HC VERMA Solutions for Class 11 Physics Chapter 3 - Rest and Motion Kinematics

Question 1

A man has to go 50m due north, 40m due east and 20m due south to reach a field.
(a) What distance he has to walk to reach the field?
(b) What is his displacement from his house to the field?

Solution 1

(a)
Distance travelled = 50+40+20
=110m
(b)
Displacement =50 ĵ +40 î- 20ĵ
=40î+30 ĵ
| disp |=$\sqrt{(40)^2+(30)^2}$
=50m at an angle of Θ=$\tan^{-1}(\frac{30}{40})$ =37° north to east

Question 2

A particle starts from the origin goes along the X-axis to the point (20m, 0) and th32en returns along the same line to the point (-20m, 0). Find the distance and displacement of the particle during the trip.

Solution 2

Distance travelled = 20+40 =60m
Displacement=20m in the negative direction

Question 3

It is 260 km from Patna to Ranchi by air and 320 km by road. An aero plane takes 30 minutes to go from Patna to Ranchi whereas a deluxe bus takes 8 hours
(a) Find the average speed of the plane.
(b) Find the average speed of the bus.
(c) Find the average velocity of the plane.
(d)Find the average velocity of the bus.

Solution 3

(a)
$\vec{V}_{avg/plane} = \frac{distance}{time} = \frac{260}{0.5}$ = 520kmph
(b)
$\vec{V}_{avg/bus} = \frac{distance}{time} = \frac{320}{8}$ = 40kmph
(c)
$\vec{V}_{avg/plane} = \frac{displacement}{time} = \frac{260}{0.5}$ = 520kmh
(d)
$\vec{V}_{avg/bus} = \frac{displacement}{time}$ =260/8 = 32.5kmph

Question 4

When a person leaves his home for sightseeing by his car, the meter reads 12352 km. When he returns home after two hours the reading is 12416 km.
(a) What is the average speed of the car during the period?
(b) What is the average velocity?

Solution 4

(a)

$$V_{avg} = \frac{\text{Total distance}}{\text{time}} = \frac{(12416-12352)}{2}$$

V_{avg} =32kmph

(b)

$\vec{V}_{avg}$=displacement/time

$\vec{V}_{avg}$ =0

Question 5

An athlete takes 2.0s to reach his maximum speed of 18.0 km/h. What is the magnitude of his average acceleration?

Solution 5

u=0; v=$18 \times \frac{5}{18}$ = 5m/s; t=2sec

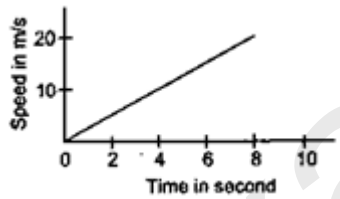
v=u+at

5=0+a(2)

a=2.5m/s^2

Question 6

The speed of a car as a function of time is shown in the given figure. Find the distance travelled by the car in 8 seconds and its acceleration.



Solution 6

Acceleration=slope of (v-t) graph

a=tan θ = $\frac{20}{8}$

=2.5m/s^2

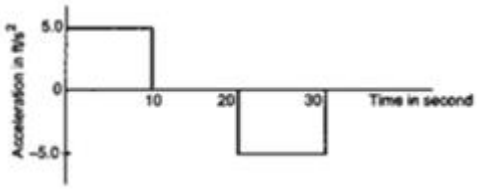
Distance=Area under (v-t) graph

= $\frac{1}{2} \times 8 \times 20$

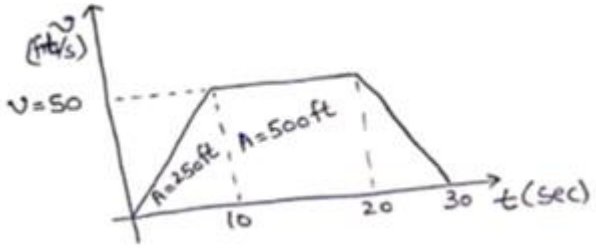
=80m

Question 7

The acceleration of a cart started at t=0, varies with time as shown in the given figure. Find the distance travelled in 30 seconds and draw the position-time graph.



Solution 7



By velocity-time graph,

Acceleration =slope=$\frac{v}{t}$

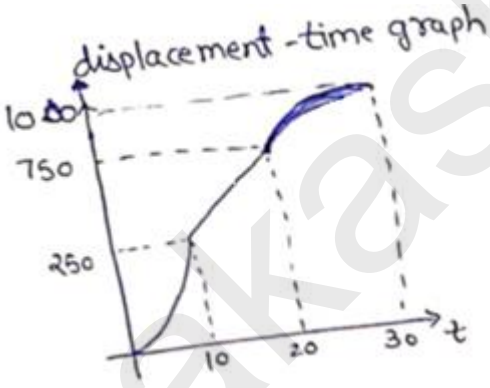
5=$\frac{v}{10}$

V=50m/s

Distance=Area of v-t graph

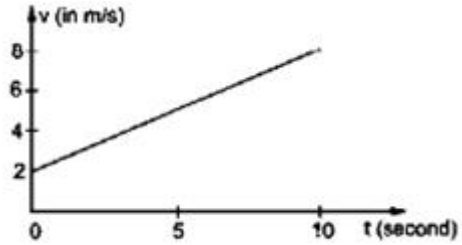
=$\frac{1}{2}$ (30+10) (50)

=1000ft



Question 8

The given figure shows the graph of velocity versus time for a particle going along the X-axis.
Find
(a) The acceleration
(b) The distance travelled in 0 to 10s and
(c) The displacement in 0 to 10s



Solution 8

(a) Acceleration=slope of v-t graph

$= \frac{(8-2)}{10} = 0.6 m/s^2$

(b) Distance travelled = Area under v-t graph

$= \frac{1}{2}(2+8)10$

=50m

(c) Displacement=50m

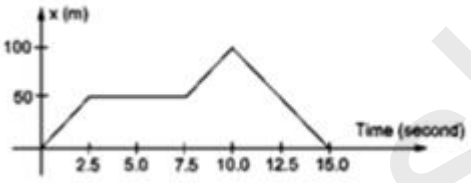
Question 9

The given figure shows the graph of x-coordinate of a particle going along the X-axis as a function of time.

Find

(a) The average velocity during 0 to 10s

(b) Instantaneous velocity at 2, 5, 8 and 12s.



Solution 9

(a) Velocity=displacement/time

$= \frac{100}{10}$ =10m/s

(b) Instantaneous velocity=slope of v-t graph

At t=2.5s; slope=$\frac{50-0}{2.5-0}$ = 20m/s

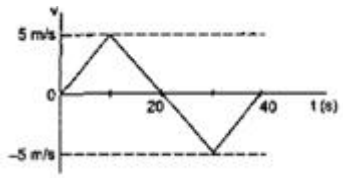
At t= 5s; slope=0m/s

At t=8s; slope= $\frac{100-50}{10.7.5}$ = 20m/s

At t=12s; slope=$\frac{0-100}{15-10}$ = -20m/s

Question 10

From the velocity-time plot shown in the given figure, find the distance travelled by the particle during the first 40seconds. Also find the average velocity during the period.



Solution 10

Distance =Area of v-t graph

$=(\frac{1}{2}\times 20\times 5)+(\frac{1}{2}\times 20\times 5)$

=100m

Displacement$=(\frac{1}{2}\times 20\times 5)+(-\frac{1}{2}\times 20\times 5)$

Displacement=0

$\vec{V}_{avg}=\frac{\text{displacement}}{\text{time}}$

$\vec{V}_{avg}=0$

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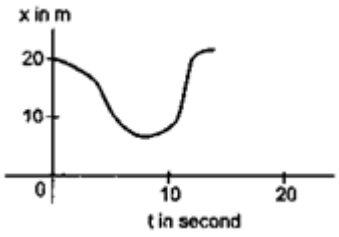
Question 11

The given figure shows *x-t* graph of a particle. Find the time t such that the average velocity of the particle during the period 0 to t is zero.



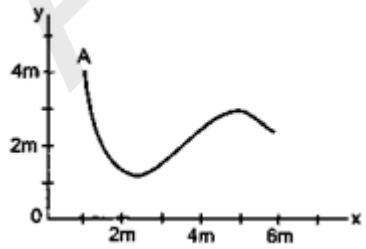
Solution 11

Average velocity is zero when displacement is zero

At t=0; *x*=20 and again at t=12; *x*=20

Question 12

A particle starts from a point A and travels along the solid curve shown in the given figure. Find approximately the position B of the particle such that the average velocity between the positions A and B has the same direction as the instantaneous velocity at B.



Solution 12

Direction of instantaneous velocity of point B must be same as direction of average velocity $\overrightarrow{AB}$.
So, point is approximately(5,3)

Question 13

An object having a velocity 4.0 m/s is accelerated at the rate of 1.2 m/s^2 for 5.0s. Find the distance travelled during the period of acceleration.

Solution 13

u=4m/s; a=1.2m/s^2; t=5sec
Distance travelled

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

$s = (4)(5) +\frac{1}{2}(1.2)\ (5)^2$
=35m

Question 14

A person travelling at 43.2 km/h applies the brake giving a deceleration of 6.0 m/s^2 to his scooter. How far will it travel before stopping?

Solution 14

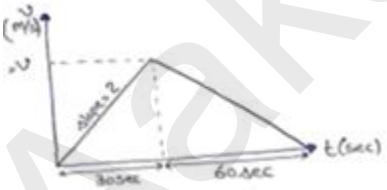
$u=43.2\times\frac{5}{18}$=12m/s; v=0; a=-6m/s^2
Using,
$v^2=u^2+2as$

$O^2=(12)^2-2\times6\times s$
s=12m

Question 15

A train starts from rest and moved with a constant acceleration of 2.0 m/s^2 for half a minute. The brakes are then applied and the train comes to rest in one minute.
(a) Find the total distance moved by the train
(b) The maximum speed attained by the train
(c) The position(s) of the train at half the maximum speed.

Solution 15

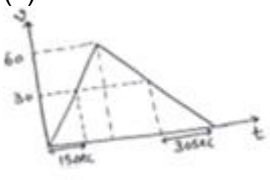


$A=\text{slope}=\frac{v}{t}$

$2=\frac{v}{30}$
v=60m/s
(a) Distance=Area of v-t graph

$=\frac{1}{2}(30+60)\ (50)$
=2700m

=2.7km
(b) Maximum speed
V=60m/s
(c)



Velocity 30m/s is achieved at t=15sec and t=60sec
Area of (v-t) graph in first 15 second
$s=\frac{1}{2}(15)(30)=225m$
Area of (v-t) graph in first 60 sec
$S=\frac{1}{2}\times30\times60+\frac{1}{2}(60+30)(3)$
=2250m
=2.25km

Question 16

A bullet travelling with a velocity of 16 m/s penetrates a tree trunk and comes to rest in 0.4m. Find the time taken during the retardation.

Solution 16

u=16m/s; v=0m/2; s=0.4m
$v^2=u^2+2as$
$0^2=(1)^2+2(a)(0.4)$
$a=-320m/s^2$
v=u+at
0=16+(-320)t
t=0.05sec

Question 17

A bullet going with speed 350 m/s enters a concrete wall and penetrates a distance 5.0 cm before coming to rest. Find the deceleration.

Solution 17

u=350m/s; v=0; $s=5\times10^{-2}m$
$v^2=2^2+2as$
$0^2=(350)^2+2(a)(0.05)$
$a=-12.25\times10^5m/s^2$

Question 18

A particle starting from rest moves with constant acceleration. If it takes 5.0s to reach the speed 18.0 km/h
Find
(a) The average velocity during this period
(b) The distance travelled by the particle during this period.

Solution 18

u=0; t=5sec; v=18×5/18=5m/s
v=u+at
5=0+a(5)
$a=1m/s^2$

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

$S=0+\frac{1}{2}(a)(5)^2$

$S=12.5m$

V_{avg}=distance/time= $\frac{12.5}{5}$

$V_{avg}=2.5m/s$

Question 19

A driver takes 0.20s to apply the brakes after he sees a need for it, This is called the reaction time of the driver. If he is driving a car at a speed of 54 km/h and the brakes cause a deceleration of 6.0 m/s^2, find the distance travelled by the car after he sees the need to put the brakes on.

Solution 19

Speed of car=$54\times\frac{5}{18}=15m/s$

Distance travelled during reaction time

$S_1=v\times t$

$=15\times0.2=3m$

When brakes are applied

$u=15m/s$; $a=-6m/s^2$;$v=0m/s$

$v^2=u^2+2as$

$0^2=(15)^2+2(-6)S_2$

$S_2=18.75m$

Total distance=S_1+S_2

$=3+18.75$

$=21.75m$

$\approx22m$

Question 20

Complete the following table:

Car Model	Driver X Reaction time 0.20s	Driver Y Reaction time 0.30s
A (deceleration on hard braking = 6.0 m/s^2	Speed = 54 km/h Breaking distance a= …… Total stopping distance b=……..	Speed = 72 km/h Breaking distance c= …….. Total stopping distance d=……
B (deceleration on hard braking = 7.5 m/s^2	Speed = 54 km/h Breaking distance e= …… Total stopping distance f=……..	Speed = 72 km/h Breaking distance g= …… Total stopping distance h=……..

Solution 20

If initial velocity is u and deacceleration is -a then braking distance

$v^2= u^2+2as$

$0^2=u^2- 2aS$

$S_b=\frac{u2}{2a}$ (Braking distance)

$S_R=u\times t_R$ (Reaction distance)

Total distance = S_b+S_R
Solve table with given values and above formulas

Question 21

A police jeep is chasing a culprit going on a motorbike. The motorbike crosses a turning at a speed of 72 km/h. The jeep follows it at a speed of 90 km/h, crossing the turning ten seconds later than the bike. Assuming that they travel at constant speeds, how far from the turning will the jeep catch up with the bike?

Solution 21

$V_{bike}=72\times\frac{5}{18}=20m/s$

$V_{police}=90\times\frac{5}{18}=25m/s$

Distance travelled by culprit in 10sec = speed × time
=20×10
=200m
Time to catch culprit by police=Relative distance/Relative speed

$=\frac{200}{(25-20)}$

T=40sec
So, police travels distance of =25×40
=1000m=1km

Question 22

A car travelling at 60 km/h overtakes another car travelling at 42 km/h. Assuming each car to be 5.0m long, find the time taken during the overtake and the total road distance used for the overtake.

Solution 22

$\vec{V}_1=60\times\frac{5}{18}=16.6m/s$

$\vec{V}_2=42\times\frac{5}{18}=11.6m/s$

Relative velocity =16.6-11.6
$V_{rel}=5m/s$
$d_{res}=10m$

Time to cross=$\frac{d_{rel}}{v_{rel}}=\frac{10}{5}=2sec$
In 2 sec, 1st car moves=16.6×2
=33.2
Length of road=33.2+length of car
=33.2+5
≈38m

Question 23

A ball is projected vertically upward with a speed of 50 m/s
Find
(a) The maximum height
(b) The time to reach the maximum height

(c) The speed at half the maximum height.
Take g = 10 m/s^2

Solution 23

u=50m/s; v=0m/s; a=-g
(a) $v^2=u^2+2as$
$0^2=(50)^2+2(g)s$
s=125m
(b) v=u+at
0=50-gt
t=5sec
(c) Speed at $s=\frac{125}{2}$ =62.5m; u=50m/s; a=-g
$v^2=u^2+2as$
$=(50)^2-2(g)(62.5)$
v≈35m/s

Question 24

A ball is dropped from a balloon going up at a speed of 7 m/s. if the balloon was at a height 60 m at the time of dropping the ball, how long will the ball take in reaching the ground?

Solution 24

u=7m/s; a=-g; s=-60
$s=ut+\frac{1}{2}at^2$
$-60=7t-\frac{1}{2}(g)t^2$
t=4.28sec

Question 25

A stone is thrown vertically upward with a speed of 28 m/s.
(a) Find the maximum height reached by the stone.
(b) Find its velocity one second before it reaches the maximum height.
(c) Does the answer pf part (b) change if the initial speed is more than 28 m/s such as 40 m/s or 80 m/s?

Solution 25

(a) u=28m/s; v=0m/s; a=-g
$v^2=u^2+2as$
$0^2=(2s)^2+2(-g)(s)$
s=40m
(b) Velocity at one second before H_{max}=Velocity after one second of H_{max}
So, after $H_{max}$is attained
u=0; a=g; t=1
v=u+at
v=9.8m/s
(c) No, answer will not change. As after one second of attaining of H_{max}
v=9.8m/s only

Question 26

A person sitting on top of a tall building is dropping balls at regular intervals of one second. Find the positions of the 3rd, 4th and 5th ball when the 6th ball is being dropped.

Solution 26

For every ball; u=0 and a=g

When 6^{th} ball is dropped, 5^{th} ball moves for 1 second, 4^{th} ball moves for 2 seconds, 3^{rd} ball moves for 3 seconds
Position

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

3^{rd} ball $S_3=0+\frac{1}{2}(g)(3)^2=44.1m$

4^{th} ball $S_4=0+\frac{1}{2}(g)(2)^2=19.6m$

5^{th} ball $S_5=0+\frac{1}{2}(g)(1)^2=4.9m$

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Question 27

A healthy young man standing at a distance of 7m from a 11:8 m high building sees a kid slipping from the top floor. With what speed (assumed uniform) should he run to catch the kid at the arms height (1.8m)?

Solution 27

For kid,
u=0; a=g; s=11.8-1.8
s=10m

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

$10=0+\frac{1}{2}(g)t^2$

t=1.42sec
In this time, man has to reach building

$\text{Speed}=\frac{\text{distance}}{\text{time}}=\frac{7}{1.42}$

=4.9m/s

Question 28

An NCC parade is going at a uniform speed of 6 km/h through a place under a berry tree on which a bird is sitting at a height of 12.1m. A particular instant the bird drops a berry. Which cadet (give the distance from the tree at the instant) will receive the berry on his uniform?

Solution 28

For berry,
u=0; a=g; s=12.1m

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

$12.1=0+\frac{1}{2}(g)t^2$

t=1.57sec
Distance moved by cadets=v× t

$=(6\times\frac{5}{18})(1.57)$

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

Question 29

A ball is dropped from a height. If it takes 0.200s to cross the last 6.00m before hitting the ground, find the height from which it was dropped. Take g= 10 m/s^2

Solution 29

For last 6m,

t=0.2sec; s=6m; a=g

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

$6=u(0.2)+\frac{1}{2}(g)(0.2)^2$

u=29m/s

Before last 6m,

u=0; a=g; v=29m/s

$v^2=u^2+2as$

$(29)^2=0^2+2(g)s$

$S_1=42m$

Total distance=42+6=48m

Question 30

A ball is dropped from a height of 5m onto a sandy floor and penetrates the sand up to 10cm before coming to rest. Find the retardation of the ball in sand assuming it to be uniform.

Solution 30

For ball in air

u=0m/s; a=g; s=5m

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

$5=0+\frac{1}{2}(g)t^2$

$t=\sqrt{\frac{10}{g}}$

$v=u+at$

$v=0+g\sqrt{\frac{10}{g}}$

$v=\sqrt{10g}$

For ball in sand

$u=\sqrt{10g}$; v=0m/s; s=0.1m

$v^2=u^2+2as$

$0^2=(\sqrt{10g})^2+2(a)(0.1)$

$a=-490m/s^2$

Question 31

An elevator is descending with uniform acceleration. To measure the acceleration a person in the elevator drops a coin at the moment the elevator starts. The coin is 6ft above the floor of the elevator at the time it is dropped, The person observes that the coin strikes the floor in 1 second. Calculate from these data the acceleration of the elevator.

Solution 31

For coin-lift

$u_{rel}=0m/s$

$t_{rel}=1sec$

$s_{rel}=6ft$

$s_{rel}=u_{rel}t+\frac{1}{2}a_{rel}t^2$

$6=\frac{1}{2}a_{rel}(1)^2$
$a_{rel}=12$ ft/sec^2
$g-a_{lift}=12$
$a_{lift}=32-12$
$a_{lift}=20$ft/sec^2

Question 32

A ball is thrown horizontally from a point 100m above the ground with a speed of 20 m/s
Find
(a) The time it takes to reach the ground
(b) The horizontal distance it travels before reaching the ground
(c) The velocity (direction and magnitude) with which it strikes the ground.

Solution 32

x-axis y-axis
$u_x=20$m/s $u_y=0$m/s
$a_x=0$m/s^2 $a_y=g$m/s^2

(a) $s_y=u_yt+\frac{1}{2}a_yt^2$
$100=0+\frac{1}{2}(9.8)t^2$
$t=4.5$sec
(b) $s_x=u_xt$
$=(20)(4.5)$
$s_x=90$m
(c) $v_x=u_x+at$ $v_y=u_y+a_yt$
$v_x=20$ $v_y=0+(9.8)(4.5)$
$v_y=44.1$m/s
$v=\sqrt{v_x^2+v_y^2}$
v=49m/s at $\tan^{-1}\left(\frac{44.1}{20}\right)$ that is 66° from ground

Question 33

A ball is thrown at a speed of 40 m/s at an angle of 60° with the horizontal.
Find
(a) The maximum height reached
(c) The range of the ball
Take g= 10 m/s^2

Solution 33

u=40m/s; θ=60°
(a)
$H_{max}=\frac{u^2\sin2\theta}{2g}=\frac{40^2(\sin^2 60)}{2g}$
$H_{max}=60$m
(b)
$R=\frac{u^2\sin2\theta}{g}=\frac{40^2\sin(2x60)}{g}$
$R=80\sqrt{3}$m

Question 34

In a soccer practice session the football is kept at the center of the field 40 yards from the 10ft goalposts. A goal is attempted by kicking the football at a speed of 64 ft/s at an angle of 45° to the horizontal. Will the ball reach the goal post?

Solution 34

$y = x \tan\theta - \frac{1}{2} g \frac{x^2}{u^2 \cos^2\theta}$

$= (40\times3)\tan45 - \frac{1}{2}\frac{(32)(40\times3)^2}{(64)^2(\cos45)^2}$

$= 120 - 112.4$

$y = 7.5\text{ft} <$ height of goalpost

So, football will reach the goalpost

Question 35

A popular game in Indian villages is goli which is played with small glass balls called golis. The goli of one player is situated at a distance of 2.0m from the goli of the second player. The second player has to project his goli by keeping the thumb of the left hand at the place of his goli, holding the goli between his two middle fingers and making the throw. If the projected goli hits the goli of the first player, the second player wins. If the height from which the goli is projected is 19.6cm from the ground and the goli is to be projected horizontally, with what speed should it be projected so that it directly hits the stationary goli without falling on the ground earlier?

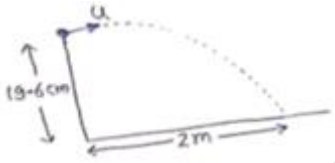
Solution 35

x-axis y-axis

$s_x = 2\text{m}$ $u_y = 0$

$a_x = 0$ $a_y = g$

$s_y = 19.6\text{cm}$



$s_y = u_y t + \frac{1}{2} a_y t^2$

$\frac{19.6}{100} = 0 + \frac{1}{2}(9.8)t^2$

$s_x = u_x t + \frac{1}{2} a_x t^2$ $t = 0.2\text{sec}$

$2 = u_x t + \frac{1}{2} a_x t^2$

$2 = u_x(0.2) + 0$

$u_x = 10\text{m/s}$

Question 36

The given figure shows a 11.7 ft wide ditch with the approach roads at tan angle of 15° with the horizontal. With what minimum speed should a motorbike be moving on the roads so that it safely crosses the ditch?

Assume that the length of the bike is 5ft and it leaves the road when the front part runs out of the approach road.

Solution 36

Range to be covered by bike=11.7+5=16.7ft

$$R=\frac{u^2\sin 2\theta}{2g}$$

$$16.6=\frac{u^2\sin(2x15)}{2(32)}$$

u=32ft/sec

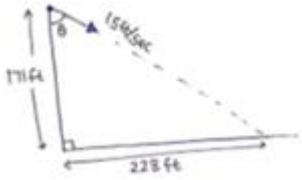
Question 37

A person standing on top of a cliff 171ft high has to throw a packet to his friend standing on the ground 228 ft horizontally away. If he throws the packet directly aiming at the friend with a speed of 15.0 ft/s, how short will the packet fall?

Solution 37

Tan θ=228/171=4/3

θ=53°



x-axis y-axis

$u_x=15\sin 53$ $u_y=15\cos 53$

$u_x=12$ft/sec $u_y=9$ft/sec

$a_y=32$ft/sec^2

$s_y=171$ft

$$s_y=u_yt+\frac{1}{2}a_yt^2$$

$$171=9t+\frac{1}{2}(32)t^2$$

t=3sec

$s_x=12\times 3$

=36ft

Packet will fall short by = 228-36=192ft

Question 38

A ball is projected from a point on the floor with a speed of 12 m/s at an angle 60° with the horizontal, Will it hit a vertical wall 5m away from the point of projection and perpendicular to the plane of projection without hitting the floor? Will the answer differ if the wall is 22m away?

Solution 38

$$R=\frac{u^2\sin 2\theta}{g}$$

$$=\frac{(15)^2\sin(2x60)}{9.8}$$

R=19.88m

Ball will hit 5m away wall

If wall is at a distance of 22m, it will not hit directly

Question 39

Find the average velocity of a projectile between the instants it crosses half the maximum height. It is projected with a speed u at an angle θ with the horizontal

Solution 39

Let particle reaches from A to B in time t.

By symmetry, AB line is horizontal

So, displacement AB=$u_x t$

Velocity= $\frac{\text{displacement}}{\text{time}} = \frac{uxt}{t}$

$V_{avg}=u\cos\theta$

Question 40

A bomb is dropped from a plane flying horizontally with uniform speed, Show that the bomb will explode vertically below the plane. Is the statement true if the plane flies with uniform speed but not horizontally?

Solution 40

During release, $u_{plane}=u_{bomb}$

Along x-axis,

$u_{rel}=0$

$a_{rel}=0$

So, at any time, $s_{rel}=0$

So, bomb will always be below and will explode

If plane is at some angle then also $u_{plane/x\text{-}axis}=u_{bomb/x\text{-}axis}$

i.e. Along x-axis $u_{rel}=0$

So, bomb explodes below plane

Question 41

A boy is standing on a long railroad car throws a ball straight upwards. The car is moving on the horizontal road with an acceleration of 1 m/s^2 and the projection velocity in the vertical direction is 9.8 m/s. How far behind the boy will the ball fall on the car?

Solution 41

Time of flight for ball= $\frac{2u\sin\theta}{g}$

$= \frac{2(9.8)\sin 90^\circ}{g}$

t=2sec

For ball-car, along horizontal direction

$u_{rel}=0$

$a_{rel}=1$

t=2

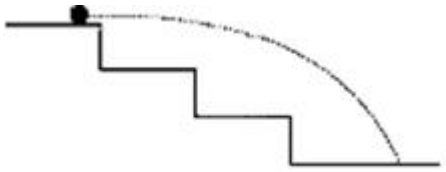
$s_{rel}=u_{rel}t+\frac{1}{2}a_{rel}t^2$

$=0+\frac{1}{2}(1)(2)^2$

$s_{rel}=2m$

Question 42

A staircase contains three steps each 10 cm high and 20 cm wide as shown in figure. What should be the minimum horizontal velocity of a hall rolling off the uppermost plane so as to hit directly the lowest plane?



Solution 42

For minimum velocity ball will just be touching point B
If A is origin then coordinates of B(40,-20)

$Y = x\tan\theta - \frac{1}{2} g \frac{x^2}{u^2\cos^2\theta}$

$-20 = 40\tan 0° - \frac{1}{2} \frac{g(40)^2}{u^2\cos^2 0°}$

u=200cm/s
u=2m/s

Question 43

A person is standing on a truck moving with a constant velocity of 14.7 m/s on a horizontal road. The man throws a ball in such a way that it returns to the truck after the truck has moved 58.8m. Find the speed and the angle of projection (a) as seen from the truck, (b) as seen from the road.

Solution 43

Time taken by ball=Time taken by truck to cover 58.8m

$\text{Time} = \frac{\text{distance}}{\text{speed}} = \frac{58.8}{14.7} = 4\text{sec}$

(a)
For Truck, ball will seems to travel in vertical direction

Time to reach H_{max} by ball$= \frac{4}{2} = 2\text{sec}$

v=0; a=-g;t=2sec
v=u+at
0=u-g×2
u=19.6m/s (upward direction)
(b)
From road, motion of ball will be projective
Now, usin θ=19.6
Ucos θ=14. 7
Squaring and adding

$u^2=(19.6)^2+(14.7)^2$
u=25m/s
On dividing,

$\text{Tan } \theta=\frac{19.6}{14.7}$

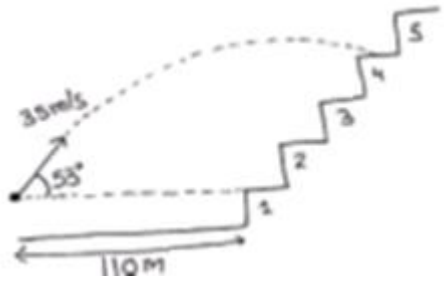
θ=53°

Question 44

The benches of a gallery in a cricket stadium are 1m wide and 1m high. A batsman strikes the ball at a level one metre above the ground and hits a mammoth sixer. The ball starts at 35 m/s at an angle of 53° with the horizontal. The benches are perpendicular to the place of motion and the first bench is 110 m from the batsman on which bench hwill the ball hit?

Solution 44

Let ball lands on the nth bench
∴ y=(n-1)
and x=110+(n-1) = 110+y



Now

$Y=x \tan \theta - \frac{1}{2} g \frac{x^2}{u^2 \cos^2 \theta}$

$(n-1)=(110+n-1)\tan 53° - g\frac{(110+n-1)^2}{2(35)^2(\cos^2 53)}$

Solving
n=6

Question 45

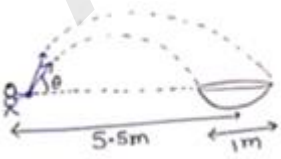
One man is sitting on the shores of a river. He is in the line of 1.0 m long boat and is 5.5m away from the center of the boat. If he can throw the apply only with a speed of 10 m/s. find the minimum and maximum angles of projection for successful shot. Assume that the point of projection and the edge pf the boat are in the same horizontal level.

Solution 45

For near point of boat

$R=5m=\frac{u^2 \sin 2\theta}{g}$ g

$5=\frac{(10)^2 \sin 2\theta}{g}$



θ=15° or 75°
For for point of boat

$$R=6m=\frac{u^2\sin 2\theta}{g}$$

$$6=\frac{(10)^2\sin 2\theta}{g}$$

θ=18° or 71°
For a successful shot angle may vary from 15° to 18° or 71° to 75°
Minimum angle=15°
Maximum angle=75°

Chapter 3 - Rest and Motion Kinematics Exercise 54

Question 46

A river 400m wide is flowing at a rate of 2.0 m/s. A boat is sailing at a velocity of 10 m/s with respect to the water, in a direction perpendicular to the river.
(a) Find the time taken by the boat to reach the opposite bank.
(b) How far from the point directly opposite to the starting point does the boat reach the opposite bank?

Solution 46

(a)
Velocity responsible for crossing is 10m/s

$$\text{So, time to cross river}=\frac{\text{distance}}{\text{speed}}$$

$$t=\frac{400}{10}=40\text{sec}$$

(b)
Velocity responsible for drift=2m/s
Distance=speed × time
=2×40=80m

Question 47

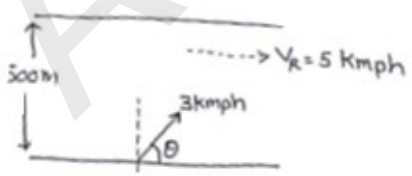
A swimmer wishes to cross 500m wide river flowing at 5 km/h. His speed with respect to water is 3 km/h.
(a) If he heads in a direction making an angle θ with the flow, find the time he takes to cross the river.
(b) Find the shortest possible time to cross the river.

Solution 47

(a) Velocity responsible for crossing=3sinθ kmph

$$=3\times\frac{5}{18}\sin\theta$$

$$\text{Time to cross}=\frac{distance}{speed}$$



$$=\frac{500x18}{3x5\sin\theta}=\frac{600}{\sin\theta}$$

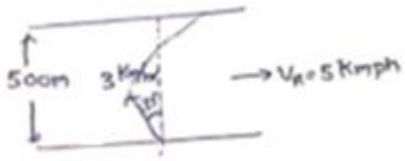
$=\frac{10}{\sin\theta}$ minutes
(b) For t_{min}; $\sin\theta=1$
When $\theta=90°$
$t_{min}=10$minutes

Question 48

Consider the situation of the previous problem. The man has to reach the other shore at the point directly opposite to his starting point. If he reaches the other shore somewhere else, he has to walk down to this point, Find the minimum distance that he has to walk.

Solution 48

When $v_{river} > v_{man}$and for minimum drift $\sin\theta=\frac{V_{Man}}{V_{river}}$
$\sin\theta=\frac{3}{5}$
$\theta=37°$



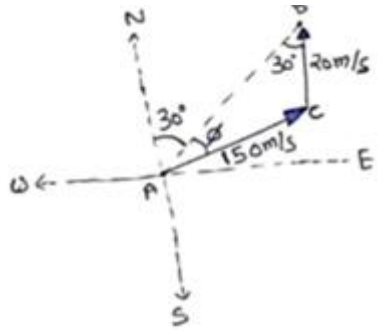
Time to cross river= $\frac{\text{distance}}{\text{speed}}$
$=\frac{0.5}{3\cos37}$
$=\frac{0.5}{3}\times\frac{5}{4}$
drift=speed × time
=(5-3sin37°)time
$=(5-d\times\frac{3}{5})(\frac{0.5x5}{12})$
drift=$\frac{2}{3}$ km

Question 49

An aero plane has to go from point A to another point B, 500km away due to 30° east of north. A wind is blowing due north at a seed of 20 m/s. The air speed of the plane is 150 m/s.
(a) Find the direction in which the pilot should head the plane to reach the point B.
(b) Find the time taken by the plane to gr from A to B.

Solution 49

(a)



In ΔACB
Using sin formula

$$\frac{20}{\sin\phi} = \frac{150}{\sin 30^\circ}$$

$$\sin\phi = \frac{1}{15}$$

$$\phi = \sin^{-1}\left(\frac{1}{15}\right)$$ east of the line AB

(b)
ø=3°48'. Angle between two vector=30 +3°48'

$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

$$= \sqrt{}(150)^2+(20)^2+2(150)(20)\cos 33^\circ.48'$$

R=167m/s

$$\text{Time} = \frac{\text{distance}}{\text{speed}} = \frac{500\times10^3}{167}$$

=2994 sec

$$T = \frac{2994}{60} \approx 50\text{min}$$

Question 50

Two friends A and B are standing a distance x apart in an open field and wind is blowing from A to B. A beats a drum and B hears the sound t_1 time after he sees the event. A and B interchange their positions and the experiment is repeated. This time B hears the drum t_2 time after he sees the event. Calculate the velocity of sound in still air v and the velocity of win u. Neglect the time light takes in travelling between the friends.

Solution 50

Initially, resultant velocity of sound=v+u

$$(v+u) = \frac{x}{t_1}$$ ----(i)

Later, resultant velocity of sound=v-u

$$(v-u) = \frac{x}{t_1}$$ ------(ii)

Add (i) and (ii)

$$V = \frac{x}{2}\left(\frac{1}{t_1}+\frac{1}{t_2}\right)$$

and

$$u = \frac{x}{2}\left(\frac{1}{t_1}-\frac{1}{t_2}\right)$$

Question 51

Suppose A and B in the previous problem change their positions in such a way that the line joining them becomes perpendicular to the direction of wind while maintaining the separation x. What will be the time lad B finds between seeing and hearing the drum beating by A?

Solution 51

Let v be the velocity of sound along direction AC so it can reach B with resultant velocity AD

Velocity along AB=$\sqrt{V^2-U^2}$

Time= $\frac{\text{distance}}{\text{speed}}$

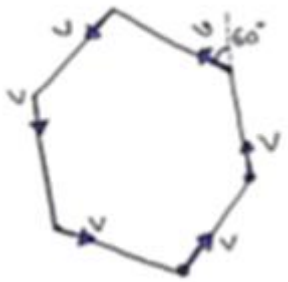
t=$\frac{x}{\sqrt{V^2-U^2}}$

Question 52

Six particles situated at the corners of a regular hexagon of side a move at a constant speed v. Each particle maintains a direction towards the particle at the next corner. Calculate the time the particle will take to meet each other.

Solution 52

Relative velocity = v-vcosθ



=$v-\frac{v}{2}$

=$\frac{v}{2}$

S_{rel}=a

Speed= $\frac{\text{distance}}{\text{time}}$

$\frac{v}{2}=\frac{a}{t}$

t= $\frac{2a}{v}$