CHAPTER 4

MOTION IN APLANE

I . ONE MARK QUESTIONS

1. What is scalar quantity ?
2. Give an example for scalar quantity.
3. Does the scalar addition obey ordinary addition rules?
4. What is vector quantity ?
5. Give an example for vector quantity.
6. Does the vector addition obey ordinary addition rules ?
7. How does vector is different from scalar ?
8. Is displacement a vector or a scalar ?
9. Give the graphical representation of vector.
10. Define null vector
11. Define unit vector
12. What is position vector ?
13. What is negative of a vector ?
14. What ar equal vectors ?
15. What are parallel vectors ?
16. What are concurrent vectors (co-initial vectors) ?
17. What are co-planar vectors ?
18. Does the vector addition obey the commutative law ?
19. Does the vector addition obey the associative law ?
20. Give the mathematical representation of unit vector.
21. Mention any one law of addition of vector .
22. State law of triangle of vectors.
23. State the law parallelogram of vectors.
24. What is resultant vector ?
25. What are components of a vector ?
26. What is resolution of a vector ?
27. What are rectangular components of a vector?
28. The magnitude of the resultant of the two equal vectors is equal to the magnitude of the either vector , what is the angle between two vectors ?
29. When the magnitude of the resultant of the two vectors is maximum ?

30. When the magnitude of the resultant of the two vectors is minimum ?
31. If $\overrightarrow{A}$ and $\overrightarrow{B}$ are acting at right angles to each other, what is the magnitude of their resultant ?
32. If two equal vectors acting at right angles to each other, what is the magnitude of their resultant ?
33. Vector $A = 3$ units ,acting along east, and vector $\overrightarrow{B} = 4$ units , acting along north. What is the magnitude of their resultant ?
34. Is scalar multiplied by a vector a vector or a scalar.
35. Give an example for scalar multiplied by a vector
36. What is the magnitude of $\vec{A}= 3\,\hat{\imath}\text{-}\hat{k}$
37. What is the unit vector of $\vec{P} = 3\hat{\imath} - 4\,\hat{j}$
38. What is two dimensional motion ?
39. Give an example for motion in two dimension .
40. What is a projectile ?
41. Give an example for a projectile .
42. Define projectile velocity ?
43. Define angle of projection of a projectile.
44. Define time of flight of a projectile.
45. Define range of a projectile.
46. What is the nature of path (trajectory) of projectile?
47. What is the maximum height of a projectile ?
48. Write the horizontal component of velocity of projectile.
49. Write the vertical component of velocity of projectile.
50. Which component of velocity of a projectile is constant?
51. Which component of velocity of a projectile is zero at maximum height ?
52. Which component of acceleration of a projectile is zero?
53. Draw the graphical representation for a projectile motion .
54. Write the expression for the path of a projectile.
55. Give the expression for the maximum height of a projectile.
56. Give the expression for the time of flight of a projectile.
57. Give the expression for the range of a projectile.
58. How does the maximum height depend upon velocity of projectile?
59. How does the time of flight depend upon velocity of projectile?
60. How does the range of projectile depend upon velocity ?

61. If velocity of projectile is doubled what happens to the maximum height of projectile?
62. When the range of projectile is maximum ?
63. Three athletes A,B and C participating in a long jump event jump by making angles 30^0 , 45^0 and $60^0$with the ground. Who will be the winner ?
64. For what two angles of projection , the range of projectile is same?
65. What is uniform circular motion?
66. Which physical quantity remains constant for uniform circular motion?
67. Is velocity of particle constant for a particle in a uniform circular motion?
68. What is the direction of velocity of a particle in a uniform circular motion?
69. What is the direction of acceleration of a particle in a uniform circular motion?
70. Give expression for centripetal acceleration.

II . TWO MARK QUESTIONS

1. Distinguish between scalar and vector with suitable example for each.
2. Classify the following into scalars and vectors.

Distance, displacement , speed, velocity, acceleration , mass, volume, time, linear momentum .

3. Pick out the scalar quantities among the following:
   Force , work, angular momentum, heat, torque.
4. Pick out the vector quantities among the following:
   Density, moment of force , temperature ,electric field.
5. State and explain the law of triangle of vectors.
6. Write the expression for the magnitude and direction of the resultant of two vectors acting at a point.
7. The horizontal and vertical component of a vector are 3 units and 4 units respectively. What is the magnitude of the vector.
8. A vector of 10 units acts at a point making an angle $30^0$with the horizontal . what are the horizontal and vertical components of the vector ?
9. Draw the diagram for the path of the projectile. And indicate the range and angle of the projectile.

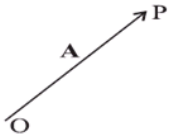
10. Write the expression for the path (trajectory) of the projectile and explain the terms.
11. Write the expression for the maximum height of the projectile and explain the terms.
12. Write the expression for the time of flight of the projectile and explain the terms.
13. Write the expression for the range of the projectile and explain the terms.
14. For particle in a uniform circular motion speed is uniform but its velocity is not uniform, explain.
15. What is centripetal acceleration? Give the expression for it.
16. Write the expression for the centripetal acceleration and explain the terms.

III 5 MARK QUESTIONS

1. State and explain ,
   I. Law of triangle of vectors
   II. Law of parallelogram of vectors
2. Derive the expression for trajectory of a projectile . OR show the trajectory (path)of a projectile is a parabola.
3. Derive the expression for maximum height and time of flight of projectile.
4. Derive the expression for time of flight and range of projectile.
5. Derive the expression for the centripetal acceleration.

CHAPTER 4
MOTION IN A PLANE

I ANSWERS FOR ONE MARK QUESTIONS:

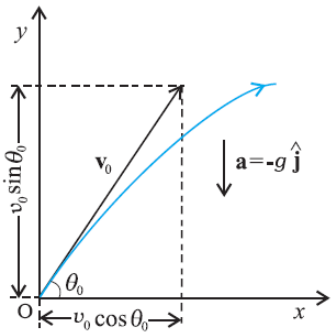
1. Physical quantity which have magnitude but no direction.
2. Distance , speed , mass, temp etc.
3. Yes.
4. Physical quantity which have both magnitude and direction.
5. Displacement , velocity acceleration, etc.
6. No.
7. Vector is having both magnitude and direction but scalar has only magnitude.
8. Vector.
9. 

10. Vector having zero magnitude.
11. It is a vector whose magnitude is unity.
12. A vector which gives the position of a particle with reference to the origin of a co-ordinate system.
13. The negative of a vector is a vector having the same magnitude but opposite direction.
14. Two vectors of equal magnitudes and same direction.
15. The vectors whose lines of action are parallel.
16. The vectors having same initial point.
17. The vectors acting in the same plane.
18. Yes.
19. Yes.
20. $\hat{n} = \frac{\vec{A}}{|\vec{A}|}$
21. Law of triangle of vector .
22. The law states that if the two vectors acting at a point represents the two sides of a triangle taken in order, then the third side of the triangle taken in reverse order gives the resultant.
23. It states that if two vectors acting on a particle at the same time are represented in magnitude and direction by the two adjacent

sides of a parallelogram drawn from a point, their resultant vector is represented in magnitude and direction by the diagonal of parallelogram drawn from the same point.

24. The resultant vector is a single vector whose effect is the same as the effect producedby the individual vectors together.
25. Effects of a vector in different directions are called components of a vector.
26. Splitting up of a vector in different directions.
27. The components of vector in two mutually perpendicular direction are called rectangular components
28. 120^0
29. When angle between two vectors is 0^0
30. When angle between two vectors is 180^0
31. R= $\sqrt{A^2 + B^2}$
32. R=$\sqrt{2}$ (magnitude of the individual vector)
33. R= $\sqrt{P^2 + Q^2}$ =$\sqrt{3^2 + 4^2}$ =$\sqrt{25}$= 5 units.
34. Vector.
35. 1. $\vec{F}$=m$\vec{a}$ 2.$\vec{P}$=m$\vec{v}$
36. $|\overrightarrow{A}| = \sqrt{3^2 + (-1)^2} = \sqrt{9+1} = \sqrt{10}$
37. $|\overrightarrow{P}| = \frac{\overrightarrow{P}}{|\overrightarrow{P}|} = \frac{3\hat{i} - 4\hat{j}}{\sqrt{9+16}} = \frac{3\hat{i} - 4\hat{j}}{5}$
38. Motion of the particle in a plane.
39. Motion of a Javelin.
40. Any particle moving in a direction making an angle $\theta$with the horizontal under the action of gravity of the earth.
41. A cricket ball thrown by a fielder.
42. Velocity with which the projectile is projected.
43. The angle made by the projectile with the horizontal.
44. Time taken by the projectile to reach the maximum height and then to the ground. OR The time during which the projectile is in air.
45. Horizontal distance travelled by the projectile is called range of the projectile.
46. Parabola.
47. The maximum vertical distance travelled by the projectile is called maximum height.

48. $V_x = v_o \cos\theta_0$
49. $V_y = v_0 \sin\theta_0$
50. The horizontal component .
51. The vertical component.
52. The horizontal component .
53.



54. $y = (\tan\theta_0)\,x - \frac{g}{2(v_o \cos\theta_0)^2} x^2$
55. $h_m = \frac{(v_0 \sin\theta_0)^2}{2g}$
56. $T_f = 2\,(v_0 \sin\theta_0) / g$
57. $R = \frac{v_0^2 \sin 2\theta_0}{g}$
58. Directly proportional to the square of the velocity.
59. Directly proportional to the velocity.
60. Directly proportional to the square of the velocity.
61. Increases by 4 times.
62. When $\theta = 45^0$.
63. Athlete B.
64. θ and (90- θ).
65. Motion of the projectile in a circular path with uniform speed.
66. Speed (angular velocity).
67. No.
68. Along tangential direction.
69. Towards the centre along the radius.
70. $a = \frac{v2}{r}$ OR $a = vw$.

II . ANSWERS FOR TWO MARK QUESTIONS:

1.

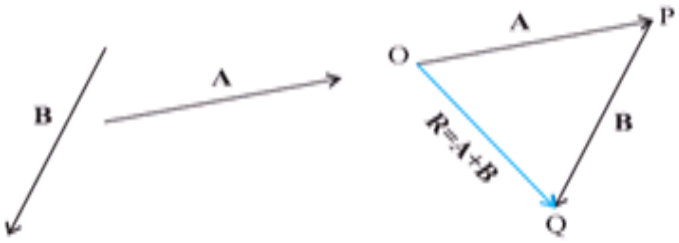
Scalar	Vector
physical quantities which are having only magnitude. Ex : mass, length, time.	physical quantities which are having both magnitude and direction. Ex : displacement, velocity.

2. Scalars: Distance, speed, mass.
Vectors: displacement , velocity, acceleration , volume, linear momentum .

3. Scalar quantities : work, heat.

4. Vector quantities : Density, moment of force , electric field.

5. The law of triangle of vectors:
It states that if two vectors can be represented in magnitude and direction by the two sides of a triangle taken in the same order , then the resultant is represented completely by the third side of the triangle taken in the reverse order.



Let two vectors $\vec{A}$ and $\vec{B}$ be represented both in magnitude and direction by the sides AB and BC of the triangle ABC taken in the same order . then the resultant $\vec{R}$ is by the third side AC taken in the opposite order.

6. The expressions for the magnitude and direction of the resultant of two vectors acting at a point are:

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

Direction , $\tan\alpha = \frac{B\sin\theta}{A+B\cos\theta}$

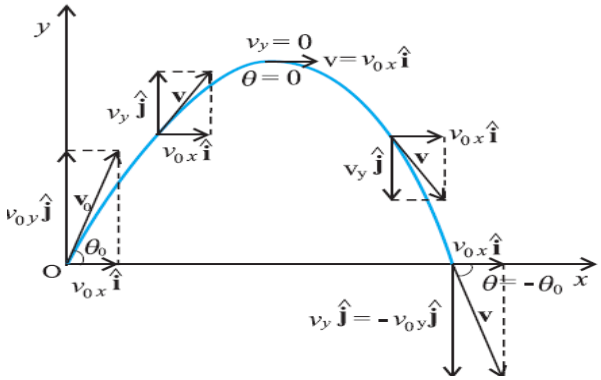
7.

$$|\vec{A}| = \sqrt{a_x^2 + a_y^2} = \sqrt{3^2 + 4^2} = \sqrt{9+16} = 5 \text{ units}$$

8. $A_x = A\cos\theta. = 10\cos 30^0 = 10 \times \frac{\sqrt{3}}{2} = 5\sqrt{3}$ units

$A_y = A \sin\theta. = 10 \sin 30^0 = 10 \text{ X } \frac{1}{2} = 5$ units

9.



10 . $y = (\ tan\theta_0\ )\ x - \frac{g}{2(vo\ cos\ \theta_0)^2}\ x^2$

11 . $h_m = \frac{(v0\ sin\ \theta_0\ )2}{2g}$, ಮಿಜಡಿಜ θ_0 ನ ಣುಜ ತಜಟಠಛಿಣಥಿ ಠಜ ಠಿಡಿಠರಿಜಛಿಣುಠಟಿ,

θ_0 is the angle of projection and g is the acceleration due to gravity at the given place.

12. $T_f = \ 2\ (v_0\ sin\ \theta_0\ ) / g$.

13. $R = \frac{v_0^2\ sin\ 2\theta_0}{g}$.

14.Because ,the direction of the velocity, given by the tangent changes at each and every point on the circumference of the circle.

15.In a cicrular motion , the acceleration of a particle is always directed towards the centre.This accerleration is called centripetal acceleration.

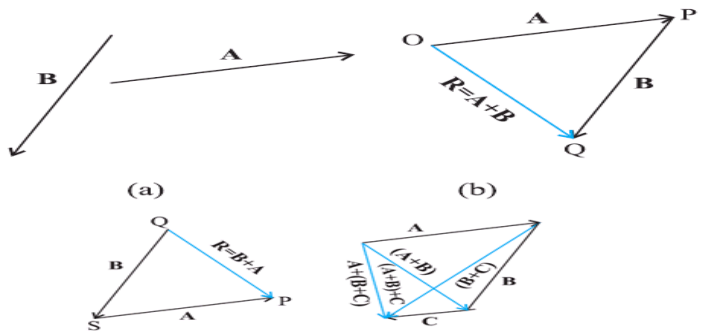
$a_c = \left(\frac{v}{R}\right) v = v^2/R.$

16. $a_c = \left(\frac{v}{R}\right) v = v^2/R$ಮಿಜಡಿಜ v–speed of the object

R- Radius of the circle.

III.ANSWERS FOR 4 AND 5 MARK QUESTIONS:

I .Triangle method of vector addition OR Tail to tip method of vector addition:



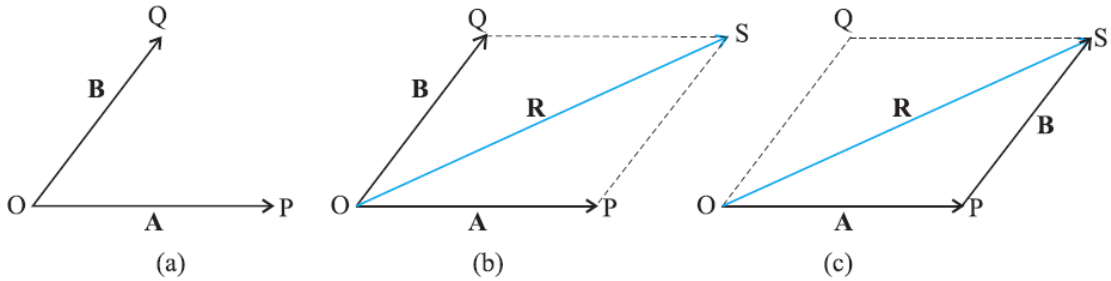
Explanation: To add$\vec{A}$. with$\vec{B}$, translate$\vec{B}$, by drawing parallel to itself so that the origin or initial point of $\vec{B}$ is at the tip of vector a. $\vec{A}$and $\vec{B}$are two vectors represented by two sides of a triangle taken in the same sense (direction). The vector sum of $\vec{A}$and $\vec{B}$(also called resultant of $\vec{A}$ and $\vec{B}$) is represented by the third side of the triangle taken in opposite sense(direction).

Statement: Triangle law of vector addition states that if two vectors can be represented in magnitude and direction by two sides of a triangle taken in the same order, then their resultant is represented completely by the third side of the triangle taken in opposite order.

II . Parallelogram method of vector addition:

To add two vectors placed with common initial point, the parallelogram method of vector is used.

Illustration:



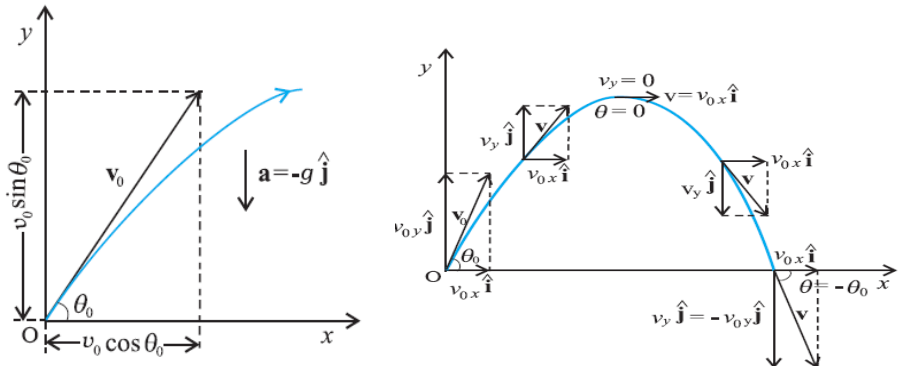
B

Explanation: To add vector $\vec{B}$ with $\vec{A}$inclined at an angle θ, draw equal vector of $\vec{A}$ at the tip of $\vec{B}$. By law of triangle method of vector addition $\vec{R}=\vec{B}+\vec{A}$Again by law of triangle method of vector addition $\vec{R}=\vec{A}+\vec{B}$. Note that $\vec{A}+\vec{B}=\vec{B}+\vec{A}$, that is vector addition follows commutative rule. $\vec{R}$, the diagonal of the completed parallelogram represents the vector sum of $\vec{A}$and $\vec{B}$completely both in magnitude and direction.

Statement of parallelogram law of vector addition:

" It states that if two vectors acting at a point can be represented both in magnitude and direction by the two adjacent sides of a parallelogram drawn from that point, the resultant is represented completely by the diagonal of the parallelogram passing through that point".

2. *Equation of path(trajectory) of a projectile (parabola):*



Consider a projectile moving in a direction making an angle θ with the horizontal.

Let v_o - velocity of the projectile.

The velocity v_o of the projectile resolved into

$V_x = v_o \cos\theta$ along horizontal (x-axis)

$V_y = v_0 \sin\theta$ along vertical (y-axis)

After the object has been projected ,the acceleration acting on it due to gravity and is directed vertically upwards

$\vec{a}=-g\hat{j}$

Therefore,$a_{x=}0$; $a_{y=}-g$

If we take the initial position to be the origin of the reference frame as shown in the fig, we have$x_0 = 0$, $y_0 = 0$

then, $x = v_{0x}t = (v_o \cos\theta_0)\, t$

and$y = (v_0 \sin\theta_0)\, t - (1/2)gt^2$

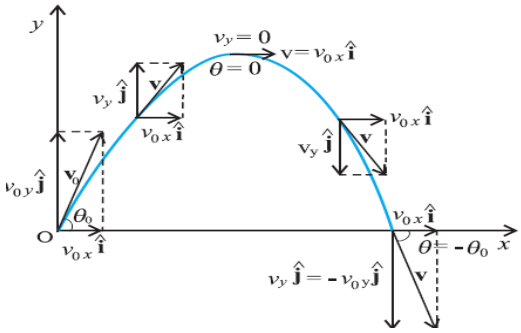
$v_x = v_{0x} = v_o \cos \theta_0$

$v_y = v_0 \sin \theta_0 - gt$

$y = (\tan\theta_0)\, x - \frac{g}{2(v_o \cos \theta_0)^2} x^2$

since g, θ_0 and v_o are constants this equation in the form of $y = ax + bx^2$ where a and b are constants.

3. *Maximum height of the projectile:*



Consider a projectile moving in a direction making an angle θ with the horizontal.

Let v_o - velocity of the projectile.

The velocity v_o of the projectile resolved into

$V_x = v_o \cos \theta$ along horizontal (x-axis)

$V_y = v_0 \sin \theta$ along vertical (y-axis)

After the object has been projected ,the acceleration acting on it due to gravity and is directed vertically upwards

$\vec{a} = -g\hat{j}$

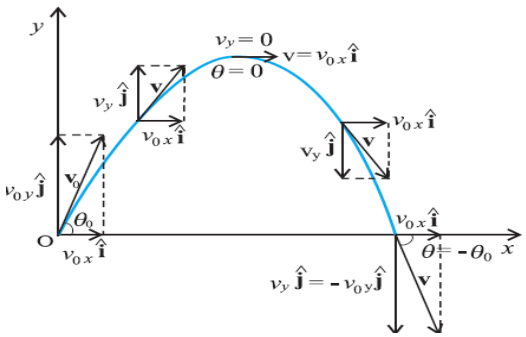
Therefore, $a_x = 0$; $a_y = -g$

The **maximum height** h_m reached by the projectile can be calculated by substituting $t = t_m$

$y = h_m = (v_0 \sin \theta_0)(v_0 \sin \theta_0 / g) - g/2 (v_0 \sin \theta_0 / g)^2$

$$h_m = \frac{(v0 \sin \theta_0)2}{2g}$$

4. *Time of flight and horizontal range of a projectile*



Consider a projectile moving in a direction making an angle θ with the horizontal.

Let v_o - velocity of the projectile.

The velocity v_o of the projectile resolved into

$V_x = v_o \cos\theta$ along horizontal (x-axis)

$V_y = v_0 \sin\theta$ along vertical (y-axis)

After the object has been projected ,the acceleration acting on it due to gravity and is directed vertically upwards

$\vec{a}$=-g$\hat{j}$

Therefore,$a_{x=}0$; $a_{y=}$-g

Let $t_m$is the time taken taken to the projectile to reach maximum height.

Since at that point $v_y = 0$

Therefore $v_y = v_0 \sin\theta_0 - g\, t_m = 0$

OR $t_m = v_0 \sin\theta_0 / g$

Total time (time of flight) $T_f$during which the projectile is in flight can be obtained by putting y= 0

$$T_f = 2 (v_0 \sin\theta_0) / g$$

We note that $T_f = 2\, t_m$

The horizontal distance travelled by a projectile from its initial position (x=y= 0) to the position where it passes y= 0 during its fall is called the **horizontal range R**

$R = (v_o \cos\theta_0)(T_f)$

$= (v_o \cos\theta_0)(2\ v_0 \sin\theta_0 / g)$

$$R = \frac{v_0^2 \sin 2\theta_0}{g}$$

For a give projection velocity v_o. R is maximum when $\sin 2\theta_0$ is maximum. i.e when $\theta_0 = 45^0$ therefore the maximum horizontal range is

$$R_m = \frac{v_0^2}{g}$$

5. The expression for the centripetal acceleration.

When an object follows a circular path at constant speed , the motion of the object is called uniform circular motion. The magnitude of its acceleration is $a_c = v^2 / R$. The direction of a_c is always towards the centre of the circle .

The angular speed ω is the rate of change of angular distance . It is related to velocity v by $v = \omega R$. The acceleration is $a_c = \omega^2 R$

If T is the time period of revolution of the object in circular motion and ϑ is its frequency. We have $\omega = 2\pi\vartheta$, $v = 2\pi R\vartheta$, $a_c = 4\pi^2\vartheta^2 R$.

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