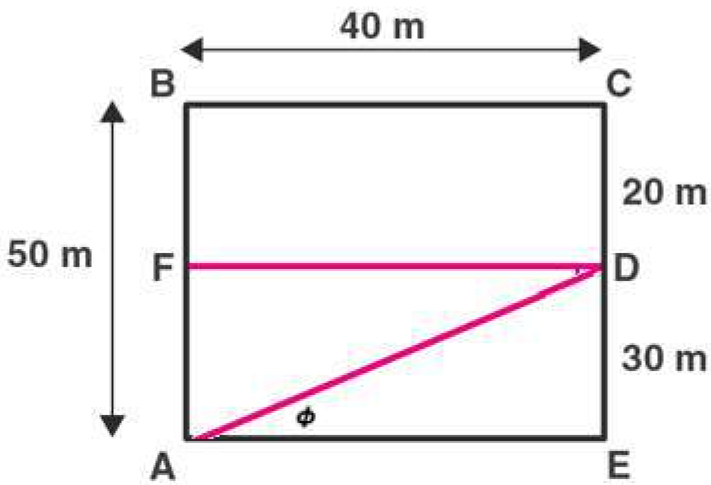
Rest and Motion: Kinematics

Exercise Solutions

Solution 1:



(a) Let A be the starting point and D be the field, ending point

Distance that man has to walk to reach the field = AB + BC + CD
= 50 + 40 + 20 = 110

So, man must walk 110 m to reach the field.

(b) Displacement from man's house to the field, which is AD

AD = $\sqrt{(AE^2 + ED^2)}$ = 50 m

From the triangle AED

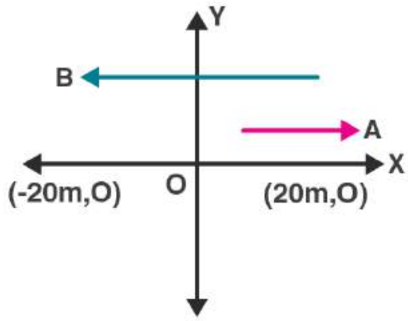
tan ϕ = DE/AE = 30/40 = 3/4

or ϕ = $\tan^{-1}(3/4)$

Therefore, his displacement from his house to the field is 50 m, $\tan^{-1}$ (3/4) north to east.

Solution 2:

Let O be the starting point and coordinates are, O(0, 0), A(20, 0) and B(-20,0)



Distance travelled = OA + AB = 20m + 40 m = 60 m

Displacement = distance between final and initial point
= OB = 20 m (negative direction)

Solution 3:

Given:
Total distance travelled by aeroplane from Patna to Ranchi =260 km
Total time taken by aeroplane = 30 min = 0.5 hour
And
Total distance travelled by deluxe bus = 320 km
Total time taken by bus = 8 hour
(a)
Average Speed of the plane = (Total distance travelled)/(Total time taken)

= 260/0.5 = 520 km/h

(b)
Average Speed of the bus = (Total distance travelled)/(Total time taken)

= 320/8

= 40 km/h

(c)
Average velocity of the plane = Displacement/Time
= 260/0.5
= 520 km/h

(d)Average velocity of Bus = Displacement/Time
= 260/8
= 32.5 km/h

Solution 4:
Using formulas:
Average Speed = (Total distance travelled)/(Total time taken)
Average velocity = Displacement/Time

(a) Average speed of the car = (12416-12352)/2 = 32 km/hr

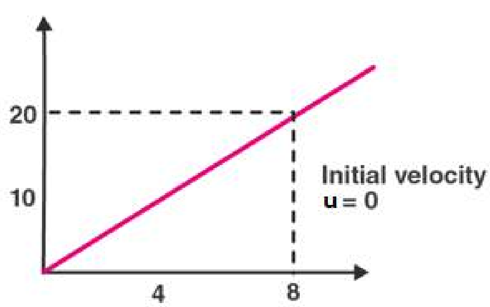
(b) Average velocity = 0/2 = 0
[As person returns to his house, the displacement is zero.]

Solution 5:
Initial velocity, u = 0
Final velocity, v = 180 km/h = 50 m/s and
Time, t = 20 s

We know, V = u + at
Where V = final velocity, u = initial velocity, a = acceleration and t= time

or a = (V-u)/t = 50/20 = 2.5 m/s^2

Solution 6:
From the given figure,
The velocity changes from 0 to 20 m/s in the interval of 8 sec.



So, average acceleration = 20/8 = 2.5 m/s^2

Now,
Distance travelled by car, S = ut + at^2/2
Here u = 0 (initial velocity)

By substituting values, we get

S = 0 + 1/2 x (2.5) x (8^2) = 80 m

Solution 7:
Let u = initial velocity and v = final velocity

In first 10 s, distance travelled, $S_1 = ut + 1/2\ at^2$

$= 0 + 1/2 \times 5 \times 100$ ft

= 250 ft

At 10 sec,

V = u + at

$= 0 + 5 \times 10$

= 50 ft/sec

Therefore, distance traveled from 10s to 20s, it moves with a uniform velocity of 50 ft/sec

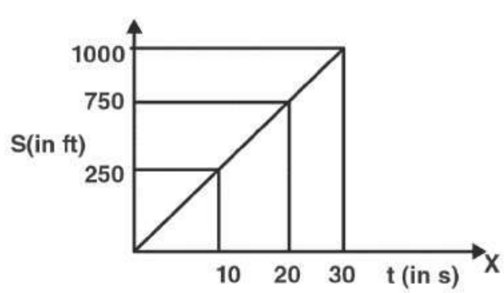
Again,
Distance covered from t=10 sec to t=20 sec,

$S_2 = vt = 50\times10 = 500$ ft
From figure, acceleration is constant between 20 s and 30 s .i.e -5 ft/m^2
At 20 s velocity is 50 ft/s

time, t = 30s - 20 s = 10 s
$S_3 = ut + 1/2\ at^2$
$= 50 \times 10 + 1/2 \times -5 \times$ (102
= 250 ft

Total distance travelled in 30 s = S1 + S2 + S3 = 250 + 500 + 250 = 1000 ft

Position –Time Graph



Solution 8:

Initial velocity = u = 2 m/s
Final velocity = V = 8 m/s and
time = t = 10 sec

(a) Acceleration

using formula: V = u + at

i.e. a = (8-2)/10 = 0.6 m/s^2

(b) Again, we know the relation, V2 - u2 = 2aS

or S = 50 m

(c) Here displacement is same as the distance travelled i.e. 50 m

Solution 9:

(a) Displacement from t=0 s to t=10 s is 100 m

Average velocity = Displacement/Time = 100/10 = 10 m/s

(b) Slope of the x-t graph gives velocity,

At t= 2 s, instantaneous velocity = 20 m/s

At t= 5 s, instantaneous velocity = 0 m/s (particle in rest)

At t= 8 s, instantaneous velocity = 20 m/s

At t= 12 s, instantaneous velocity = -20 m/s
[Velocity is negative as it move towards initial position]

Solution 10:
Area of the V-T graph gives distance travelled

Distance in first 40 sec = Area of triangle OAB+ Area of triangle BCD

= 1/2 x 5 x 20 + 1/2 x 5 x 20

= 100 m

Here the displacement is zero as average velocity is zero.

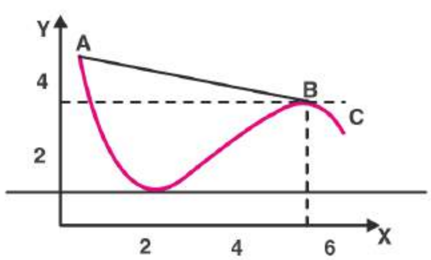
Solution 11:
Let the point B at t = 12 sec
At t = 0, distance = S = 20 m
At t = 12, distance= S = 20 m

From the figure, change in displacement is zero between time interval t=0 to t=12 sec

So. average velocity = 0

Therefore, the average velocity =0 m/s at t=12 sec.

Solution 12:



At position B, the instantaneous velocity has a direction along BC.
Now, the average velocity between A and B = AB/t

As AB and BC are in same direction, so the point is B (5,3)

Solution 13:

Initial velocity = u = 4.0 m/s

Time = t = 5.0 s

Acceleration = a = 1.2 m/s^2

Let S be the distance travelled, we have

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

$= 4x\ 5 + 1/2 \times 1.2 \times 5 \times 5$

= 35 m

Solution 14:

Initial velocity = u = 43.2 km/h = 12 m/s

Final velocity = v = 0 km/h

Acceleration = a = -6.0 m/s^2

Using relation, $V^2 - u^2 = 2as$

-144= -12 s

or s = 12 m

Hence person will travel 12 m before stopping

Solution 15:
Initial velocity = u = 0
Acceleration = a = 2 m/s^2
Let V = final velocity before apply breaks
and time=t= 30 sec

Now, V = u + at = 0 + 60 = 60 m/s

(a)

$s = ut + 1/2\ at^2 = 900$ m

At $u_1 = 60$ m/s (when break applied)
then $v_1 = 0$ and at t = 60 sec
$s_1 = ut + 1/2\ at^2$

$a_1 = (V_1 - u_1)/t = -1\ m/s^2$

and $S_1 = (V_1^2 – u_1^2)/2a_1 = 1800$ m

Therefore, total distance travelled by train = $s+s_1$ = 2700 m or 2.7 km

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

(c) Find position of the train

Half the maximum speed = 60/2 m/s = 30 m/s

When acceleration of the train, a=2 m/s^2

Distance = $S = (V^2-u^2)/2a = 225$ m

When the train is decelerating with, a_1=-2 m/s^2

then distance = $S = (V^2-u^2)/2a_1 = 1350$ m

Therefore, Position is 900 + 1350 = 2250 m or 2.25 km from the starting point.

Solution 16:
Initial velocity= u = 16 m/s
Distance covered = s = 0.4 m
Time, t=?

We know acceleration, a = $(V^2-u^2)/2s$
= $(0-16^2)/(2x0.4)$
= -320 m/s^2

Also, t = (V-u)/a
= (0-16)/-320 = 0.05 sec

Solution 17:
Initial velocity = u = 350 m/s

Final velocity = V = 0 m/s

Distance = s = 5 cm = 0.05 m

Now,
a = $(V^2-u^2)/2s$

= $(0-350^2)/(2x0.05)$ = -12.2 x 10^5 m/s^2

Solution 18:

Initial velocity = u = 0 m/s

Final velocity = V = 18 km/h = 5 m/s and

Time = t = 5 sec
Now,

a = (V-u)/t = 5/5 = 1 m/s^2

Consider, S be the travelled distance, so

S = ut + 1/2 at^2

= 12.5 m

(a) Average velocity = (12.5)/5 = 2.5 m/s
(b) Distance travelled = 12.5 m

Solution 19:
Given information's,
Speed of the car = 54 km/hr = 15 m/s (This is the constant speed)

Consider d be the distance travelled while applying brake, then
d = s × t = 15 × 0.2 = 3 m

When driver applied the break,
Initial velocity = u = 15 m/s

Final velocity = v = 0 m/s

Acceleration = a = -6 m/s2

Now,

$S = (V^2 - u^2)/2a$

= 18.75 m

Total distance = d + s = 3 + 18.75 = 21.75 m or 22 m

Solution 20:
Here,
Braking distance means Distance travelled after the brakes are applied.
Total stopping distance = Braking distance + Distance travelled in the reaction time

For Car Model A:
Deceleration = 6.0 m/s^2

F driver X:
Initial velocity= u = 54 km/h = 15 m/s
Final velocity = v = 0

Braking distance,

Using relation: $a = (V^2-u^2)/2s = 19$ m

Distance travelled in the reaction time = 15 × 0.20 = 3 m
Total stopping distance, b = 19 + 3 = 22 m

For driver Y:

Initial velocity= u = 72 km/h = 20 m/s
Final velocity = v = 0

Braking distance,

$c = (V^2-u^2)/2s = 33$m

Distance travelled in the reaction time = 20 × 0.30 = 6 m
Total stopping distance, d = 33 + 6 = 39 m

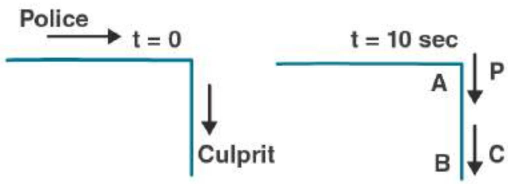
For Car Model B:
Deceleration = 6.0 m/s^2
Similarly, we have e = 15 m
Therefore,
f = 18 m
g = 27 m
and h = 33 m

Answer:
a = 19m
b= 22 m
c= 33 m
d= 39 m
e = 15 m
f = 18 m
g = 27 m
and h = 33 m

Solution 21:

Velocity of the police jeep = 90 km/h = 25 m/s

Velocity of the motorbike = 72 km/h = 20 m/s



In 10 seconds, the culprit reaches point B from point A on motorbike.

So distance covered by the culprit, say s = vt = 20 × 10 = 200 m

It means, Police jeep is 200 m behind the culprit at t = 10 s.

Now, relative velocity between both: Time = s/v = 200/5 = 40 s

Police jeep will move in 40 sec from A to cover distance s,

=> s = vt = 25 x 40 = 1000 m or 1 km away.

Thus, the police jeep will catch up with the bike 1.0 km away from the turning.

Solution 22:
Velocity of the first car, say v_1 = 60 km/h = 16.7 m/s
Velocity of the second car, say v_2 = 42 km/h = 11.7 m/s

Relative velocity between both the cars = 16.7 - 11.7 = 5 m/s

Consider s be the distance travelled by the first car w.r.t. second car while overtaking,

So, s = 5 + 5 = 10 m

Let t be the time taken while overtaking, t = s/v = 10/5 = 2 s

Now,

Distance covered by first car in 2 sec is,

$d = v_1 \times t = 16.7 \times 2 = 33.4$ m
Also, car covered its own length i.e. 5 m.

Thus, the total road distance used for the overtake = 33.4 m + 5 m = 38.4 m

Solution 23:
Initial velocity = u = 50 m/s

Also given, g = a = -10 m/s^2

(a) At highest point velocity, v=0.

Using relation, $s = (V^2-u^2)/2a = 125$ m

maximum height = 125 m

(b) let t be the time taken to reach at maximum height

t = (V-u)/a = (0-50)/-10 = 5 s

(c)
Half the maximum height = 125/2 = 62.5 m

using relation,

$$s = \frac{v^2 - u^2}{2a}$$

$$v = \sqrt{2as + u^2}$$

$$= \sqrt{2 \times -10 \times 62.5 + 50^2}$$

$$= 35\ m/s$$

Solution 24:

Height of the balloon= s = 60 m

Velocity of the Balloon moving upwards = 7 m/s.

When the ball is dropped, its initial velocity, say u = −7 m/s.

Acceleration due to gravity, a = g = 9.8 m/s^2

Using equation: $s = ut + 1/2\ at^2$

$60 = -7t + 1/2 \times 9.8 \times t^2$

=> $4.9t^2 - 7t - 60 = 0$

or $49t^2 - 70t - 600 = 0$

Solving above quadratic equation, we get

=>$(7t + 20)(7t - 30) = 0$

Either $7t + 20 = 0$ or $7t - 30 = 0$

$t = -20/7$ or $t = 30/7$

time cannot be negative, so neglect negative value.

Therefore, ball will take 4.3 sec to reach on the ground.

Solution 25:
A stone is thrown vertically upward with a speed of 28 m/s.
=> $u = 28$ m/s

Final velocity = $V = 0$ (when stone reaches the ground)

Also, Acceleration due to gravity = $a = g = 9.8\ m/s^2$

(a)
We know, $V^2 - u^2 = 2as$

or $s = 40$ m

The maximum height reached by the stone is 40 m.

(b)
Using relation, $V = u + at$

or $t = (V-u)/a$

or $t = 2.85$ s

As per the question, we need to find the velocity of the stone one second before it reaches the maximum height.

$t' = 2.85 - 1 = 1.85$ s

Again, $v' = u + at' = 28 - 9.8 \times 1.85 = 9.87$ m/s

The required velocity is 9.87 m/s

(c) No,
Reason: After one second, the velocity becomes zero for any initial velocity and acceleration ($a = -9.8\ m/s^2$) remains the same.

Solution 26:

Initial velocity = u = 0 (As person releasing balls at regular intervals of one second.)
Acceleration due to gravity, a = g = 9.8 m/s^2

Also, When the 6th ball is dropped, the 5th ball moves for 1 second, the 4th ball moves for 2 seconds and the 3rd ball moves for 3 seconds.

Position of the 3rd ball from the top of the building after t = 3 sec:

$S_1 = ut + 1/2\ at^2$

= 44.1 m

Position of the 4th ball from the top of the building after t = 2 sec:

$S_2 = ut + 1/2\ at^2$

= 19.6 m

Position of the 5th ball from the top of the building after t = 1 sec:

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

= 4.9 m

Solution 27:

Distance of man from the building = 7 m
Height of the building = 11.8 m

As the kid is slipping, his initial velocity is u which is zero, u = 0.
Acceleration, a = 9.8 m/s^2
Let s be the distance before which the kid has to be caught by the young man.

$s = 11.8 - 1.8 = 10$ m

Using equation, $s = ut + 1/2\ at^2$

=> $10 = 0 + 1/2 \times 9.8 \times t^2$

=> $t = 1.42$ sec

Man needs 1.42 sec to reach the bottom of the building to catch the kid.

Again, Velocity = s/t = 7/1.42 = 4.9 m/sec

Man should run with the velocity 4.9 m/sec to catch the kid at the arms.

Solution 28:
As per statement,
Distance of the bird from the ground, s = 12.1 m
Speed of the NCC cadets = 6 km/h = 1.66 m/s
Initial velocity of the berry dropped by the bird, u = 0
Acceleration due to gravity, a = g = 9.8 m/s^2

Now,
$s = ut + 1/2\ at^2$

12.1 = 0 + 1/2 x 9.8 x t2

=> t = 1.57 s

Distance moved by the cadets, say d = v × t = 1.57 × 1.66 = 2.6 m

Therefore, the cadet who is 2.6 m away from tree will receive the berry on his uniform.

Solution 29:

Distance travelled by the ball in 0.200 sec = 6 m
$t = 0.200$ s

Distance, $s = 6$ m
and $a = g = 10\ m/s^2$

Now,
$s = ut + 1/2\ at^2$

$6 = u \times 0.2 + 1/2 \times 10 \times 0.04$

or $u = 29$ m/s

Let h be the height from which the ball is dropped.
and $u = 0$ and $v = 29$ m/s
Now,
$h = (V^2 - u^2)/2a = (29)^2/(2 \times 10) = 42.05$ m

Therefore, total height = 42.05 + 6 = 48.05 m

Solution 30:

A ball is dropped from a height of 5 m above the sand level.

The same ball penetrates the sand up to 10 cm before coming to rest.
Initial velocity of the ball, $u = 0$
and, $a = g = 9.8\ m/s^2$

Now,
$s = ut + 1/2\ at^2$

$5 = 0 + 1/2 \times 9.8 \times t^2$

=> $t = 1.01$ s

The time 1.01 seconds taken by the ball to cover the distance of 5 m.

Again,
Velocity of the ball after 1.01, here $u = 0$
Using, $v = u + at$
=> $v = 9.8 \times 1.01 = 9.89$ m/s

Hence, for the motion of the ball in the sand,
initial velocity = 9.89 m/s and
final velocity = 0.

=> s = 10 cm = 0.1 m

Using equation of motion, we have
$a = (V^2 - u^2)/2s$

$a = -490$

The sand offers the retardation of 490 m/s^2.

Solution 31:
As the elevator descends with uniform acceleration "a" the coin has to move more distance than 6 ft or 1.83 m to strike floor.

Time taken = t = 1 sec and initial velocity = u = 0

Acceleration of coin w.r.t. lift = acceleration of coin w.r.t. earth - acceleration of lift
= g - a = 9.8 - a

Height of the coin from elevator floor = 1.83 m

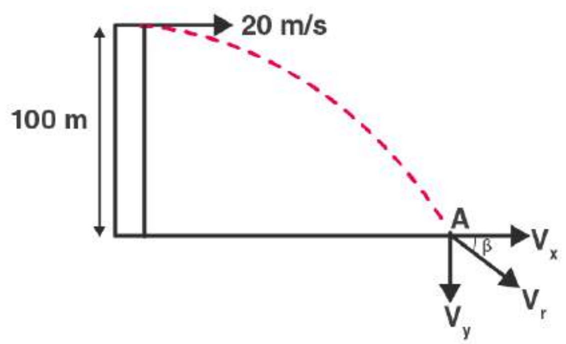
Using relation, $s = ut + 1/2\ at^2$, where a = acceleration of coin w.r.t. lift

$1.83 = 0 + 1/2 \times (9.8 - a)$

$a = 6.2\ m/s^2$

Solution 32:
A ball is thrown horizontally from a point 100 m above the ground with a speed of 20 m/s.
It is a case of projectile fired horizontally from a given height.

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



a) Time taken to reach the ground = t = $\sqrt{(2h/g)} = \sqrt{((2 \times 100)/9.8)}$ = 4.51 sec.

b) Horizontal distance travelled by the ball, x = ut = 20 × 4.5 = 90 m.

c) Horizontal velocity remains constant through out the motion of the ball.

From the figure, at point A, Velocity along x-axis Vx= 20 m/s and velocity along y-axis, Vy = u + at = 0 + 9.8 × 4.5 = 44.1 m/s.

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

Let β be the angle, then

tan β = Vy/Vx = 44.1/20 = 2.205

or β = $\tan^{-1}$ (2.205) = 66°.

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

Solution 33:
A ball is thrown at a speed of 40 m/s at an angle of 60o with the horizontal.
Here,
Initial speed of the ball = u = 40 m/s
Angle of projection of the ball with the horizontal, say $\theta = 60°$
Also, $a = g = 10\ m/s^2$

(a) Maximum height reached by ball

$H = (u^2 \sin^2\theta)/2g = 60$ m

(b) Range of the ball.

$R = (u^2 \sin 2\theta)/g = 80\sqrt{3}$ m

Solution 34:

initial velocity = u = 40 m/s
angle of projection = $\theta = 60^o$
and $a = g = 9.8\ m/s^2$

Now,
Maximum Height, say $h = u^2\sin^2\theta/2g$

h = 60 m

And, Horizontal Range, $R = u^2\sin2\theta/g = 80\sqrt{3}$ m

Solution 35:
The goli of one player is situated at a distance of 2.0 m from the goli of the second player.

Horizontal range = R = 2.0 m

let h be the height from which the goli is projected by the second player = 19.6 cm or 0.196 m.

As goli moves in projectile motion, its acceleration dur to gravity is $a = g = 9.8\ m/s^2$

Now,
$s = h = u + 1/2\ gt^2$
Here u = 0, as the initial velocity in vertical direction is zero.

=> t = $\sqrt{2h/g}$ = 0.2 sec

Let goli is projected with the horizontal velocity U m/s, then the horizontal range, R is

R = Ut

or U = R/t = 2/0/2 = 10 m/s

Hence, second player has to project the goli with a speed of 10 m/s to hit the goli of the first player.

Solution 36:
Length of the bike = 5 ft
Width of the ditch = 11.7 ft

The approach road makes an angle of 15° with the horizontal.

Total horizontal range to be covered by the biker to cross the ditch safely,
R = 11.7 + 5 = 16.7 ft
Acceleration due to gravity, a = g = 9.8 m/s = 32.2 ft/s^2

Now, the horizontal range, R, is given by

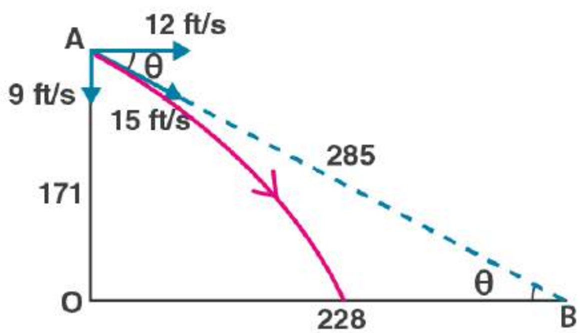
R = (u^2 sin 2α)/g

Substituting values, we have u = 32

Therefore, the minimum speed with which the motorbike should be moving is 32 ft/s.

Solution 37:

Let a person at point A is standing at a height 171 feet.
Person A throwing a packet to his friend standing at B, who is 228 feet horizontally away.



Distance between A and B = AB = $\sqrt{(171^2+228^2)}$ = 85 ft

The person throws the packet directly aiming to his friend at the initial speed (u) of 15.0 ft/s.

Let us find out speed into vertical component and horizontal component.

Vertical component = 15 $\sin\theta$ = 15×171/285 = 9 ft/s and
Horizontal component = 15 $\cos\theta$ = 15×228/285 = 12 ft/s

And, acceleration due to gravity is ft/s^2. 1 m = 3.281 ft, so g = 9.8×3.281 ft

Now,

$S = ut + (1/2)gt^2$

$171 = 9\times t+(1/2)\times 9.8\times 3.281\times t^2$
$= 9\times t+16.08\times t^2$

Solving above equation, we have t = 3s

Therefore,
Horizontal distance travelled by the packet = 12×3 = 36 ft.

Distance at which packet will fall short = 288-35.81=192.19 ft.

Solution 38:
Initial speed of the ball = u = 15 m/s
Angle of projection with horizontal, θ = 60°
Distance of the wall from the point of projection = 5 ma = g = 9.8 m/s^2

Horizontal range for a projectile

$R = (u^2 \sin 2\theta)/g = 19.88$

The ball will hit the wall 5 m away from the point of projection.
If the wall is 22 m away from the point of projection, the ball will hit the wall as it is not in its horizontal range.

Solution 39:

Initial velocity of the projectile = u
Angle of projection = θ

Average velocity = (change in displacement)/time

From the given data, it can be taken as horizontal. So there is no effect of vertical component of the velocity during this displacement.

The projectile moves at a constant velocity 'u cos θ' in horizontal direction.

The average velocity of the projectile is u cos θ.

Solution 40:

The bomb follows horizontally projectile with same horizontal velocity as the plane.
Both the plane and bomb are travelling in the same direction.
Distance travelled by the bomb in horizontal direction is "ut", where u is the speed of the plane and t be the time taken by the bomb to reach the ground.
Also
Distance travelled by the plane in the same time = ut
Hence, the bomb will explode vertically below the plane.

When the plane is flying with a uniform speed but not horizontally:

Again, the bomb will explode vertically below the plane.

because, both will have the same horizontal speed, u cos θ, where u is the initial speed of the plane and the bomb. And the distance travelled by the bomb and the plane will be u cos θ t.

Solution 41:

Acceleration of the car = 1 m/s^2
Projection velocity of the ball in the vertical direction = 9.8 m/s
Angle of projection, say $\theta = 90^o$

Both the car and the ball have the same horizontal velocity.

Distance travelled by the ball in horizontal direction, s = ut ...(1)
Where u be the initial velocity of the car when the ball is thrown and t = time.

Now,
Distance travelled by the car in horizontal direction:

$S = ut + 1/2\ at^2$ ....(2)

Time of flight of projectile:

$t = (2u \sin\theta)/g = 2$ sec
[substituting values, u = 9.8, $\sin 90^o = 1$, and g = 9.8]

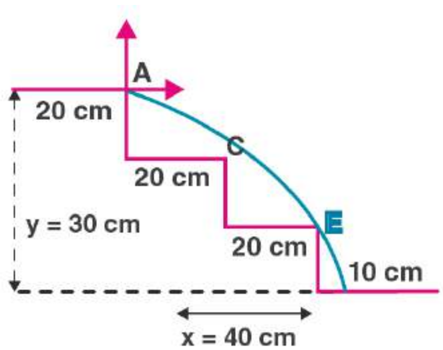
Distance between the accelerated car and the projectile:
From (1) and (2), we have

$S - s = 1/2\ at^2 = 1/2 \times 1 \times 4 = 2$ m

Thus, ball drops 2m behind the boy.

Solution 42:

Dimension of one step:
Height = 10 cm
Width = 20 cm



form figure,
Total height of the staircase = y = 30 cm
Total width of the staircase = x = 40 cm

To directly hit the lowest one, the ball should just touch E.

Let u = minimum speed of the ball.
Let us consider, A be the origin of reference coordinate.

x = 40 cm, y= -20 cm, g = 10 m/s^2 or 1000 cm/s^2 and θ = 0o

Now,

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

=> -20 = -800000/2u^2

or u = 2 m/s

The minimum horizontal velocity of the ball is 2 m/s.

Solution 43:

Velocity of the truck = 14.7 m/s
Distance covered by the truck when ball returns back to the truck= 58.8 m

(a)
Here, time taken by the truck to cover 58.8 m distance = time of the flight of the truck.
T = s/v = 58.8/14.7 = 4 sec

Let us consider, the motion of the ball going upwards at T = 4 s

Time taken to reach the maximum height when v = 0, where v= final velocity

t = T/2 = 2 sec

Again,
V = u - at

where $a = g = -9.8\ m/s^2$ and u = initial velocity with which the ball is thrown upwards.

=> $u = 19.6\ m/s$

(b) seen from the road,

The motion of ball seems to be a projectile motion, so total time of flight (T) = 4 seconds

Let R be the horizontal range covered by the ball in this time, i.e. R = 58.8 m
We know, the angle of projection, $R = u \cos \alpha t$, where α is the angle of projection.
and $u \cos \alpha = 14.7$ ...(1)

Let us work on vertical component of velocity using below equation,

$V^2 - u^2 = 2ay$
[substituting values v=0(final velocity), u = 19.6, and a = -9.8]
or y = 19.6 m

Vertical displacement of the ball at t = 2 s:
$y = u \sin \alpha t - 1/2\ gt^2$

or $u \sin \alpha = 19.6$ ...(2)

On dividing (2) by (1), $\tan \alpha = 1.33$

or $\alpha = 53^o$

Again, from (1), u = 25 m/s

Thus, the speed of the ball is 25 m/s and the angle of projection is 53° with horizontal when seen from the road.

Solution 44:
Width and height of the bench = 1 m
Initial speed of the ball = 35 m/s
Distance of the first bench from the batsman = 110 m.

Angle of projection of the ball = 53 $^{\circ}$

or α = 53 $^{\circ}$

Let the ball land on the nth bench if batsman strikes the ball 1 m above the ground.

y = n-1 ...(1)

and x = 110+n-1 = 110 + y

Again,

$$y = x\tan\alpha - \left(\frac{gx^2\sec^2\alpha}{2u^2}\right)$$

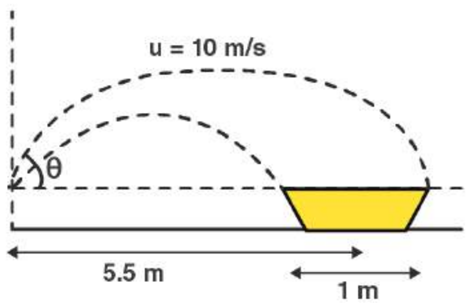
By substituting the values, we get

y = 5
(1)=> n-1 = 5 => n = 6

The ball will hit the 6th bench.

Solution 45:
Initial speed of throwing the apple by the man= u = 10 m/s
Length of the boat = 1.0 m
Distance between the man and the center of the boat (R) = 5.5 m

Acceleration due to gravity =g = 10 m/s^2



The horizontal range:
R = $(u^2 \sin 2\theta)/g$

by substituting the values, we get

$\sin 2\theta = 1/2$

or $\theta = 15^{o}$ or 75^{o}

For the end point of the boat:

Horizontal range (R) = 6 m

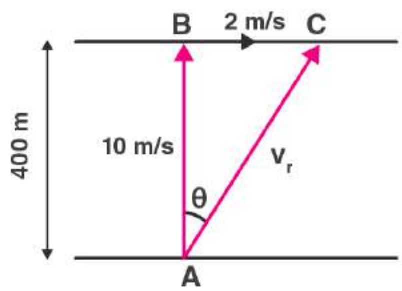
for the end point of the boat, we have:
Horizontal range (R) = 6 m
R = $(u^2 \sin 2\theta)/g$
Here $\theta = 18^{o}$ or 71^{o}

For a successful shot, the angle of projection with initial speed 10 m/s may vary from 15° to 18° or from 71° to 75°.

Solution 46:
Distance between the opposite shore of the river or width of the river = 400 m
Boat is sailing at the rate of 10 m/s.

Rate of flow of the river = 2.0 m/s

let v be the resultant velocity of the boat when vertical component of velocity 10 m/s takes the boat to the opposite shore.
Time taken = 400/10 = 40 sec



Now,
tan θ = 2/10 = 1/5

When boat reach at point C
From the figure, in triangle ABC

tan θ = BC/AB = 1/5

or BC = 400/5 = 80 m

Also, $|v| = \surd(10^2+2^2) = 10.2$ m/s

Let α be the angle made by the boat sailing with respect to the direction of flow.

tan α = 10/2 or α = 78.7^o

The distance boat has to travel to reach the opposite shore = 400/sinα = 407.9 m

(a)
Time taken by the boat to reach the opposite bank = 407.9/10.2 = 40 sec

(b)
Distance = $\surd(407.9^2-400^2)$ = 79.9 m or 80 m (approx)

Solution 47:

Width of the river = 500 m
Swimmer's speed with respect to water = 3 km/h
Rate of flow of the river = 5 km/h

The swimmer heads in a direction making an angle θ with the flow.

So, 3 sinθ is the vertical component of velocity which takes swimmer to the opposite side of the river.

Vertical component of velocity = 3sinθ km/h
Distance to be travelled = 0.5 km

(a)
Time = 0.5h/3sinθ = (500x6)/5sinθ) = 600/sinθ sec or 10/sinθ min

(b)
Here θ = 90^{o}

Time = 0.5h/3sinθ = (500x6)/5sin90° = 600 sec

Therefore, shortest possible time to cross the river is 10 mins.