Rightarrow 12.1 = 0 + 1/2\ (9.8) \times t^2$

$\Rightarrow t^2 = \frac{12.1}{4.9} = 2.46 \Rightarrow t = 1.57$ sec

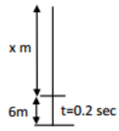
For cadet velocity = 6 km/hr = 1.66 m/sec

Distance = vt = 1.57 × 1.66 = 2.6 m.

The cadet, 2.6 m away from tree will receive the berry on his uniform.

29. For last 6 m distance travelled s = 6 m, u = ?

t = 0.2 sec, a = g = 9.8 m/s^2



$S = ut + \frac{1}{2}at^2 \Rightarrow 6 = u(0.2) + 4.9 \times 0.04$

$\Rightarrow u = 5.8/0.2 = 29$ m/s.

For distance x, u = 0, v = 29 m/s, a = g = 9.8 m/s^2

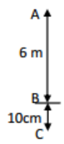
$S = \frac{v^2 - u^2}{2a} = \frac{29^2 - 0^2}{2 \times 9.8} = 42.05$ m

Total distance = 42.05 + 6 = 48.05 = 48 m.

30. Consider the motion of ball form A to B.

B $\rightarrow$ just above the sand (just to penetrate)

u = 0, a = 9.8 m/s^2, s = 5 m



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

$\Rightarrow 5 = 0 + 1/2\ (9.8)t^2$

$\Rightarrow t^2 = 5/4.9 = 1.02 \Rightarrow t = 1.01.$

$\therefore$ velocity at B, v = u + at = 9.8 × 1.01 (u = 0) =9.89 m/s.

From motion of ball in sand

$u_1 = 9.89$ m/s, $v_1 = 0$, a = ?, s = 10 cm = 0.1 m.

$a = \frac{v_1^2 - u_1^2}{2s} = \frac{0-(9.89)^2}{2 \times 0.1} = -490$ m/s^2

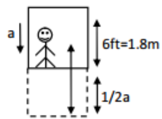
The retardation in sand is 490 m/s^2.

31. For elevator and coin u = 0

As the elevator descends downward with acceleration a' (say)

The coin has to move more distance than 1.8 m to strike the floor. Time taken t = 1 sec.

$S_c = ut + \frac{1}{2}a't^2 = 0 + 1/2\ g(1)^2 = 1/2\ g$



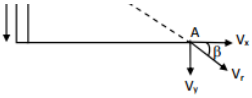
$S_e = ut + \frac{1}{2}at^2 = u + 1/2\ a(1)^2 = 1/2\ a$

Total distance covered by coin is given by = 1.8 + 1/2 a = 1/2 g

$\Rightarrow 1.8 + a/2 = 9.8/2 = 4.9$

$\Rightarrow a = 6.2$ m/s^2 = 6.2 × 3.28 = 20.34 ft/s^2.

32. It is a case of projectile fired horizontally from a height.



c) Horizontal velocity remains constant through out the motion.

At A, V = 20 m/s

A $V_y = u + at = 0 + 9.8 \times 4.5 = 44.1$ m/s.

Resultant velocity $V_r = \sqrt{(44.1)^2 + 20^2} = 48.42$ m/s.

$\text{Tan } \beta = \frac{V_y}{V_x} = \frac{44.1}{20} = 2.205$

$\Rightarrow \beta = \tan^{-1}(2.205) = 60°$.

The ball strikes the ground with a velocity 48.42 m/s at an angle 66° with horizontal.

33. u = 40 m/s, a = g= 9.8 m/s^2, θ = 60° Angle of projection.

a) Maximum height $h = \frac{u^2 \sin^2 \theta}{2g} = \frac{40^2(\sin 60°)^2}{2 \times 10} = 60$ m

b) Horizontal range $X = (u^2 \sin 2\theta) / g = (40^2 \sin 2(60°)) / 10 = 80\sqrt{3}$ m.

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