Question Bank

CHAPTER 04- MOTION IN A PLANE

Each question scores One

1	The physical quantities having only magnitude but no direction are called as..... Ans: Scalars
2	The physical quantities having both magnitude and direction are called as..... Ans: Vectors
3	The vectors having zero magnitude are called as..... Ans: Null vectors or Zero vectors.
4	The angle between $\vec{A}=\hat{i}+\hat{j}$ and $\vec{B}=\hat{i}-\hat{j}$ is ..... a)45^0 b) 60^0 c) 90^0 d)180^0 Ans; 90^0
5	Identify the scalar quantity from the following alternatives. (i) Momentum (ii) Work (iii)Torque (iv) Acceleration Ans: Work.
6	A ball is dropped through the window of a train travelling with high velocity, to a man standing near the track. The ball..... i.Falls down vertically ii.Moves straight horizontally iii.Follows an elliptical path iv.Follows a parabolic path Ans: Follows a parabolic path.
7	At the top of a projectile vertical velocity of the object will be..... Ans: zero.
8	At the top of a projectile, angle between velocity and acceleration is.... a)0° b) 45° c)60° d) 90°. Ans: zero.90°
9	From a height an object A is dropped, at the same time another object B is thrown horizontally with a velocity 20m/s from the same point. Which one will reach the ground first?

	Ans: both will reach the ground at the same time
10	An object is projected with a velocity u at an angle 20° with horizontal. To get the same range another object projected from the same point with same velocity at an angle of..... Ans :70°
11	Maximum range of a projectile is 1.6 m. Then the velocity of projection will be..... ($g=10m/s^2$) Ans : 4 m/s.
12	If two vectors can be connected by the equation b= 4a. Then a and b will be.....Vectors? Ans: Colinear vectors
13	The physical quantity which is constant at any point in projectile motion is..... a)Velocity b)Acceleration c)Kinetic energy d)Linear momentum Ans : Acceleration

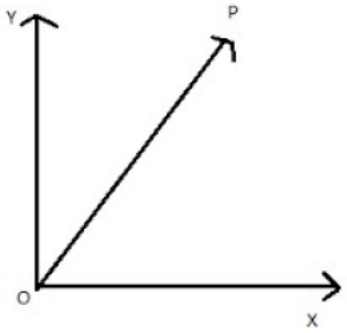
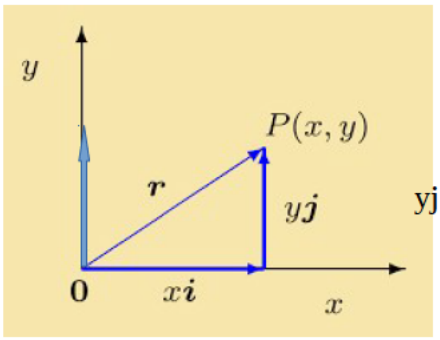
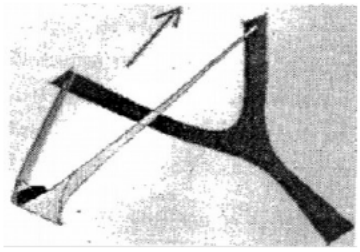
Each question scores Two

1	A boy throws a ball of mass 200 g with a velocity 20 ms $^{-1}$ at an angle of 40° with the horizontal. What is the kinetic energy of the ball at the highest point of the trajectory? Ans: At the highest point $V_x=u\cos\theta$ and $V_y=0$. Given m=0.2 kg u=20 m/s and $\theta=40^0$. KE at the highest point = $\frac{1}{2}mV_x^2$ = $\frac{1}{2}m(u\cos\theta)^2$ = $\frac{1}{2}x0.2\,x\,(20\cos 40)^2$ = 23.47 J
2	A particle is projected up into the air from the point with a speed of 20 m/s at an angle of projection 30°. What is the maximum height reached by it.? Ans: Given u=20m/s, $\theta=30^0$. $H=\frac{u^2\sin^2\theta}{2g}$ $H=\frac{20^2\sin^2 30}{2\,x\,9.8}$ ie H=5.1 m
3	A football is kicked into the air vertically upwards. What is its (a) acceleration at the highest point (b) velocity at the highest point? Ans: (a) At highest point the acceleration remains same as acceleration due to gravity (b) At highest point, velocity becomes zero
4	If horizontal range is equal to 4 times maximum height. Find the angle of projection?

	Ans: tan θ= $\frac{4H}{R}$ Here R = 4H So θ=45
5	A ball is thrown with a velocity u at an angle θ at the same time a boy running towards the ball from the point projection with a velocity u/2. Can the boy be able to catch the ball? Ans : Yes. When ucosθ = $\frac{u}{2}$ Cosθ= 1/2 θ=60°.
6	Why electric current is a scalar quantity? Ans : Electric current will not obey the law of Vector Algebra.(Vector Addition Laws) So it can be considered as a scalar
7	A ball is projected with a velocity 30m/s. Find the maximum range?(take g=10m/s^2) Ans : R = $\frac{u^2}{g}$ R= 30x30/10 R=900/10 R=90m
8	A ball thrown by one player is caught by another player in 5 seconds then calculate the maximum height reached by the ball (g= 10 m/s^2) given 2usinθ /g= 5 usinθ= 25 Now. H = u^{2}Sin^2 θ/ 2g = 25^2/2 x 10 = 31.25 m
9	A food packet is released from a plane flying horizontally, reaches the surface of the earth in 10 second. Calculate the height from which the packet is dropped - h = - 1/2 gt^2 h = 1/2 x 10 X 100 = 500m

Each question scores Three

1	(a) Give the expression to find the unit vector of a given vector $\vec{A}$ (b) Find the unit vector of $\vec{A} = 4\hat{i}-3\hat{j}+\hat{k}$ Ans: (a) The unit vector of $\vec{A}$, $\hat{A}=\frac{\vec{A}}{\lvert\vec{A}\rvert}$ (b) $\vec{A} = 4\hat{i}-3\hat{j}+\hat{k}$ Here $\lvert\vec{A}\rvert=\sqrt{A_x^2+A_y^2+A_z^2}$ $\lvert\vec{A}\rvert=\sqrt{4^2+(-3)^2+1^2}$ $\lvert\vec{A}\rvert=\sqrt{16+9+1}=\sqrt{26}$

	There fore $\hat{A}=\frac{\vec{A}}{\lvert\vec{A}\rvert} = \frac{4\hat{i}-3\hat{j}+\hat{k}}{\sqrt{26}}$
2	The position vector $\vec{r}$ of a particle P located in an x-y plane is shown in figure.  a) Redraw the figure by showing the rectangular components. b) Write the position vector in terms of rectangular components. c) Write an equation to find the magnitude of the resultant of two vectors A and B Ans: a)  b) $\vec{r}=x\hat{i}+y\hat{j}$ c) $R=\sqrt{A^2+B^2+2ABcos\,\theta}$
3	A stone is thrown with the help of a sling with initial velocity ‘u’ at an angle 'θ' from the horizontal.  a) Working of sling is based on..... law of vector addition. b) Derive the expression for the maximum height reached by the stone. Ans: a)Parallelogram law of vector addition.

b) **Expression for Maximum height(H):**

We have $V^2=u^2+2as$

Taking the vertical components;

$$V_y^2=u_y^2+2a_y s_y$$

Here Vy=0, u_y=usinθ , a_y=-g and S_y =H

Therefore $0=(usin\theta)^2-2gH$

$$2gH=u^2\sin^2\theta$$

Maximum Height , $H=\frac{u^2\sin^2\theta}{2g}$

4 Show that maximum horizontal range is 4 times the maximum height attained by the projectile.

Ans:

For maximum horizontal range θ=45°

$R_{max}=\frac{[u^2\sin 2\theta]}{g}=\frac{[u^2\sin 2(45)]}{g}=\frac{[u^2\sin(90)]}{g}$

$R_{max}=\frac{u^2}{g}$

For maximum height,

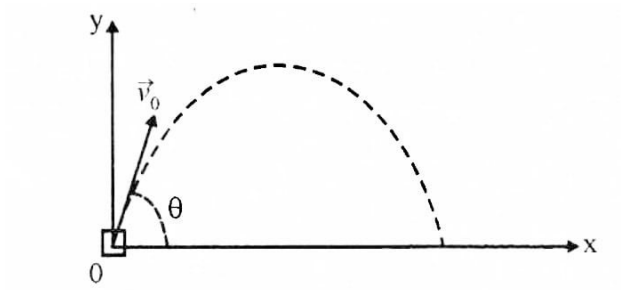
$h_{max}=\frac{[u^2\sin^2\theta]}{2g}=\frac{[u^2\sin^2\theta]}{2g}=\frac{[u^2\sin^2 45]}{2g}$

$h_{max}=\frac{u^2}{4g}$

$\frac{R_{max}}{h_{max}}=\frac{u^2}{g}.\frac{4g}{u^2}=4$ or $R_{max}=4\times h_{max}$

Each question scores Four

1 The figure below shows the path of a projectile motion.



a)Obtain the expressions for maximum height and time of flight.

b)What is the angle of projection for maximum horizontal range?

Ans: a)**Expression for Maximum height(H):**

We have $V^2=u^2+2as$

Taking the vertical components;

$$V_y^2=u_y^2+2a_y s_y$$

Here Vy=0, u_y=usinθ , a_y=-g and S_y =H

Therefore $0=(usin\theta)^2-2gH$

$$2gH = u^2 \sin^2\theta$$

Maximum Height , $H = \frac{u^2 \sin^2\theta}{2g}$

Expression for Time of flight (T):

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

Taking vertical components;

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

Here S_y=0, u_y=usinθ , a_y=-g and t=T, time of flight.

Therefore $0 = u\sin\theta T - \frac{1}{2}gT^2$

$$\frac{1}{2}gT^2 = usin\,\theta T$$

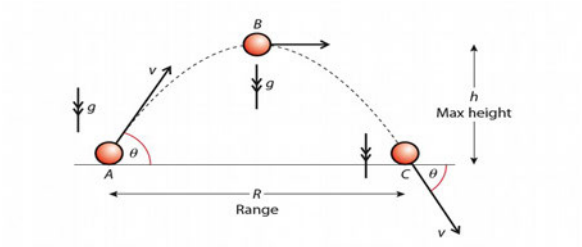
$$\frac{1}{2}gT = usin\,\theta$$

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

b) For Maximum horizontal range , angle of projection θ=45^0

2 a)A man throws a stone up into air at an angle 'θ' with the horizontal. Draw the path of the projectile and mark directions of velocity and acceleration at the highest position.
b) Derive an expression for the maximum height reached by the stone.

Ans: a)



b)**Expression for Maximum height(H):**

We have $V^2 = u^2 + 2as$

Taking the vertical components;

$$V_y^2 = u_y^2 + 2a_y s_y$$

Here Vy=0, u_y=usinθ , a_y=-g and S_y =H

Therefore $0 = (usin\,\theta)^2 - 2gH$

$$2gH = u^2 \sin^2\theta$$

Maximum Height , $H = \frac{u^2 \sin^2\theta}{2g}$

3 The ceiling of a long hall is 25 m high. What is the maximum horizontal distance that a ball thrown with a speed of 40 m/s can go without hitting the ceiling of the hall?

Ans: Given H=25m , u= 40 m/s.

$$H = \frac{u^2 \sin^2\theta}{2g} = \frac{40^2 \sin^2\theta}{9.8} = 25\,m$$

$$\sin^2\theta = \frac{25\,x\,9.8}{40^2}$$

Therefore θ=33.6^0.

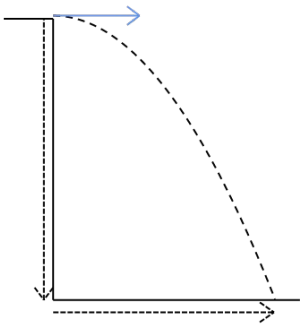
Range $R=\frac{u^2\sin 2\theta}{g}=\frac{40^2\sin 2(33.6)}{9.8}=150.5\,m$

4 A ball is thrown horizontally from the top of a tower with a velocity of 40 m/s. Take g=10 m/s2.
(a)Find the horizontal and vertical displacement after 1,2,3,4,5 seconds, then plot the path of motion of the ball.
(b)If the ball reaches the ground in 4 s , find the height of the tower.

Ans: (a) Horizontal displacement $S_x=u_x t$ because a_x=0

Vertical displacement $S_y=\frac{1}{2}gt^2$ because u_y=0 a_y=g

t	1	2	3	4	5
S_x	40	80	120	160	200
S_y	5	20	45	80	125

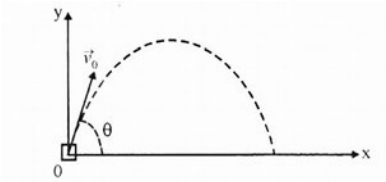


(b) Hight of the tower , $H=\frac{1}{2}gt^2=\frac{1}{2}x\,10\,x\,4^2$

H=80m.

Each question scores Five

1 A projectile is any body that is given an initial velocity and then follows a path determined entirely by the effects of gravitational acceleration and air resistance.
a) The path of a projectile is.....
i) straight line
ii) parabola
iii) circle
iv) semi circle
b) Derive an expression for time to reach maximum height and hence the time of flight of a projectile.
c) A baseball leaves a bat with an initial speed of 37 m/s at an angle of 53.1^o . Find the position of the ball when t = 2s (treat baseball as a projectile and g = 9.8 m/s^2)
Ans: a)(ii) parabola.
b)**Expression for time to reach maximum height:**



At the maximum height , V_y=0 , u_y=usinθ and a_y=-g
We have $v_y=u_y-gt$
0=usinθ-gt
Therefore time to reach maximum height , $t=\frac{u\sin\theta}{g}$

Expression for Time of flight (T):

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

Taking vertical components;

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

Here $S_y=0$, $u_y=u\sin\theta$, $a_y=-g$ and t=T, time of flight.

Therefore $0 = u\sin\theta T - \frac{1}{2}gT^2$

$$\frac{1}{2}gT^2 = usin\,\theta T$$

$$\frac{1}{2}gT = usin\,\theta$$

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

c) Here u= 37 m/s θ= 53.1° g=9.8 m/s²

u_x = ucos θ=37 cos (53.1)=37x 0.6=22.2m/s

u_y=usin θ=37 sin (53.1)=37x0.79=29.59 m/s.

The x-coordinate is given by

$$S_x = u_x t + \frac{1}{2}a_x t^2 = u_x t \qquad (a_x=0)$$

Therefore at t=2s, x=22.2 x 2=44.4 m

The y-coordinate is given by

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

$$y = 29.59\,x\,2 - \frac{1}{2}9.8\,x\,2^2 \qquad (a_y=-g=-9.8\ m/s^2)$$

y=39.6m

Therefore the position of the ball when t = 2s is given by (44.4, 39.6)

2 A body is projected into air at an angle θ with the horizontal.

a) What is the trajectory followed by this projectile?

i) Ellipse
ii) Parabola
iii) Straight line
iv) Circle

b) Give a mathematical proof for your answer.

c) Trajectory of a body in a projectile motion is given by $y = x - \frac{x^2}{80}$ where x and y are in meters.

Find maximum height of this projectile.

Ans:

a)Parabola.

b) Here $u_x=u\cos\theta$, $u_y=u\sin\theta$, $a_y=-g$

Let 'x' be the horizontal distance covered in a time 't' , then

$$t = \frac{x}{u\cos\theta} \quad \text{-----(1)}$$

Let 'y' be the vertical distance covered in a time 't' , then

$$y = u\sin\theta t - \frac{1}{2}gt^2$$

$$y = u\sin\theta\frac{x}{u\cos\theta} - \frac{1}{2}g\left(\frac{x}{u\cos\theta}\right)^2$$

Therefore $y = (\tan\theta)x - \left(\frac{g}{2u^2\cos^2\theta}\right)x^2$

The above equation is similar to

$y = ax - bx^2$ and represents a parabola.

c)Given $y = x - \frac{x^2}{80}$ and We have $y = (\tan\theta)x - \left(\frac{g}{2u^2\cos^2\theta}\right)x^2$

Comparing, we get

$\tan\theta = 1$ Therefore $\theta = 45^0$.

And $\frac{g}{2u^2\cos^2\theta} = \frac{1}{80}$

That is $\frac{u^2}{g} = 80$

We have Maximum height $H = \frac{u^2\sin^2\theta}{2g}$

$$H = \frac{80}{2x2} = 20\,m.$$