# *Chapter # 02 (Vectors and Equilibrium)*
## *Important Short Questions*

**1. Differentiate between scalars and vectors.**

**Ans:**

| Scalars | Vectors |
|---|---|
| • The quantities which are describe completely by its magnitudes only are called scalar quantities.<br>• For example, length, mass, time. Temperature etc | • The quantities which are describe completely by its magnitude as well as direction are called vector quantities.<br>• For example, force, displacement. Torque etc. |

**2. How a vector is represented?**

**Ans:** Vectors can be represented by two methods: -

- Numerical method
- Graphical method

**1) Numerical method: -**

We can represent vector quantities by using bold letters such ad **F, a, d** or a bar or arrow over their symbols such as $\overline{F}, \overline{a}, \overline{d}$ or $\vec{F}, \vec{a}$ and $\vec{d}$.

**2) Graphical method: -**

A vector can be represented graphically by line segment with an arrow head. The line AB with arrow head represents a vector **V**. The length of line AB gives the magnitude of the



**3. What is rectangular coordinate system? Discuss its two types.**

**Ans: Rectangular Coordinate system (Cartesian coordinate system):-**

"The set of two or three mutually perpendicular lines intersecting at a point is called rectangular coordinate system."

The lines are called coordinate axes. One of these is called x-axis (Horizontal axis), the other is called y-axis (Vertical axis). The axis that is perpendicular to x-axis and y-axis is called z-axis.

**(i) Two dimensional coordinate system (Plane):-**

"The system in which two mutually perpendicular lines intersect at a point is called two-dimensional coordinate system"

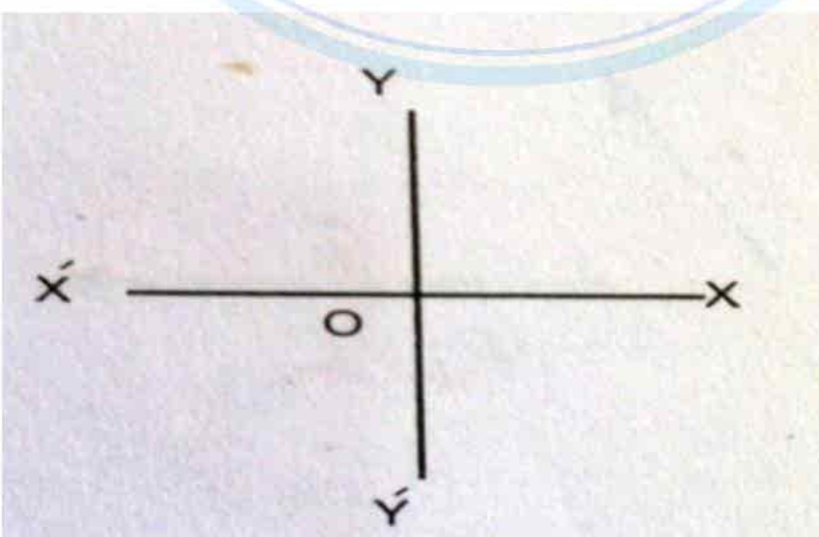


Fig. 2.1(a)

**Direction of vector in xy- plane:**

It is represented by the angle which the vector makes with positive x-axis in anti-clockwise direction.

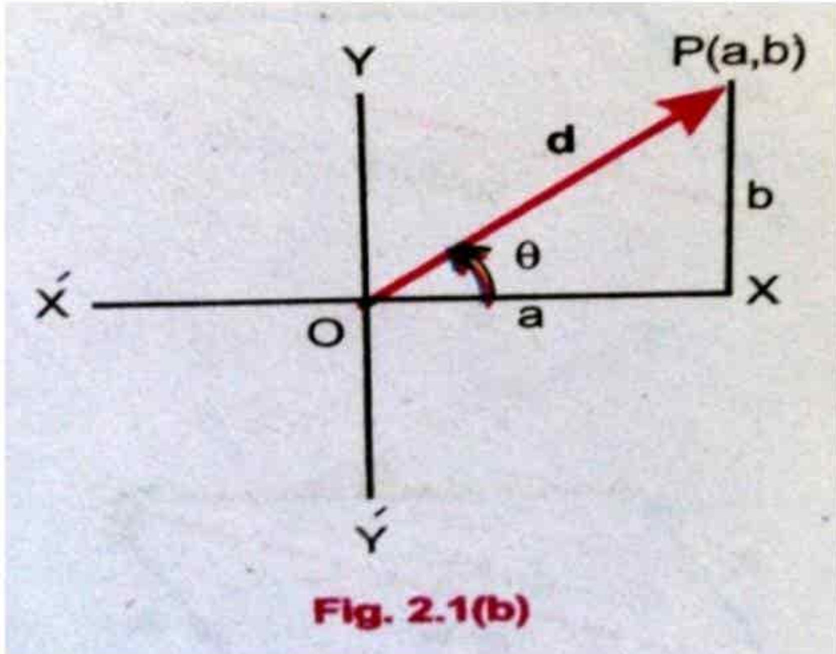


Fig. 2.1(b)

**(i) Three dimensional coordinate system (Space):-**

"The system in which three mutually perpendicular lines are intersecting at a point is called three-dimensional coordinate system"

**Direction of vector in space:**

It is represented by three angles which the vector makes with x, y and z-axis.

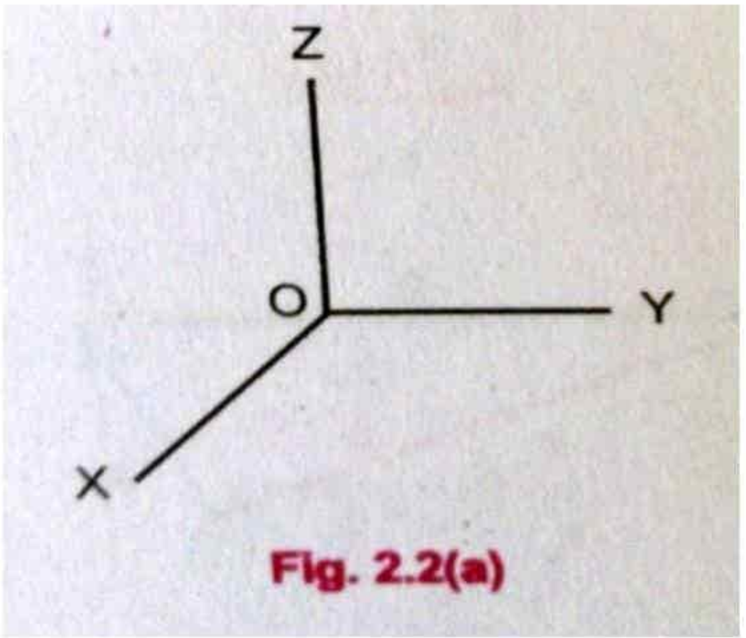


Fig. 2.2(a)

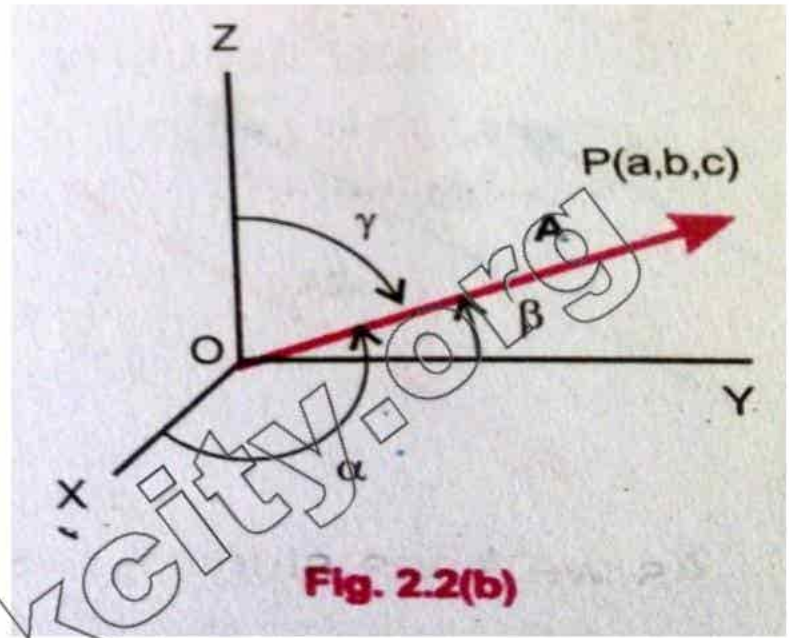


Fig. 2.2(b)

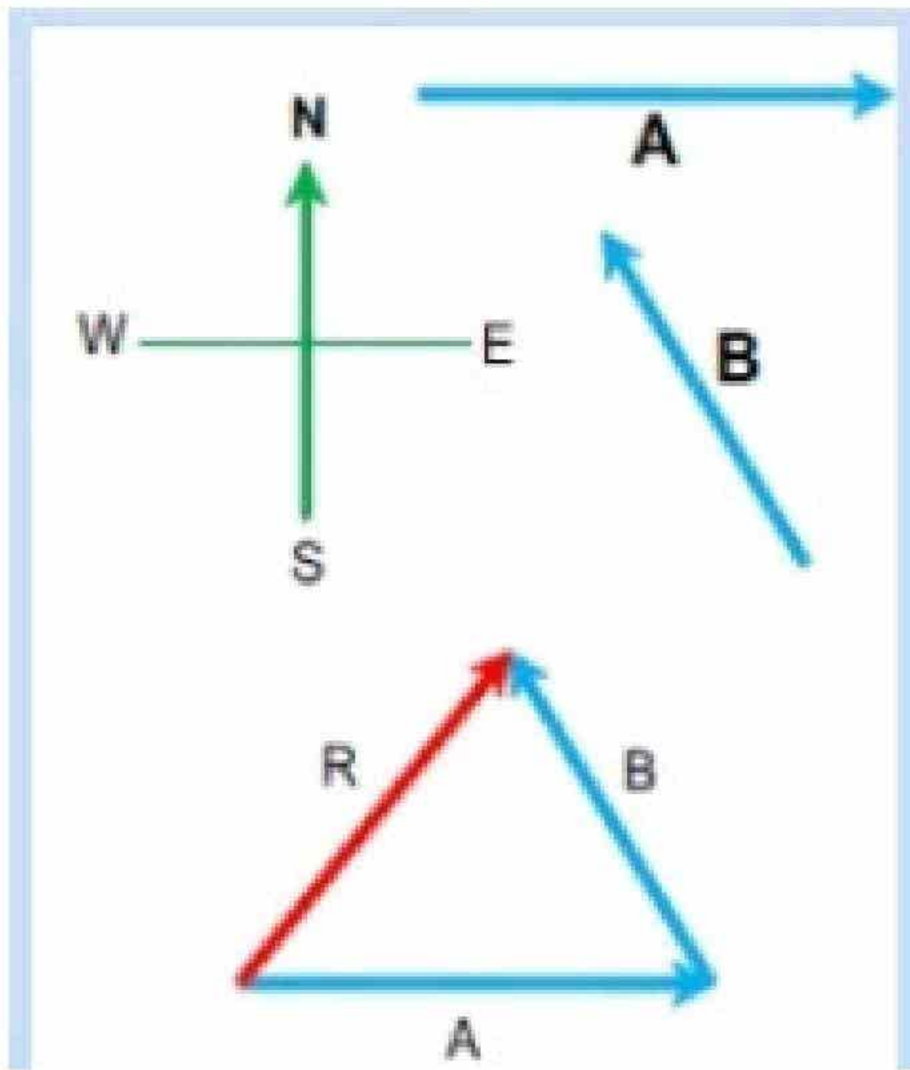


**4. What is head to tail rule?**

**Ans: Ans:** It is a graphical method used for the addition of the forces.

**Explanation: -**

- First draw all forces according to suitable scale such as **A** and **B**.
- Take one of the forces as a first vector. For example, vector **A**.
- Then draw the next vector **B** such as its tail coincides with the head of the first vector.
- Similarly draw the all-next forces (if any) with its tail coinciding with the head of the previous force and so on.
- Now draw a vector **R** such that its tail is at the tail of vector **A**, the first vector, while its head is at the head of vector **B**, the last vector.




**5. How a vector is subtracted?**

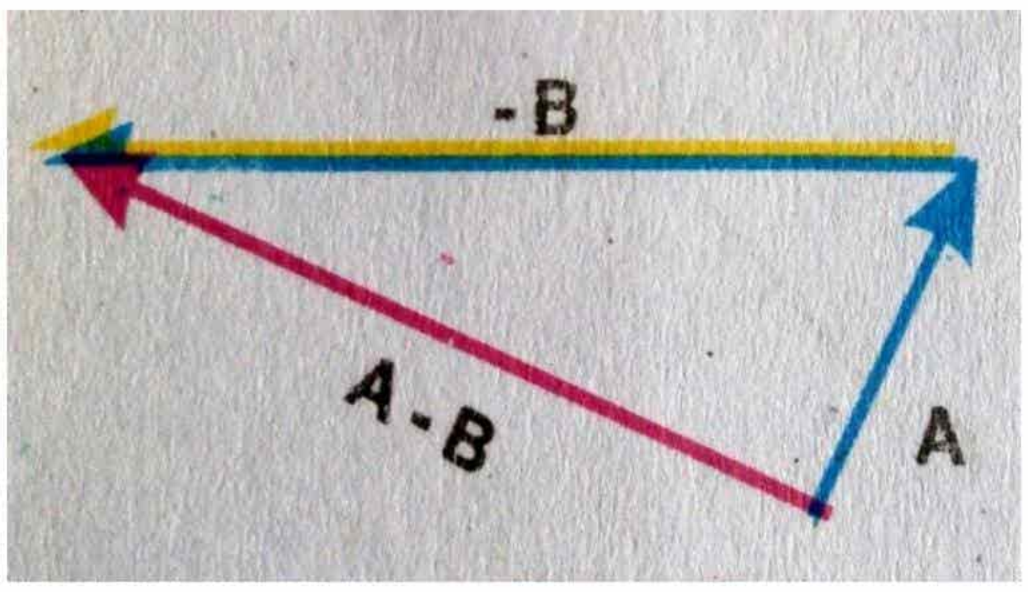
**Ans: <u>Vector Subtraction:</u>**

The subtraction of vector is equivalent to the addition of same vector with the direction reversed.

**Explanation:**

Consider two vectors $\vec{A}$ and $\vec{B}$. To subtract $\vec{B}$ from vector $\vec{A}$. First take the negative of vector $\vec{B}$. Add ($-\vec{B}$) into vector $\vec{A}$ graphically as shown in fig.

$$\vec{A} - \vec{B} = \vec{A} + (-\vec{B})$$




**6. Discuss multiplication of a vector.**

**Ans: <u>Multiplication of a vector by a scalar:</u>**

A vector can be multiplied by:

- A positive number.
- A negative number.
- A scalar with dimension.

**(i) Multiplication with a positive number:**

When a vector $\vec{A}$ is multiplied by a positive number n ($n > 0$) then the product vector will have magnitude equal to nA and same direction as that of $\vec{A}$.

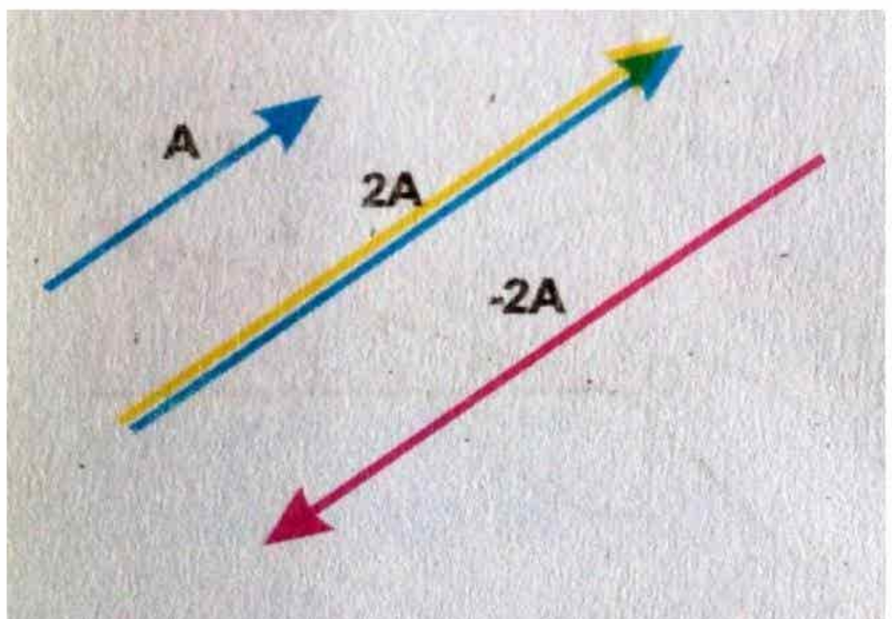


Fig. 2.4

**(ii) Multiplication with a negative number:**

When a vector $\vec{A}$ is multiplied by a negative number n ($n < 0$) then the product vector will have magnitude equal to nA and opposite direction as that of $\vec{A}$.

**(iii) Multiplication with a scalar quantity:**

When a vector $\vec{A}$ is multiplied by a scalar quantity n. then the product vector will be a new physical quantity whose dimension equal to product of the dimension of n and $\vec{A}$.

**Examples:**

- Product of mass and velocity is momentum ($\vec{P} = m\vec{v}$)
- Product of mass and acceleration is force ($\vec{F} = m\vec{a}$)
- Product of force and time is impulse ($\vec{I} = \vec{F} \times t$)

**7. Define resultant vector, unit vector, null vector and equal vector.**

**Ans: (i) <u>Resultant vector:</u>**

"A vector which has the same effect as the combined effect of all the vectors to be added is called resultant vector."

**<u>(ii) Unit vector:</u>**

"A vector whose magnitude is equal to one with no unit in a given direction is called unit vector." It is represented by a letter with a cap or hat on it.

**Mathematically Form:**

If $\vec{A}$ is a vector with magnitude A, then $\vec{A} = A\hat{A}$

$$\hat{A} = \frac{\vec{A}}{A}$$

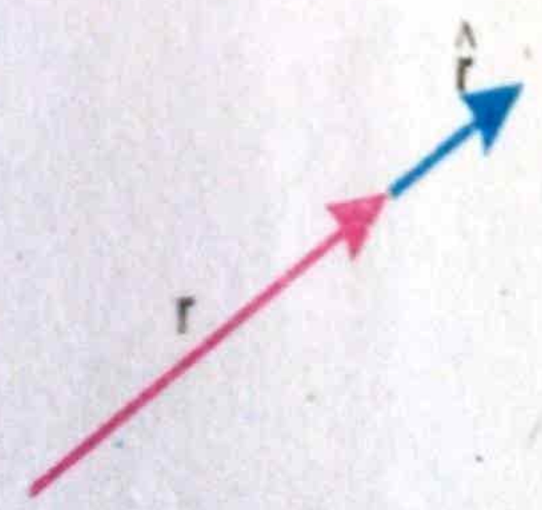


Fig. 2.5(b)

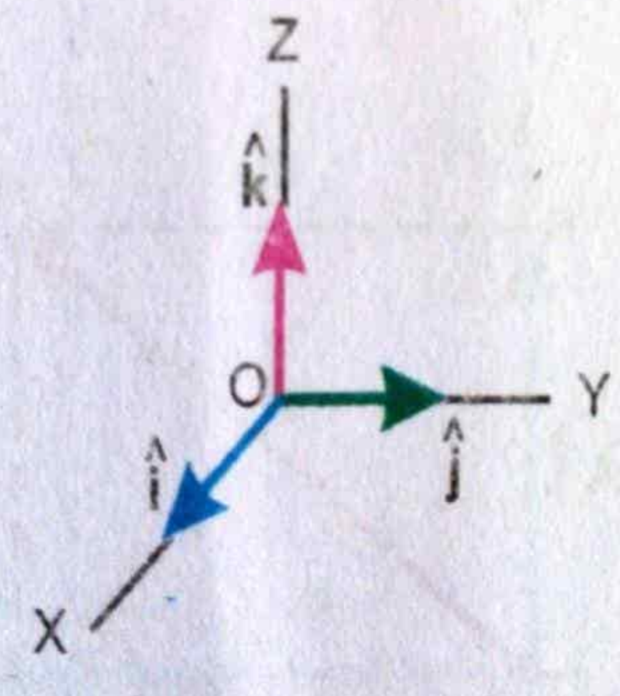


Fig. 2.5(a)

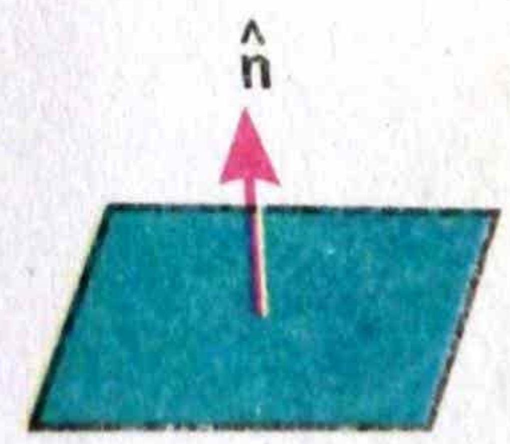


Fig. 2.5(c)

**Examples:**

- Direction along x, y and z-axis are represented by $\hat{i}$, $\hat{j}$ and $\hat{k}$ respectively.
- Unit vector $\hat{r}$ represent the direction of $\vec{r}$.
- Unit vector $\hat{n}$ represent the direction of normal drawn on a certain surface.

**(iii) Null or zero vector:**

"A vector whose magnitude is zero and direction arbitrary is called a null vector."

It is represented by $\vec{O}$.

**Examples:**

- The sum of $\vec{A}$ and its negative vector $(-\vec{A})$ is a null vector.

$$\vec{A} + (-\vec{A}) = \vec{O}$$

- Sum of vectors by head to tail along the sides of closed triangle is null vector.

**(iv) Equal Vectors:**

"The vectors are said to be equal to be equal vectors if they have same magnitude and same direction regardless of the position of their initial points."



**8. Define rectangular components. Drive its formula.**

**Ans: Rectangular Component of a vector:**

"The components that are perpendicular to each other are called rectangular components."

**X-component of $\vec{A}$:-**

In right angle triangle OPM,

$$\frac{OM}{OP} = \cos\theta$$

$$\frac{A_x}{A} = \cos\theta$$

$$\mathbf{A_x = A\cos\theta} \qquad ----(ii)$$

**Y-component of $\vec{A}$ :-**

In right angle triangle OPM,

$$\frac{PM}{OP} = \sin\theta$$

$$\frac{A_y}{A} = \sin\theta$$

$$\mathbf{A_y = A\sin\theta} \qquad ----(iii)$$



**9. Define position vector.**

**Ans: <u>Position Vector:</u>**

"The vector which represent the position of a point or a particle with respect to fixed origin is called position vector."

It is represented by $\vec{r}$.

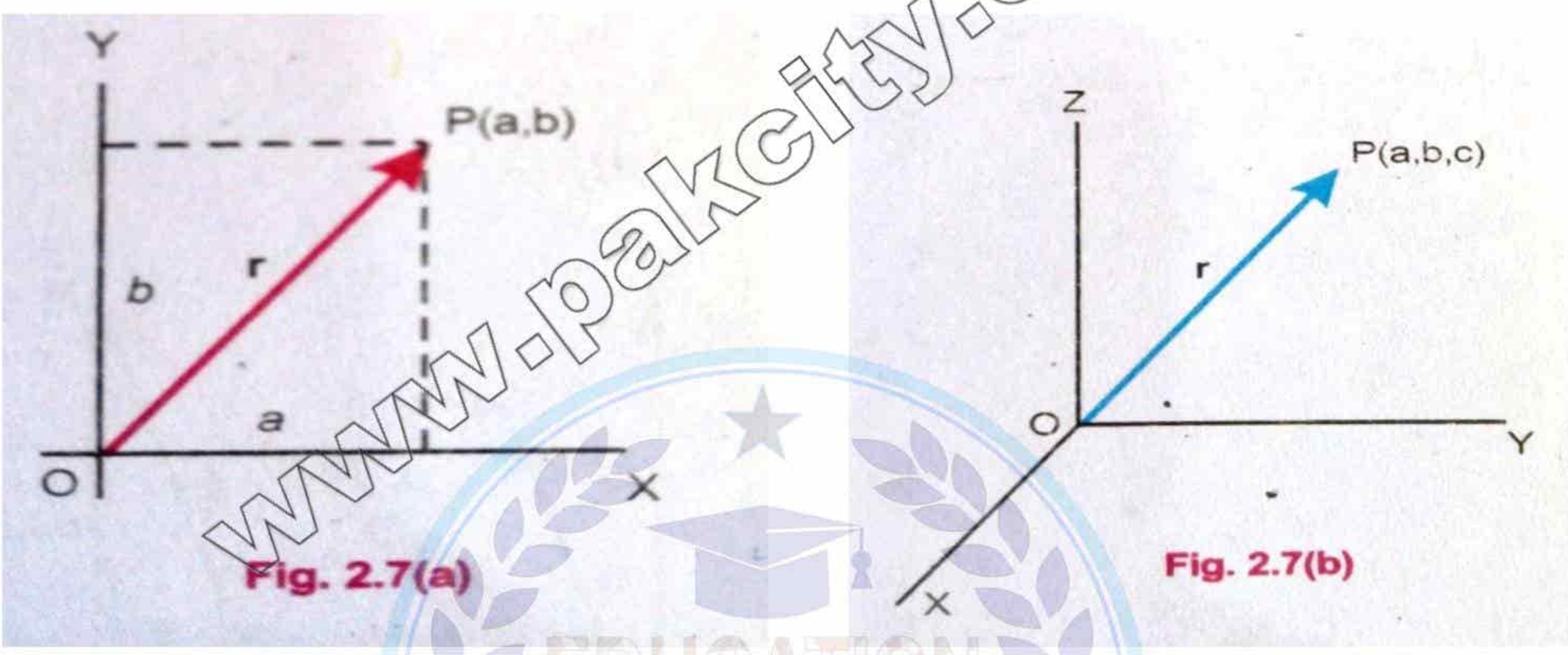
**Explanation:**

In two dimensional coordinated system (plane), the position of a point P(a,b) is represented by

$$\vec{r} = a\hat{i} + b\hat{j}$$

The magnitude of this position vector is

$$r = \sqrt{a^2 + b^2}$$






In three dimension coordinated system (space) , the position of P(a,b,c) is represented by

$$\vec{r} = a\hat{i} + b\hat{j} + c\hat{k}$$

And its magnitude is

$$r = \sqrt{a^2 + b^2 + c^2}$$



**10. Define dot product. Give its two examples.**

**Ans: <u>Scalar product or Dot product:</u>**

"If the product of two vectors is a scalar quantity, then the product is called scalar product."

Scalar product of two vectors $\vec{A}$ and $\vec{B}$ is defined as

$$\vec{A}.\vec{B} = AB\cos\theta$$

Where A and B are the magnitudes of vectors $\vec{A}$ and $\vec{B}$ and $\theta$ is the angle between them.

**<u>Examples:</u>**

**(i)** **Work** is a scalar product of force and displacement.

$$w = \vec{F}.\vec{d}$$

**(ii)** **Power** is the scalar product of force and velocity.

$$P = \vec{F}.\vec{V}$$

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**11. Explain four characteristics of dot product.**

**Ans: Characteristics of dot product:**

**(i) Commutative property:**

Scalar product of two vectors is commutative.

If $\vec{A}$ and $\vec{B}$ are two vectors and $\theta$ is the angle between them. Then,

$$\vec{A}.\vec{B} = AB\cos\theta \quad \text{------ (i)}$$

$$\vec{B}.\vec{A} = BA\cos\theta \quad \text{------ (ii)}$$

$$\vec{A}.\vec{B} = \vec{B}.\vec{A}$$

**(ii) Perpendicular vectors:**

If two vectors are mutually perpendicular to each other ($\theta = 90^o$). Their scalar product will be zero.

$$\vec{A}.\vec{B} = AB\cos 90^o$$

$$\vec{A}.\vec{B} = AB(0)$$

$$\vec{A}.\vec{B} = 0$$

In case of unit vectors,

$$\hat{i}.\hat{j} = (1)(1)\cos 90^o = (1)(1)(0) = 0$$

$$\hat{j}.\hat{k} = 0 \text{ and } \hat{k}.\hat{i} = 0$$

$$\hat{i}.\hat{j} = \hat{j}.\hat{k} = \hat{k}.\hat{i} = 0$$

**(iii) Parallel and anti-parallel vectors:**

- If two vectors are parallel ($\theta = 0^o$) to each other then, their scalar is equal to the product of their magnitudes.

$$\vec{A}.\vec{B} = AB\cos 0^o$$

$$\vec{A}.\vec{B} = AB(1)$$

$$\vec{A}.\vec{B} = AB$$

This is the positive maximum value of scalar product.

- If two vectors are anti-parallel ($\theta = 180^o$) to each other then, their scalar is equal to the negative of product of their magnitudes.

$$\vec{A}.\vec{B} = AB\cos 180^o$$

$$\vec{A}.\vec{B} = AB(-1)$$

$$\vec{A}.\vec{B} = -AB$$

**(iv) Self-scalar product:**

The self product of a vector is equal to the square of its magnitude.

$$\vec{A}.\vec{A} = AA\cos 0^\circ$$

$$\vec{A}.\vec{A} = A^2(1)$$

$$\vec{A}.\vec{A} = A^2$$

In case of unit vectors,

$$\hat{i}.\hat{i} = (1)(1)\cos 0^\circ = (1)(1)(1) = 1$$

$$\hat{j}.\hat{j} = 1 \text{ and } \hat{k}.\hat{k} = 1$$

$$\hat{i}.\hat{i} = \hat{j}.\hat{j} = \hat{k}.\hat{k} = 1$$

**12. Define cross product. Give its two examples.**

**Ans: <u>Vector product or Dot product:</u>**

"If the product of two vectors is a vector quantity, then the product is called vector product."

vector product of two vectors $\vec{A}$ and $\vec{B}$ is defined as

$$\vec{A}\times\vec{B} = AB\sin\theta\hat{n}$$

Where A and B are the magnitudes of vectors $\vec{A}$ and $\vec{B}$ and $\theta$ is the angle between them. And $\hat{n}$ is the unit vector perpendicular to plane containing $\vec{A}$ and $\vec{B}$.

**Examples:**

- Torque is the vector product of vector $\vec{r}$ and force $\vec{F}$ ($\vec{\tau} = \vec{r}\times\vec{F}$)

**13. Explain right hand rule to find the direction of cross product.**

**Ans: Direction of cross product:**

The direction of vector product can be found by right hand rule.

**Right hand rule:**

- Join the tails of two vectors to define a plane.
- Rotate $\vec{A}$ into $\vec{B}$ through smaller possible angles.
- Curl the fingers of the right hand in the direction of rotation.
- The erected thumb will represent the direction of vector product.

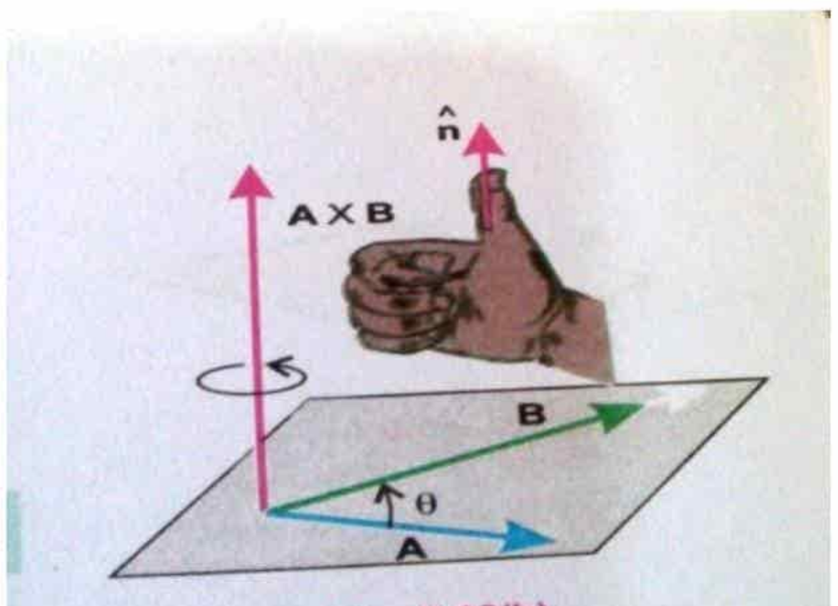


Fig. 2.12(b)

**14. Explain four characteristics of cross product.**

**Ans: Characteristics of cross product:**

**(i) <u>Commutative property:</u>**

The cross product of two vectors is not commutative.

If $\vec{A}$ and $\vec{B}$ are two vectors and $\theta$ is the angle between them. Then,

$$\vec{A}\times\vec{B} = AB\sin\theta\hat{n} \quad \text{------ (i)}$$

$$\vec{B}.\times\vec{A} = BA\sin\theta(\hat{n}) \quad \text{------ (ii)}$$

$$\vec{A}.\vec{B} \neq \vec{B}.\vec{A}$$

$$\vec{A}.\vec{B} = -\vec{B}.\vec{A}$$

**<u>(ii) Perpendicular vectors:</u>**

If two vectors are mutually perpendicular to each other ($\theta = 90^\circ$). Their cross product will be maximum.

$$\vec{A}.\vec{B} = AB\cos 90^\circ \hat{n}$$

$$\vec{A}.\vec{B} = AB(1)\hat{n}$$

$$\vec{A}.\vec{B} = AB\hat{n}$$

In case of unit vectors,

$$\hat{i}\times\hat{j} = (1)(1)\sin 90^\circ \hat{k} = (1)(1)(1)\hat{k} = \hat{k}$$

$$\hat{j}\times\hat{k} = \hat{i} \text{ and } \hat{k}\times\hat{i} = \hat{j}$$

$$\hat{j}.\hat{i} = -\hat{k}$$

$$\hat{k}.\hat{j} = -\hat{i}$$

$$\hat{i}.\hat{k} = -\hat{j}$$

**(iii) Parallel and anti-parallel vectors:**

- If two vectors are parallel (θ = 0°) to each other then, vector product is equal to zero.

$$\vec{A}\times\vec{B} = AB\sin 0^\circ \hat{n}$$

$$\vec{A}\times\vec{B} = AB(0)\hat{n}$$

$$\vec{A}\times\vec{B} = \vec{O}$$

This is the minimum value of vector product.

- If two vectors are anti-parallel (θ = 180°) to each other then, vector product is equal to zero.

$$\vec{A}\times\vec{B} = AB\sin 180^\circ \hat{n}$$

$$\vec{A}\times\vec{B} = AB(0)\hat{n}$$

$$\vec{A}\times\vec{B} = \vec{O}$$

**(iv) Self scalar product:**

The self-product of a vector is equal to null vector.

$$\vec{A}\times\vec{A} = AA\sin 0^\circ \hat{n}$$

$$\vec{A}\times\vec{A} = A^2(0)\hat{n}$$

$$\vec{A}\times\vec{A} = \vec{O}$$

In case of unit vectors,

$$\hat{i}\times\hat{i} = (1)(1)\sin 0^\circ \hat{n} = (1)(1)(0)\hat{n} = \vec{O}$$

$$\hat{j}\times\hat{j} = \vec{O} \text{ and } \hat{k}\times\hat{k} = \vec{O}$$

$$\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = \vec{O}$$

**15. Prove that area of parallelogram is equal to magnitude of cross product.**

**Ans: Area of parallelogram:**

The magnitude of the cross product of two vectors represents the area of the parallelogram.

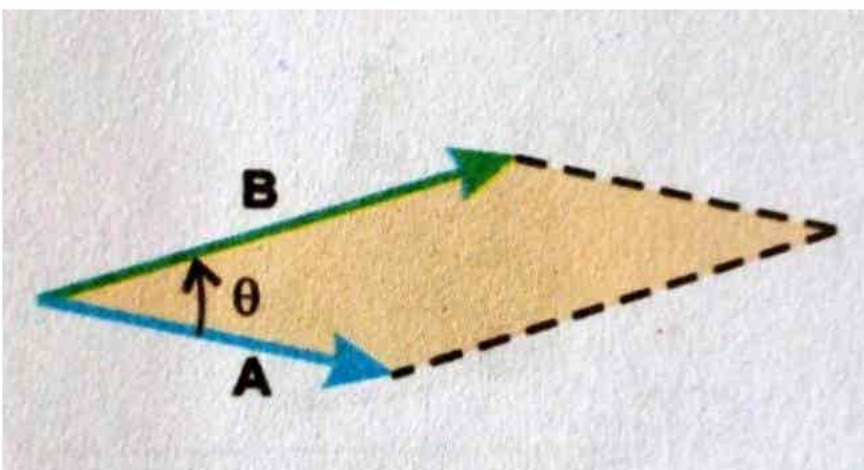


Fig. 2.12(d)

$$\text{Area of parallelogram} = (\text{Length})(\text{Height})$$

$$= A(B\sin\theta)$$

$$= \text{Magnitude of } (\vec{A}\times\vec{B})$$

Area of parallelogram = $|\vec{A} \times \vec{B}|$

**16. Define torque. Write its formula and unit.**

**Ans: <u>Torque:</u>**

"The turning effect of force produced in a body about an axis is called torque."

OR

"The product of magnitude of force and the perpendicular distance from axis of rotation to line of action of the force is called torque."

OR

"The Cross or Vector product of force and moment arm is called torque."

$$\tau = \vec{r} \times \vec{F}$$

$$\tau = rF\sin\theta$$

Where r = perpendicular distance.

F = Magnitude of Force.

θ = The angle between Force and moment arm.

**Dependence of torque:**

Torque depends upon the following factors:

- Magnitude of force
- Moment arm (perpendicular distance from axis of rotation to line of action of the force)
- Angle between force and the moment arm.

**Unit:**

Its S.I unit is Nm ($Kgm^2s^{-2}$) and its dimension is $[ML^2T^{-2}]$.

**Example:**

- Tightening of a nut with a spanner (wrench)
- A seesaw rotates on and off the ground due to torque imbalance.

**17. Define equilibrium. Discuss its types.**

**Ans: <u>Equilibrium:</u>**

"A body is said to be in equilibrium if it is at rest or moving with uniform velocity under the action of a force or a number of forces."

OR

A body is said to be in equilibrium if no net force acts on it.

**Types of Equilibrium:**

There are two types of equilibrium:

**(i) Static Equilibrium:**

"If a body is at rest, then it is said to be in static equilibrium."

**Example:** Book lying on the table.

**(ii) Dynamic Equilibrium:**

"If a body is moving with uniform velocity, it is said to be in dynamic equilibrium."

**Example:** A car moving with uniform velocity, Motion of paratrooper etc.

**<u>(iii) Translational Equilibrium:</u>**

"When first condition of equilibrium is satisfied, the linear acceleration of body is zero and the body is said to be in translational equilibrium."

**(iv) Rotational Equilibrium:**

"When second condition of equilibrium is satisfied, angular acceleration of a body is zero and the body is said to be in rotational equilibrium."

For a body to be in complete equilibrium, both conditions must be satisfied. i.e, both linear acceleration and angular acceleration must be zero.

**18. What are conditions for equilibrium?**

**Ans: First condition of Equilibrium:**

"The vector sum of all the forces acting on a body must be equal to zero."

$$\Sigma\vec{F} = 0$$

In case of rectangular components, then

$$\Sigma\vec{F}_x = 0$$

$$\Sigma\vec{F}_y = 0$$

- If the rightward forces are taken as positive, then leftward forces are taken as negative.
- If the upward forces are taken as positive, then downward forces are taken as negative.
- Forces which lie in a same (common) plane are said to be coplanar.

**Second condition of Equilibrium:**

"The vector sum of all the torques acting on a body must be zero"

$$\Sigma\vec{\tau} = 0$$

- Clockwise torque is taken as negative.
- Anti-clockwise torque is taken as positive.



## *Exercise Short Questions*

**1. Define the terms (i) Unit vector (ii) Position Vector and (iii) Component of a Vector.**

**Ans: Unit Vector:**

"A vector whose magnitude is **One with no units** in a given direction is called unit vector."

It is represented by **a letter** with a **cap or hat** on it. A unit vector in the direction of **A** is written as $\hat{A}$.

$$\vec{A} = A\hat{A}$$

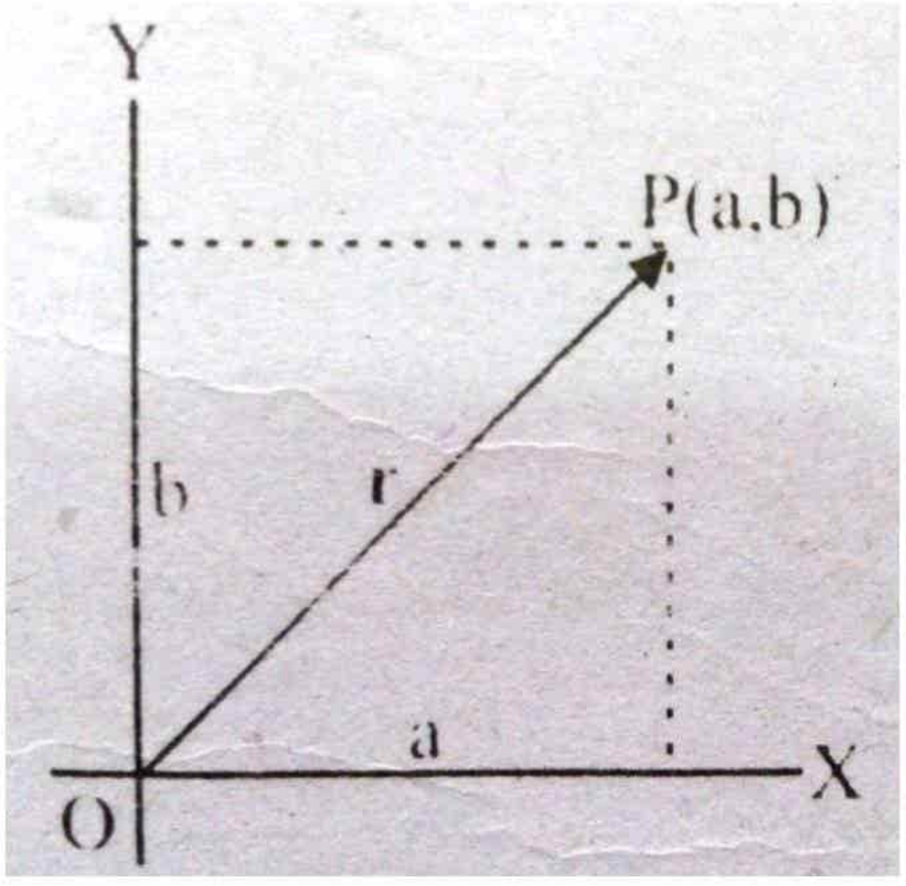
$$\hat{A} = \frac{\vec{A}}{A} \quad \text{OR} \quad \hat{A} = \frac{A_x\hat{i}+A_y\hat{j}+A_z\hat{k}}{\sqrt{A_x^2+A_y^2+A_z^2}}$$

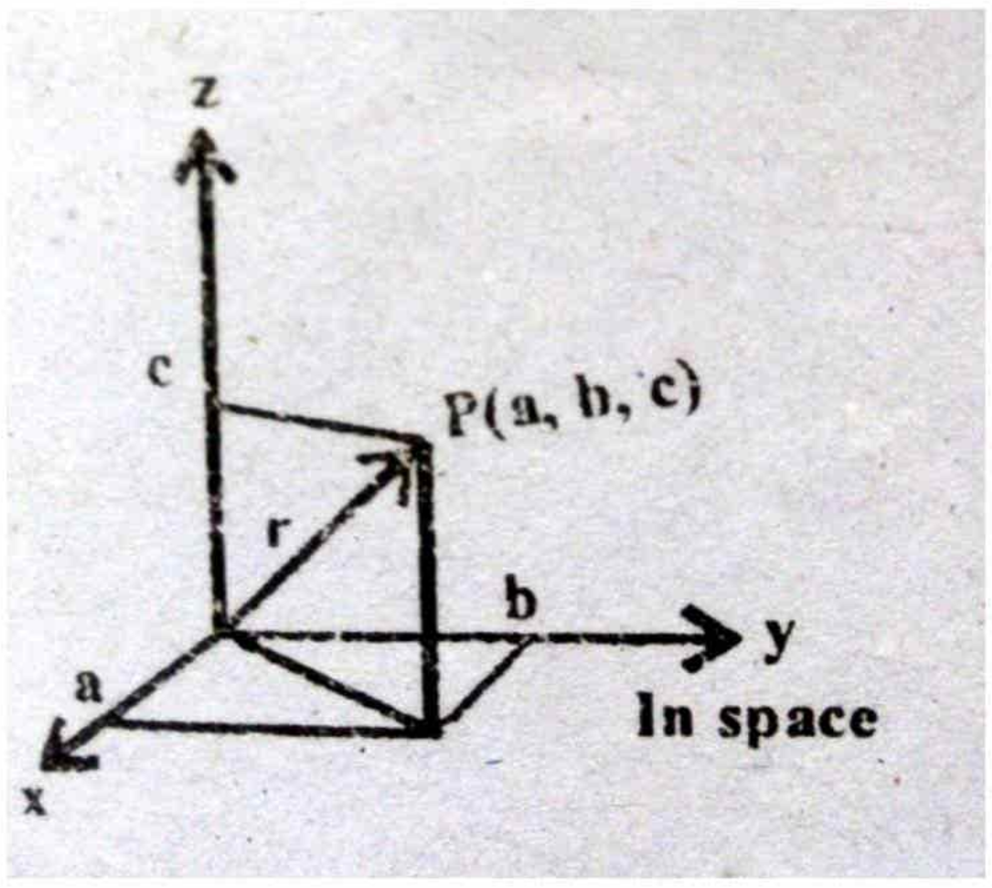
**Examples of Unit vectors: -**

- $\hat{i}$ is a unit vector along x- axis.
- $\hat{j}$ is a unit vector along y- axis.
- $\hat{k}$ is a unit vector along z- axis.

**Position Vector:** "A Vector that describe the position of a particle or a point with respect to a fixed origin is called Position vector."

- It is represented by $\vec{r}$. In two-dimensional coordinate system (plane), the position vector of a point P (a, b) is represented by $\vec{r} = a\hat{i} + b\hat{j}$ $\quad r = \sqrt{a^2 + b^2}$ .
- In three-dimensional coordinate system (space), the position vector of a point P (a , b , c) is represented by $\vec{r} = a\hat{i} + b\hat{j} + c\hat{k}$ $\quad r = \sqrt{a^2 + b^2 + c^2}$ .




**Position Vector:** "The **effective value** of a vector in a given direction is called component of a vector." A vector may split into **two or more** components.

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**2. The vector sum of three vectors gives zero resultant. What can be the possible orientation of the vectors?**

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**Ans:** If the three vectors are represented by the **sides of a triangle** joined by head to tail rule, there sum will be zero.

**Explanation:** Consider three vectors $\vec{F}_1$ , $\vec{F}_2$ and $\vec{F}_3$ as shown in figure. It is clear that the sum of the vectors is zero because tail of first vector **coincides** with the head of the last vector.

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**3. Vector $\vec{A}$ lies in xy-plane.**

**(i) For what orientation both of the rectangular components be negative?**

**(ii) For what orientation will its components have opposite sign?**

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**Ans: (i)** If the vector lies in **3rd quadrant**, both of its rectangular components will be **negative**.

**(ii)** If the vector lies in **2nd and 4th quadrants**, both of its rectangular components will have **opposite sign.**

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**4. If one of the rectangular components of a vector is not zero. Can its magnitude be zero? Explain.**

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**Ans:** **No**, it's magnitude cannot be zero.

**Reason: -**

The magnitude of vector $\vec{A}$ is given by $A = \sqrt{A_x^2 + A_y^2 + A_z^2}$ .

This equation shows that magnitude of a vector will be zero only when all components of the vector are **zero**.

Otherwise, if any of the rectangular component is zero. The magnitude of a vector can never be zero.

**5. Can a vector have components greater than the vector's magnitude?**

**Ans:** The rectangular components of a vector can **never** be greater than the vector's magnitude. It may **equal or less** than vector's magnitude.

**Explanation: -**

The magnitude of a vector $\vec{A}$ is given by

$$A = \sqrt{A_x^2 + A_y^2}$$

$$A^2 = A_x^2 + A_y^2$$

$$A^2 \geq A_x^2 \quad OR \quad A^2 \geq A_y^2$$

$$A \geq A_x \quad \text{OR} \quad A \geq A_y$$

The component of a vector **other than rectangular components** may be greater than the magnitude of the vector.

**6. Can the magnitude of a vector have a negative value?**

**Ans:** **No**, it can never be **negative.**

**Reason: -**

As

$$A = \sqrt{A_x^2 + A_y^2}$$

$A_x$ and $A_y$ may be negative but the squares of negative values always positive. So, the magnitude of a vector cannot be negative.

**7. If $\vec{A} + \vec{B} = \vec{0}$, What can you say about the components of two vectors?**

**Ans:** Sum of their respective components will be zero.

**Explanation: -**

If

$$\vec{A} = A_x\hat{i} + A_y\hat{j} \text{ and } \vec{B} = B_x\hat{i} + B_y\hat{j}$$

Then $$\vec{A} + \vec{B} = \vec{0}$$

**8. Under what circumstances would a vector have components that are equal in magnitude?**

**Ans:** It is possible only when the vectors make an angle of **$45^o$ with positive x-axis.**

**Proof: -**

Let $A_x$ and $A_y$ be the rectangular components of a vector $\vec{A}$

If $$A_x = A_y$$

OR $$A\sin\theta = A\cos\theta$$

$$\frac{\sin\theta}{\cos\theta} = 1$$

$$\tan\theta = 1$$
$$\theta = \tan^{-1}(1)$$
$$\theta = 45^\circ$$

Hence, it is proved.

**9. Is it possible to add a scalar quantity into a vector quantity? Explain.**

**Ans:** **No**, it is not possible.

**Reason: -**

By the rule of vectors addition, only similar quantities can be added, whereas vector and scalar are both **different physical quantities**. Vectors have both magnitude and direction, but scalar only have magnitude. So, they can never be added.

**10. Can you add zero to a null vector?**

**Ans:** **No**, it is not possible.

**Reason: -**

Both zero and null vector are different physical quantities, one is scalar and other is vector. So, zero cannot be added to a null vector.

**11. Two vectors have unequal magnitude. Can their sum be equal to zero? Explain.**

**Ans:** **No**, their sum cannot be zero.

**Reason: -**

Because it is only possible if two vectors have **equal magnitude** and **same direction.**

**12. Show that the sum and difference of two perpendicular vectors of equal lengths are also perpendicular and of the same length?**

**Ans:** Consider two vectors $\vec{A}$ and $\vec{B}$ as shown in figure.

By using head to tail rule,

$$\vec{R} = \vec{A}+\vec{B} \quad \text{and} \quad \vec{R}` = \vec{A}-\vec{B}$$

Now A = B and angle between two vectors is 90°

**Proof: -**

**Magnitude of $\vec{R}$ :-**

$$R = \sqrt{(A)^2+(B)^2} = \sqrt{A^2+B^2} \quad \rightarrow \quad (i)$$

**Magnitude of $\vec{R}`$ :-**

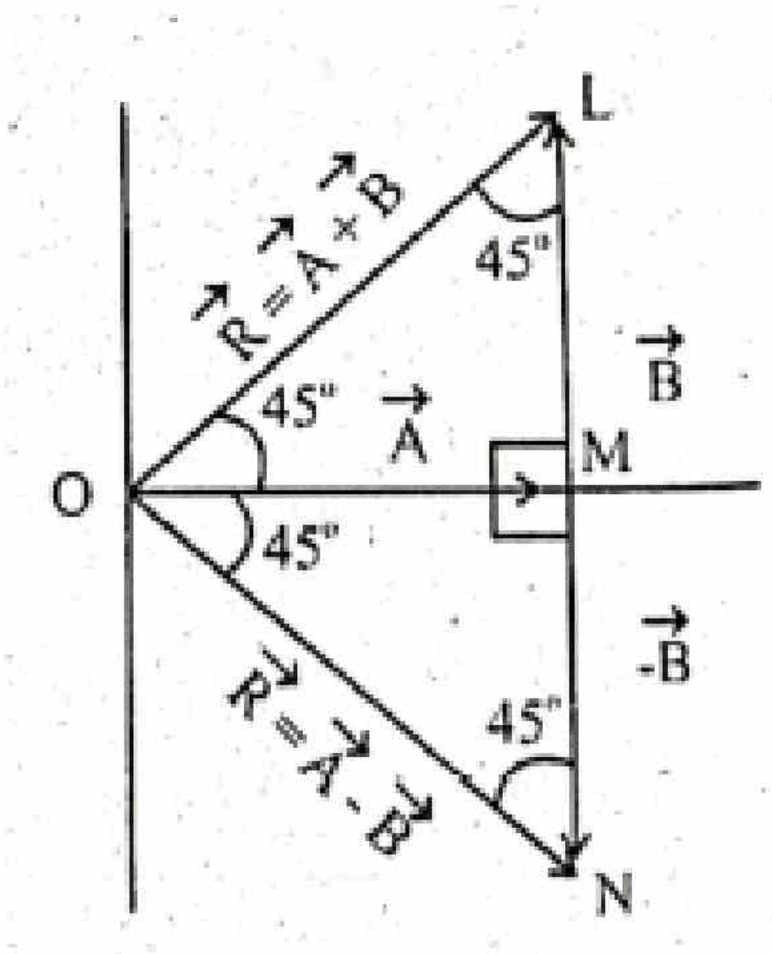
$$R` = \sqrt{(A)^2+(-B)^2} = \sqrt{A^2+B^2} \quad \rightarrow \quad (ii)$$

From equation (i) and (ii), it is clear that

$$R = R` \quad \rightarrow (iii)$$

Since A = B

$$\angle LOM = \angle NOM = 45^\circ$$



Therefore,

The angle between $\vec{R}$ and $\vec{R}`$ = $\angle LON = \angle LOM = \angle NOM = 45^\circ + 45^\circ$

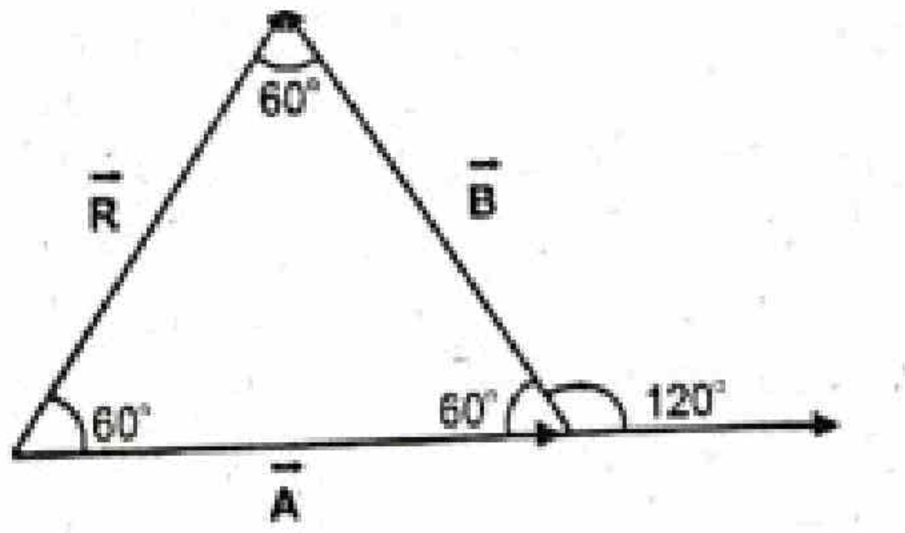
$$\angle LON = 90^\circ$$

So $\vec{R}$ and $\vec{R}`$ are perpendicular to each other.

Hence proved.

**13. How would be the two vectors of the same magnitude have to be oriented, if they were to be combined to give the resultant equal to a vector of the same magnitude?**

**Ans:** It is possible only when the angle between two vectors will be **120°**.




**Explanation: -**

If two vectors are represented by the sides of an equilateral triangle, then the third side represents resultant such that A = B = R as shown in figure. In this case the angle between two vectors is **120°**.

**14. The two vectors two be combined have magnitudes of 60N and 35N. Pick up the correct answer from those give below and tell what is the only one of the three that is correct?**

**(i) 100N (ii) 70N (iii) 20N**

**Ans:** The correct answer is **70N**.

**Reason: -**

$$\vec{F}_1 = 60N$$

$$\vec{F}_2 = 35N$$

(a) Resultant Force will be maximum when two vectors are parallel (angle will be 0°).

$$60N + 35N = 95N$$

(b) Resultant Force will be minimum when two vectors are antiparallel (angle will be 180°)

$$60N - 35N = 25N$$

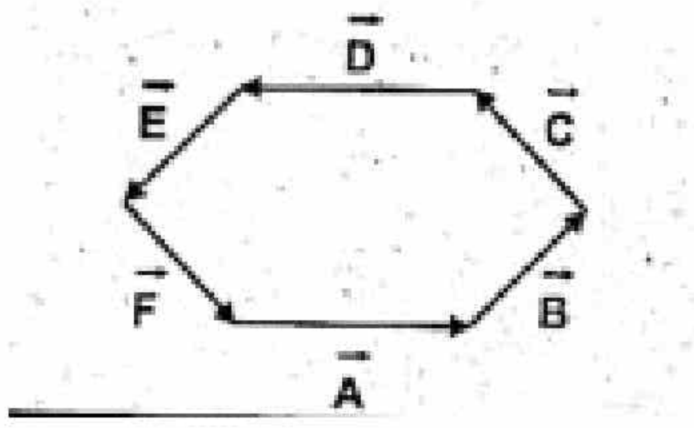
This shows that the resultant Force cannot be greater than 95N and cannot be less than 25N. So, the correct answer is 70N.

**15. Suppose the sides of closed polygon represent vector arranged head to tail rule. What is the sum of these vectors?**

**Ans:** The sum of these vectors will be zero.

**Reason: -**

In this case, the tail of first vector **coincides** with the head of the last vector as shown in figure.




$$\vec{A} + \vec{B} + \vec{C} + \vec{D} + \vec{E} + \vec{F} = \vec{O}$$

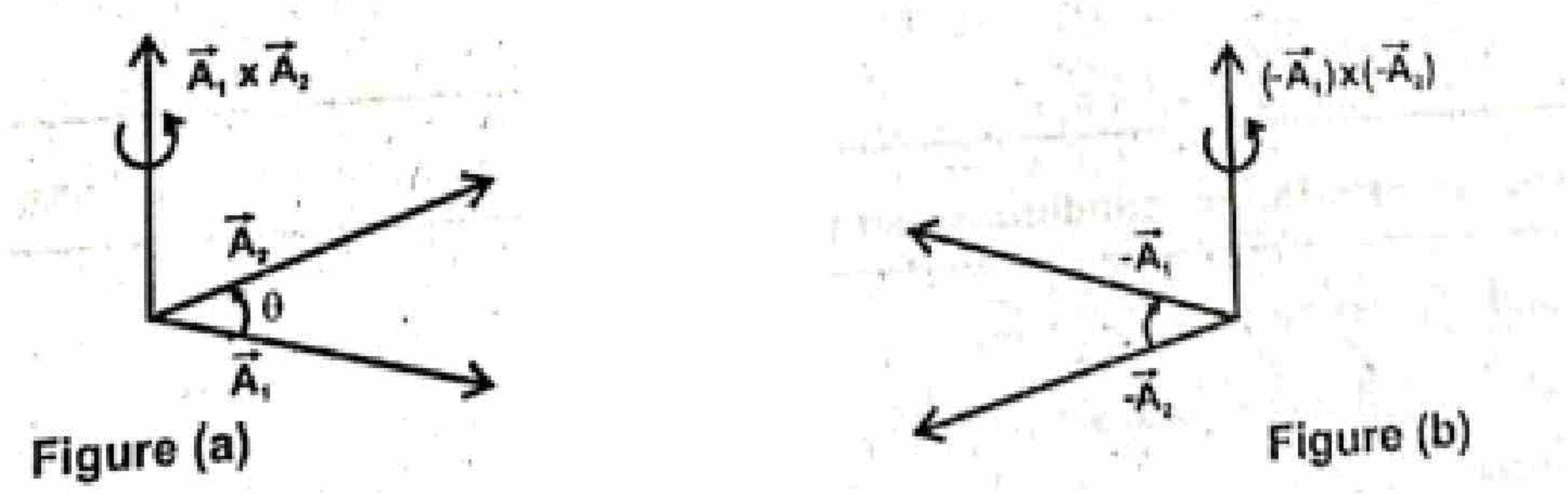
**17. If all the components of the vectors $\vec{A_1}$ and $\vec{A_2}$ were reversed, how would this alter $\vec{A_1} \times \vec{A_2}$**

**Ans:** It would **not change** in this case.

**Explanation: -**

We know that direction of $\vec{A_1} \times \vec{A_2}$ is perpendicular to the plane.

Containing $\vec{A_1}$ and $\vec{A_2}$ as shown in figure (a)




Now, if all the components of vector $\vec{A_1}$ and $\vec{A_2}$ are reversed (i.e. if we take negative of $\vec{A_1}$ and $\vec{A_2}$), then again, the direction of $(-\vec{A_1}) \times (-\vec{A_2})$ remains the same as shown in figure in (b).

i.e. $\vec{A_1} \times \vec{A_2} = (-\vec{A_1}) \times (-\vec{A_2})$

**18. Name the three different conditions that could make $\vec{A_1} \times \vec{A_2} = \vec{O}$**

**Ans:** If $\vec{A_1}$ and $\vec{A_2}$ are two vectors then,

$$\vec{A_1} \times \vec{A_2} = A_1 A_2 \sin\theta \hat{n}$$

**Conditions: -**

$\vec{A_1} \times \vec{A_2}$ is **null** vector if

- $\vec{A_1}$ or $\vec{A_2}$ is **null** vector.
- $\vec{A_1}$ and $\vec{A_2}$ parallel [ i.e. $\theta = 0^\circ$ ]
- $\vec{A_1}$ and $\vec{A_2}$ antiparallel [i.e. $\theta = 180^\circ$ ]

**19. Identify true or false statements and explain the reason**

**(a) A body in equilibrium implies that it is neither moving nor rotating.**

**(b) If coplanar Forces acting on a body form closed polygon, the body is said to be in equilibrium.**

**Ans:** (a) This statement is **false**.

**Reason: -**

Because in **dynamic equilibrium** body **may move or rotate** with **uniform velocity.**

(b) The $2^{nd}$ statement is true.

**Reason: -**

In this case **$1^{st}$ condition** of equilibrium is satisfied and the body is said to be in **translational equilibrium**.

**20. A picture is suspended from a wall by two strings. Show by diagram the configuration of the strings for which the tension in the string will be minimum.**

**<u>Ans:</u>** The tension will be minimum when the strings will be **vertical** ($\theta = 90^\circ$)

**<u>Proof: -</u>**

Let the picture is suspended from wall by two strings, as shown in figure. Resolve the tension into its rectangular components.

$$\sum \overrightarrow{F_y} = 0$$

$$T\sin\theta + T\sin\theta - W = 0$$

$$2T\sin\theta = 0$$

$$T = \frac{W}{2\sin\theta}$$

Tension will be minimum if $\sin\theta$ is

As $\sin\theta = 1$

$$\theta = \text{Sin}^{-1}(1)$$

$$\theta = 90^\circ$$

$$T = \frac{W}{2\sin 90^\circ}$$

$$T = \frac{W}{2} \qquad (\sin 90^\circ = 1)$$

Thus, the tension will be minimum when the strings will be **vertical**.

**21. Can a body rotate about its centre of gravity under the action of its weight?**

**<u>Ans:</u>** **No,** it is not possible.

**<u>Reason: -</u>**

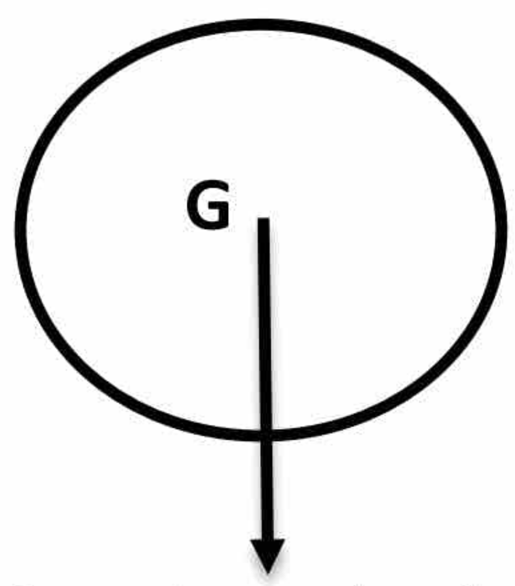
In this case the line of action of force (weight) passes through **<u>pivot point</u>** (centre of gravity). So, the moment arm becomes zero.

As,

$$\tau = rF$$

$$\tau = (0)F$$

$$\tau = 0$$




**W**

Hence, torque of the body is zero. So, the body cannot rotate about centre of gravity under the action of its weight.

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