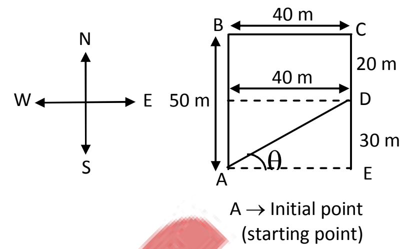
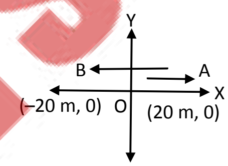
SOLUTIONS TO CONCEPTS
CHAPTER – 3

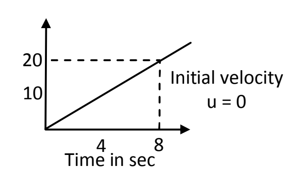
1. a) Distance travelled = 50 + 40 + 20 = 110 m
   b) AF = AB – BF = AB – DC = 50 – 20 = 30 M
   His displacement is AD
   AD = $\sqrt{AF^2 - DF^2} = \sqrt{30^2 + 40^2} = 50m$
   In ΔAED tan θ = DE/AE = 30/40 = 3/4
   $\Rightarrow \theta = \tan^{-1}(3/4)$
   His displacement from his house to the field is 50 m,
   $\tan^{-1}(3/4)$ north to east.



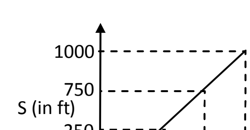
2. O → Starting point origin.
   i) Distance travelled = 20 + 20 + 20 = 60 m
   ii) Displacement is only OB = 20 m in the negative direction.
   Displacement → Distance between final and initial position.



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 ($\therefore$ 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 × 5 × 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

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

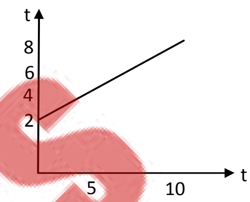
$= 50 \times 10 + (1/2)(-5)(10)^2 = 250$ m

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 $= \dfrac{v^2-u^2}{2a} = \dfrac{8^2-2^2}{2\times 0.6} = 50$ m.

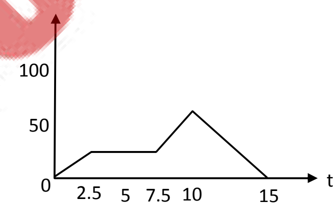
c) Displacement is same as distance travelled.

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.



(slope of the graph at t = 2 sec)

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

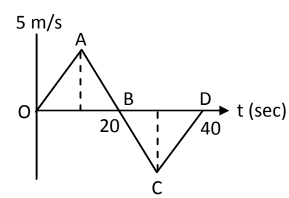
$V_{inst} = 20$ m/s

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

$= \dfrac{1}{2} \times 5 \times 20 + \dfrac{1}{2} \times 5 \times 20 = 100$ 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

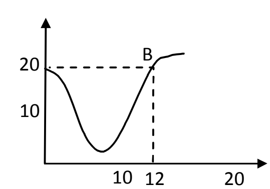
and t = 12 sec s = 20 m

So for time interval 0 to 12 sec

Change in displacement is zero.

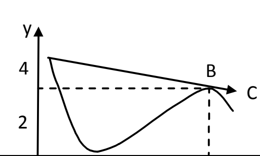
So, average velocity = displacement/ time = 0

$\therefore$ 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

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

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

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

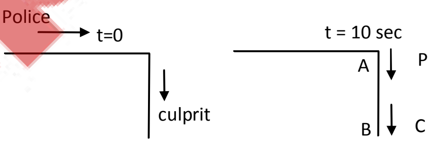
Similarly other can be calculated.

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.

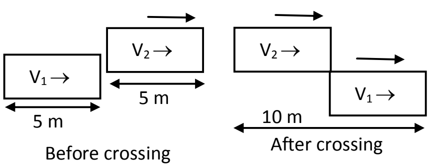
Relative velocity between the cars = (16.6 – 11.6) = 5 m/s.

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.

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

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

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

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

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

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

taking positive sign $t = \frac{7 + 35.34}{10} = 4.2$ 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) $S = \frac{v^2 - u^2}{2a} = \frac{0^2 - 28^2}{2(9.8)} = 40$ m

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

$t' = 2.85 - 1 = 1.85$

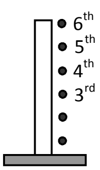
$v' = u + at' = 28 - (9.8)(1.85) = 9.87$ m/s.

$\therefore$ 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.

26. For every ball, $u = 0$, $a = g = 9.8$ m/s^2

$\therefore$ 4th ball move for 2 sec, 5th ball 1 sec and 3rd ball 3 sec when 6th ball is being dropped.



For 3rd ball t = 3 sec

$S_3 = ut + \frac{1}{2}at^2 = 0 + 1/2\ (9.8)3^2 = 4.9$ m below the top.

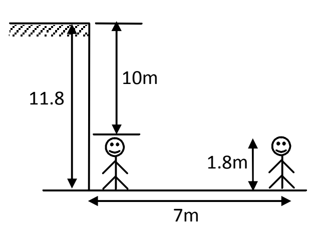
For 4th ball, t = 2 sec

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

For 5th 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

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

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

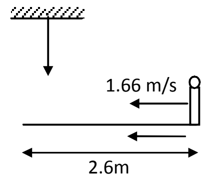
In this time the man has to reach at the bottom of the building.

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) × t^2

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

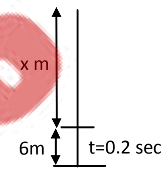
For cadet velocity = 6 km/hr = 1.66 m/sec

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 × 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

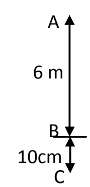
$S = \frac{v^2 - u^2}{2a} = \frac{29^2 - 0^2}{2 \times 9.8} = 42.05$ m

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

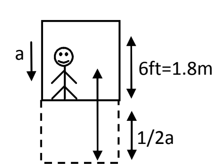
The retardation in sand is 490 m/s^2.

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

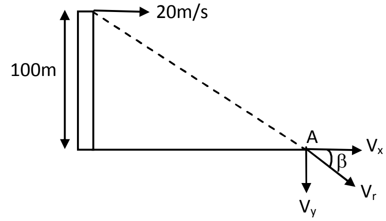
$\Rightarrow$ a = 6.2 m/s^2 = 6.2 × 3.28 = 20.34 ft/s^2.

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

$h = 100$ m, $g = 9.8$ m/s^2

a) Time taken to reach the ground $t = \sqrt{(2h/g)}$

$= \sqrt{\dfrac{2 \times 100}{9.8}} = 4.51$ sec.



b) Horizontal range $x = ut = 20 \times 4.5 = 90$ m.

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.

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

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

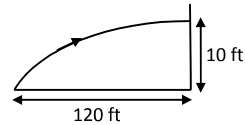
The ball strikes the ground with a velocity 48.42 m/s at an angle 66° with horizontal.

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

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

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

34. $g = 9.8\ m/s^2$, $32.2\ ft/s^2$; 40 yd = 120 ft



horizontal range x = 120 ft, u = 64 ft/s, $\theta = 45°$

We know that horizontal range $X = u \cos \theta t$

$$\Rightarrow t = \frac{x}{u\cos\theta} = \frac{120}{64\cos 45°} = 2.65 \text{ sec.}$$

$$y = u \sin \theta(t) - 1/2\, gt^2 = 64\frac{1}{\sqrt{2}(2.65)} - \frac{1}{2}(32.2)(2.65)^2$$

= 7.08 ft which is less than the height of goal post.

In time 2.65, the ball travels horizontal distance 120 ft (40 yd) and vertical height 7.08 ft which is less than 10 ft. The ball will reach the goal post.

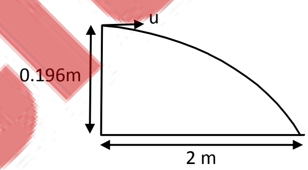
35. The goli move like a projectile.

Here h = 0.196 m

Horizontal distance X = 2 m

Acceleration $g = 9.8\ m/s^2$.

Time to reach the ground i.e.



$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2\times 0.196}{9.8}} = 0.2 \text{ sec}$$

Horizontal velocity with which it is projected be u.

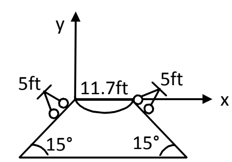
$\therefore x = ut$

$$\Rightarrow u = \frac{x}{t} = \frac{2}{0.2} = 10 \text{ m/s.}$$

36. Horizontal range X = 11.7 + 5 = 16.7 ft covered by te bike.

$g = 9.8\ m/s^2 = 32.2\ ft/s^2$.

$$y = x \tan \theta - \frac{gx^2 \sec^2\theta}{2u^2}$$



To find, minimum speed for just crossing, the ditch

y = 0 ($\therefore$ A is on the x axis)

$$\Rightarrow x \tan \theta = \frac{gx^2\sec^2\theta}{2u^2} \Rightarrow u^2 = \frac{gx^2\sec^2\theta}{2x\tan\theta} = \frac{gx}{2\sin\theta\cos\theta} = \frac{gx}{\sin 2\theta}$$

$$\Rightarrow u = \sqrt{\frac{(32.2)(16.7)}{1/2}} \text{ (because } \sin 30° = 1/2)$$

$\Rightarrow$ u = 32.79 ft/s = 32 ft/s.

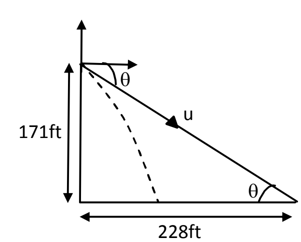
37. $\tan \theta = 171/228 \Rightarrow \theta = \tan^{-1}(171/228)$

The motion of projectile (i.e. the packed) is from A. Taken reference axis at A.

$\therefore \theta = -37°$ as u is below x-axis.

$u = 15$ ft/s, $g = 32.2\ ft/s^2$, $y = -171$ ft

$$y = x \tan \theta - \frac{x^2 g \sec^2\theta}{2u^2}$$



$$\therefore -171 = -x\,(0.7536) - \frac{x^2 g(1.568)}{2(225)}$$

$$\Rightarrow 0.1125x^2 + 0.7536\,x - 171 = 0$$

x = 35.78 ft (can be calculated)

Horizontal range covered by the packet is 35.78 ft.

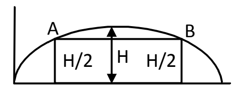
So, the packet will fall 228 – 35.78 = 192 ft short of his friend.

38. Here u = 15 m/s, θ = 60°, g = 9.8 m/s^2

Horizontal range X = $\frac{u^2 \sin 2\theta}{g} = \frac{(15)^2 \sin(2\times 60°)}{9.8}$ = 19.88 m

In first case the wall is 5 m away from projection point, so it is in the horizontal range of projectile. So the ball will hit the wall. In second case (22 m away) wall is not within the horizontal range. So the ball would not hit the wall.

39. Total of flight T = $\frac{2u\sin\theta}{g}$



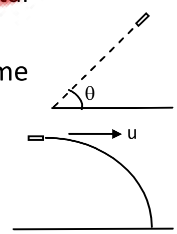
Average velocity = $\frac{\text{change in displacement}}{\text{time}}$

From the figure, it can be said AB is horizontal. So there is no effect of vertical component of the velocity during this displacement.

So because the body moves at a constant speed of 'u cos θ' in horizontal direction.

The average velocity during this displacement will be u cos θ in the horizontal direction.

40. During the motion of bomb its horizontal velocity u remains constant and is same



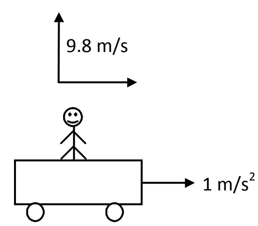
as that of aeroplane at every point of its path. Suppose the bomb explode i.e. reach the ground in time t. Distance travelled in horizontal direction by bomb = ut = the distance travelled by aeroplane. So bomb explode vertically below the aeroplane.

Suppose the aeroplane move making angle θ with horizontal. For both bomb and aeroplane, horizontal distance is u cos θ t. t is time for bomb to reach the ground.

So in this case also, the bomb will explode vertically below aeroplane.

41. Let the velocity of car be u when the ball is thrown. Initial velocity of car is = Horizontal velocity of ball.

Distance travelled by ball B S_b = ut (in horizontal direction)



And by car S_c = ut + 1/2 at^2 where t $\to$ time of flight of ball in air.

$\therefore$ Car has travelled extra distance $S_c - S_b$ = 1/2 at^2.

Ball can be considered as a projectile having θ = 90°.

$\therefore$ t = $\frac{2u\sin\theta}{g} = \frac{2\times 9.8}{9.8}$ = 2 sec.

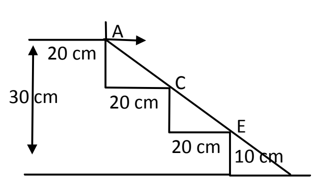
$\therefore$ $S_c - S_b$ = 1/2 at^2 = 2 m

$\therefore$ The ball will drop 2m behind the boy.

42. At minimum velocity it will move just touching point E reaching the ground.

A is origin of reference coordinate.

If u is the minimum speed.



X = 40, Y = –20, θ = 0°

$\therefore$ Y = x tan θ – g $\frac{x^2 \sec^2\theta}{2u^2}$ (because g = 10 m/s^2 = 1000 cm/s^2)

$\Rightarrow$ –20 = x tan θ – $\frac{1000 \times 40^2 \times 1}{2u^2}$

$\Rightarrow$ u = 200 cm/s = 2 m/s.

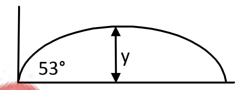
$\therefore$ The minimum horizontal velocity is 2 m/s.

43. a) As seen from the truck the ball moves vertically upward comes back. Time taken = time taken by truck to cover 58.8 m.

$\therefore$ time = $\frac{s}{v} = \frac{58.8}{14.7}$ = 4 sec. (V = 14.7 m/s of truck)

u = ?, v = 0, g = –9.8 m/s^2 (going upward), t = 4/2 = 2 sec.

v = u + at $\Rightarrow$ 0 = u – 9.8 × 2 $\Rightarrow$ u = 19.6 m/s. (vertical upward velocity).



b) From road it seems to be projectile motion.

Total time of flight = 4 sec

In this time horizontal range covered 58.8 m = x

$\therefore$ X = u cos θ t

$\Rightarrow$ u cos θ = 14.7 ...(1)

Taking vertical component of velocity into consideration.

$$y = \frac{0^2 - (19.6)^2}{2 \times (-9.8)} = 19.6 \text{ m [from (a)]}$$

$\therefore$ y = u sin θ t – 1/2 gt^2

$\Rightarrow$ 19.6 = u sin θ (2) – 1/2 (9.8)2^2 $\Rightarrow$ 2u sin θ = 19.6 × 2

$\Rightarrow$ u sin θ = 19.6 ...(ii)

$$\frac{u\sin\theta}{u\cos\theta} = \tan\theta \Rightarrow \frac{19.6}{14.7} = 1.333$$

$\Rightarrow \theta = \tan^{-1}$ (1.333) = 53°

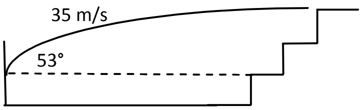
Again u cos θ = 14.7

$$\Rightarrow u = \frac{14.7}{u\cos 53^\circ} = 24.42 \text{ m/s.}$$

The speed of ball is 42.42 m/s at an angle 53° with horizontal as seen from the road.

44. θ = 53°, so cos 53° = 3/5

Sec^2 θ = 25/9 and tan θ = 4/3



Suppose the ball lands on nth bench

So, y = (n – 1)1 ...(1) [ball starting point 1 m above ground]

Again $y = x\tan\theta - \frac{gx^2\sec^2\theta}{2u^2}$ [x = 110 + n – 1 = 110 + y]

$$\Rightarrow y = (110 + y)(4/3) - \frac{10(110+y)^2(25/9)}{2 \times 35^2}$$

$$\Rightarrow \frac{440}{3} + \frac{4}{3}y - \frac{250(110+y)^2}{18 \times 35^2}$$

From the equation, y can be calculated.

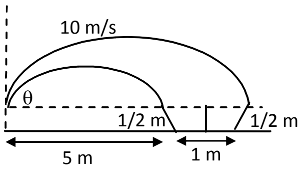
$\therefore$ y = 5

$\Rightarrow$ n – 1 = 5 $\Rightarrow$ n = 6.

The ball will drop in sixth bench.

45. When the apple just touches the end B of the boat.

x = 5 m, u = 10 m/s, g = 10 m/s^2, θ = ?



$x = \dfrac{u^2 \sin 2\theta}{g}$

$\Rightarrow 5 = \dfrac{10^2 \sin 2\theta}{10} \Rightarrow 5 = 10 \sin 2\theta$

$\Rightarrow \sin 2\theta = 1/2 \Rightarrow \sin 30° \text{ or } \sin 150°$

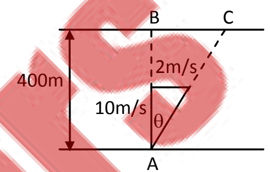
$\Rightarrow \theta = 15° \text{ or } 75°$

Similarly for end C, x = 6 m

Then $2\theta_1 = \sin^{-1}(gx/u^2) = \sin^{-1}(0.6) = 182°$ or 71°.

So, for a successful shot, θ may very from 15° to 18° or 71° to 75°.

46. a) Here the boat moves with the resultant velocity R. But the vertical component 10 m/s takes him to the opposite shore.



Tan θ = 2/10 = 1/5

Velocity = 10 m/s

distance = 400 m

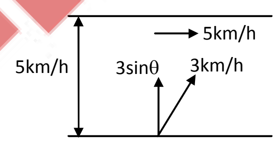
Time = 400/10 = 40 sec.

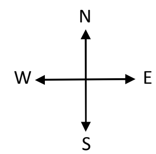
b) The boat will reach at point C.

In ΔABC, $\tan\theta = \dfrac{BC}{AB} = \dfrac{BC}{400} = \dfrac{1}{5}$

$\Rightarrow BC = 400/5 = 80$ m.

47. a) The vertical component 3 sin θ takes him to opposite side.



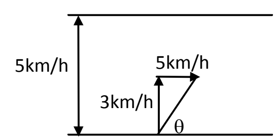


Distance = 0.5 km, velocity = 3 sin θ km/h

$\text{Time} = \dfrac{\text{Distance}}{\text{Velocity}} = \dfrac{0.5}{3\sin\theta}\text{ hr}$

= 10/sinθ min.

b) Here vertical component of velocity i.e. 3 km/hr takes him to opposite side.



$\text{Time} = \dfrac{\text{Distance}}{\text{Velocity}} = \dfrac{0.5}{3} = 0.16\text{ hr}$

∴ 0.16 hr = 60 × 0.16 = 9.6 = 10 minute.

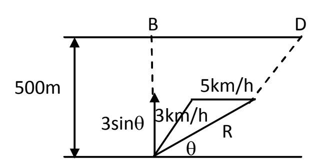
48. Velocity of man $\vec{V}_m = 3$ km/hr

BD horizontal distance for resultant velocity R.

X-component of resultant $R_x = 5 + 3\cos\theta$

t = 0.5 / 3sinθ

which is same for horizontal component of velocity.



$H = BD = (5 + 3\cos\theta)(0.5 / 3\sin\theta) = \dfrac{5 + 3\cos\theta}{6\sin\theta}$

For H to be min (dH/dθ) = 0

$\Rightarrow \dfrac{d}{d\theta}\left(\dfrac{5+3\cos\theta}{6\sin\theta}\right) = 0$

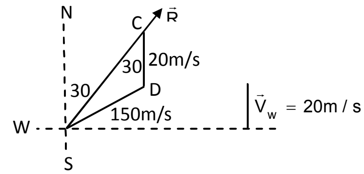
$\Rightarrow -18(\sin^2\theta + \cos^2\theta) - 30\cos\theta = 0$

$\Rightarrow -30\cos\theta = 18 \Rightarrow \cos\theta = -18/30 = -3/5$

$\text{Sin}\,\theta = \sqrt{1-\cos^2\theta} = 4/5$

$\therefore H = \dfrac{5+3\cos\theta}{6\sin\theta} = \dfrac{5+3(-3/5)}{6\times(4/5)} = \dfrac{2}{3}\,\text{km.}$

49. In resultant direction $\vec{R}$ the plane reach the point B.



Velocity of wind $\vec{V}_w = 20$ m/s

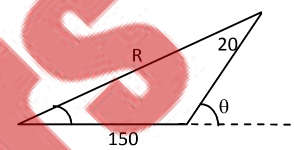
Velocity of aeroplane $\vec{V}_a = 150$ m/s

In ΔACD according to sine formula

$\therefore \dfrac{20}{\sin A} = \dfrac{150}{\sin 30°} \Rightarrow \sin A = \dfrac{20}{150}\sin 30° = \dfrac{20}{150}\times\dfrac{1}{2} = \dfrac{1}{15}$

$\Rightarrow A = \sin^{-1}(1/15)$

a) The direction is $\sin^{-1}(1/15)$ east of the line AB.



b) $\sin^{-1}(1/15) = 3°48'$

$\Rightarrow 30° + 3°48' = 33°48'$

$R = \sqrt{150^2 + 20^2 + 2(150)20\cos 33°48'} = 167$ m/s.

Time $= \dfrac{s}{v} = \dfrac{500000}{167} = 2994$ sec $= 49 = 50$ min.

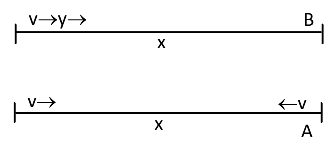
50. Velocity of sound v, Velocity of air u, Distance between A and B be x.

In the first case, resultant velocity of sound = v + u

$\Rightarrow (v+u)\,t_1 = x$

$\Rightarrow v + u = x/t_1$ ...(1)

In the second case, resultant velocity of sound = v – u



$\therefore (v-u)\,t_2 = x$

$\Rightarrow v - u = x/t_2$ ...(2)

From (1) and (2) $2v = \dfrac{x}{t_1} + \dfrac{x}{t_2} = x\left(\dfrac{1}{t_1} + \dfrac{1}{t_2}\right)$

$\Rightarrow v = \dfrac{x}{2}\left(\dfrac{1}{t_1} + \dfrac{1}{t_2}\right)$

From (i) $u = \dfrac{x}{t_1} - v = \dfrac{x}{t_1} - \left(\dfrac{x}{2t_1} + \dfrac{x}{2t_2}\right) = \dfrac{x}{2}\left(\dfrac{1}{t_1} - \dfrac{1}{t_2}\right)$

$\therefore$ Velocity of air $V = \dfrac{x}{2}\left(\dfrac{1}{t_1} + \dfrac{1}{t_2}\right)$

And velocity of wind $u = \dfrac{x}{2}\left(\dfrac{1}{t_1} - \dfrac{1}{t_2}\right)$

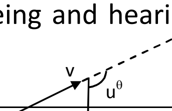
51. Velocity of sound v, velocity of air u

Velocity of sound be in direction AC so it can reach B with resultant velocity AD.

Angle between v and u is $\theta > \pi/2$.

Resultant $\overrightarrow{AD} = \sqrt{(v^2 - u^2)}$

Here time taken by light to reach B is neglected. So time lag between seeing and hearing = time to here the drum sound.



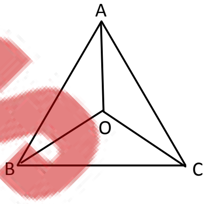
$$t = \frac{\text{Displacement}}{\text{velocity}} = \frac{x}{\sqrt{v^2 - u^2}}$$

$$\Rightarrow \frac{x}{\sqrt{(v+u)(v-u)}} = \frac{x}{\sqrt{(x/t_1)(x/t_2)}} \quad \text{[from question no. 50]}$$

$$= \sqrt{t_1 t_2}\,.$$

52. The particles meet at the centroid O of the triangle. At any instant the particles will form an equilateral ΔABC with the same centroid.

Consider the motion of particle A. At any instant its velocity makes angle 30°. This component is the rate of decrease of the distance AO.



$$\text{Initially AO} = \frac{2}{3}\sqrt{a^2 - \left(\frac{a}{2}\right)^2} = \frac{a}{\sqrt{3}}$$

Therefore, the time taken for AO to become zero.

$$= \frac{a/\sqrt{3}}{v\cos 30^\circ} = \frac{2a}{\sqrt{3}v \times \sqrt{3}} = \frac{2a}{3v}\,.$$

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