

# Mathematics

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(Chapter 10)(Vector Algebra)

XII

## Exercise 10.2

### Question 1:

Compute the magnitude of the following vectors:

$$\vec{a} = \hat{i} + \hat{j} + \hat{k}; \quad \vec{b} = 2\hat{i} - 7\hat{j} - 3\hat{k}; \quad \vec{c} = \frac{1}{\sqrt{3}}\hat{i} + \frac{1}{\sqrt{3}}\hat{j} - \frac{1}{\sqrt{3}}\hat{k}$$

### Answer 1:

The given vectors are:

$$\vec{a} = \hat{i} + \hat{j} + \hat{k}; \quad \vec{b} = 2\hat{i} - 7\hat{j} - 3\hat{k}; \quad \vec{c} = \frac{1}{\sqrt{3}}\hat{i} + \frac{1}{\sqrt{3}}\hat{j} - \frac{1}{\sqrt{3}}\hat{k}$$

$$|\vec{a}| = \sqrt{(1)^2 + (1)^2 + (1)^2} = \sqrt{3}$$

$$\begin{aligned} |\vec{b}| &= \sqrt{(2)^2 + (-7)^2 + (-3)^2} \\ &= \sqrt{4 + 49 + 9} \\ &= \sqrt{62} \end{aligned}$$

$$\begin{aligned} |\vec{c}| &= \sqrt{\left(\frac{1}{\sqrt{3}}\right)^2 + \left(\frac{1}{\sqrt{3}}\right)^2 + \left(-\frac{1}{\sqrt{3}}\right)^2} \\ &= \sqrt{\frac{1}{3} + \frac{1}{3} + \frac{1}{3}} = 1 \end{aligned}$$

### Question 2:

Write two different vectors having same magnitude.

### Answer 2:

$$\text{Consider } \vec{a} = (\hat{i} - 2\hat{j} + 3\hat{k}) \text{ and } \vec{b} = (2\hat{i} + \hat{j} - 3\hat{k}).$$

$$\text{It can be observed that } |\vec{a}| = \sqrt{1^2 + (-2)^2 + 3^2} = \sqrt{1 + 4 + 9} = \sqrt{14} \text{ and}$$

$$|\vec{b}| = \sqrt{2^2 + 1^2 + (-3)^2} = \sqrt{4 + 1 + 9} = \sqrt{14}.$$

Hence,  $\vec{a}$  and  $\vec{b}$  are two different vectors having the same magnitude. The vectors are different because they have different directions.

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#### Question 3:

Write two different vectors having same direction.

#### Answer 3:

Consider  $\vec{p} = (\hat{i} + \hat{j} + \hat{k})$  and  $\vec{q} = (2\hat{i} + 2\hat{j} + 2\hat{k})$ .

The direction cosines of  $\vec{p}$  are given by,

$$l = \frac{1}{\sqrt{1^2+1^2+1^2}} = \frac{1}{\sqrt{3}}, \quad m = \frac{1}{\sqrt{1^2+1^2+1^2}} = \frac{1}{\sqrt{3}}, \quad \text{and } n = \frac{1}{\sqrt{1^2+1^2+1^2}} = \frac{1}{\sqrt{3}}.$$

The direction cosines of  $\vec{q}$  are given by

$$l = \frac{2}{\sqrt{2^2+2^2+2^2}} = \frac{2}{2\sqrt{3}} = \frac{1}{\sqrt{3}}, \quad m = \frac{2}{\sqrt{2^2+2^2+2^2}} = \frac{2}{2\sqrt{3}} = \frac{1}{\sqrt{3}},$$

$$\text{and } n = \frac{2}{\sqrt{2^2+2^2+2^2}} = \frac{2}{2\sqrt{3}} = \frac{1}{\sqrt{3}}.$$

The direction cosines of  $\vec{p}$  and  $\vec{q}$  are the same. Hence, the two vectors have the same direction.

#### Question 4:

Find the values of x and y so that the vectors  $2\hat{i} + 3\hat{j}$  and  $x\hat{i} + y\hat{j}$  are equal

#### Answer 4:

The two vectors  $2\hat{i} + 3\hat{j}$  and  $x\hat{i} + y\hat{j}$  will be equal if their corresponding components are equal.

Hence, the required values of x and y are 2 and 3 respectively.

#### Question 5:

Find the scalar and vector components of the vector with initial point (2, 1) and terminal point (-5, 7).

#### Answer 5:

The vector with the initial point P (2, 1) and terminal point Q (-5, 7) can be given by,

$$\overline{PQ} = (-5-2)\hat{i} + (7-1)\hat{j}$$

$$\Rightarrow \overline{PQ} = -7\hat{i} + 6\hat{j}$$

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Hence, the required scalar components are  $-7$  and  $6$  while the vector components are  $-7\hat{i}$  and  $6\hat{j}$ .

#### Question 6:

Find the sum of the vectors  $\vec{a} = \hat{i} - 2\hat{j} + \hat{k}$ ,  $\vec{b} = -2\hat{i} + 4\hat{j} + 5\hat{k}$  and  $\vec{c} = \hat{i} - 6\hat{j} - 7\hat{k}$ .

#### Answer 6:

The given vectors are  $\vec{a} = \hat{i} - 2\hat{j} + \hat{k}$ ,  $\vec{b} = -2\hat{i} + 4\hat{j} + 5\hat{k}$  and  $\vec{c} = \hat{i} - 6\hat{j} - 7\hat{k}$

$$\begin{aligned}\therefore \vec{a} + \vec{b} + \vec{c} &= (1-2+1)\hat{i} + (-2+4-6)\hat{j} + (1+5-7)\hat{k} \\ &= 0\hat{i} - 4\hat{j} - 1\hat{k} \\ &= -4\hat{j} - \hat{k}\end{aligned}$$

#### Question 7:

Find the unit vector in the direction of the vector  $\vec{a} = \hat{i} + \hat{j} + 2\hat{k}$ .

#### Answer 7:

The unit vector  $\hat{a}$  in the direction of vector  $\vec{a} = \hat{i} + \hat{j} + 2\hat{k}$

$$\begin{aligned}|\vec{a}| &= \sqrt{1^2 + 1^2 + 2^2} = \sqrt{1+1+4} = \sqrt{6} \\ \therefore \hat{a} &= \frac{\vec{a}}{|\vec{a}|} = \frac{\hat{i} + \hat{j} + 2\hat{k}}{\sqrt{6}} = \frac{1}{\sqrt{6}}\hat{i} + \frac{1}{\sqrt{6}}\hat{j} + \frac{2}{\sqrt{6}}\hat{k}\end{aligned}$$

#### Question 8:

Find the unit vector in the direction of vector  $\overrightarrow{PQ}$ , where P and Q are the points (1, 2, 3) and (4, 5, 6), respectively.

#### Answer 8:

The given points are P (1, 2, 3) and Q (4, 5, 6).

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$$\therefore \overline{PQ} = (4-1)\hat{i} + (5-2)\hat{j} + (6-3)\hat{k} = 3\hat{i} + 3\hat{j} + 3\hat{k}$$

$$|\overline{PQ}| = \sqrt{3^2 + 3^2 + 3^2} = \sqrt{9+9+9} = \sqrt{27} = 3\sqrt{3}$$

Hence, the unit vector in the direction of  $\overline{PQ}$  is

$$\frac{\overline{PQ}}{|\overline{PQ}|} = \frac{3\hat{i} + 3\hat{j} + 3\hat{k}}{3\sqrt{3}} = \frac{1}{\sqrt{3}}\hat{i} + \frac{1}{\sqrt{3}}\hat{j} + \frac{1}{\sqrt{3}}\hat{k}$$

#### Question 9:

For given vectors,  $\vec{a} = 2\hat{i} - \hat{j} + 2\hat{k}$  and  $\vec{b} = -\hat{i} + \hat{j} - \hat{k}$ , find the unit vector in the direction of the vector  $\vec{a} + \vec{b}$

#### Answer 9:

The given vectors are  $\vec{a} = 2\hat{i} - \hat{j} + 2\hat{k}$  and  $\vec{b} = -\hat{i} + \hat{j} - \hat{k}$ .

$$\vec{a} = 2\hat{i} - \hat{j} + 2\hat{k}$$

$$\vec{b} = -\hat{i} + \hat{j} - \hat{k}$$

$$\therefore \vec{a} + \vec{b} = (2-1)\hat{i} + (-1+1)\hat{j} + (2-1)\hat{k} = 1\hat{i} + 0\hat{j} + 1\hat{k} = \hat{i} + \hat{k}$$

$$|\vec{a} + \vec{b}| = \sqrt{1^2 + 1^2} = \sqrt{2}$$

Hence, the unit vector in the direction of  $(\vec{a} + \vec{b})$  is

$$\frac{(\vec{a} + \vec{b})}{|\vec{a} + \vec{b}|} = \frac{\hat{i} + \hat{k}}{\sqrt{2}} = \frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{k}$$

#### Question 10:

Find a vector in the direction of vector  $5\hat{i} - \hat{j} + 2\hat{k}$  which has magnitude 8 units.

#### Answer 10:

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Let  $\vec{a} = 5\hat{i} - \hat{j} + 2\hat{k}$ .

$$\therefore |\vec{a}| = \sqrt{5^2 + (-1)^2 + 2^2} = \sqrt{25 + 1 + 4} = \sqrt{30}$$

$$\therefore \hat{a} = \frac{\vec{a}}{|\vec{a}|} = \frac{5\hat{i} - \hat{j} + 2\hat{k}}{\sqrt{30}}$$

Hence, the vector in the direction of vector  $5\hat{i} - \hat{j} + 2\hat{k}$  which has magnitude 8 units is given by,

$$\begin{aligned} 8\hat{a} &= 8 \left( \frac{5\hat{i} - \hat{j} + 2\hat{k}}{\sqrt{30}} \right) = \frac{40}{\sqrt{30}}\hat{i} - \frac{8}{\sqrt{30}}\hat{j} + \frac{16}{\sqrt{30}}\hat{k} \\ &= 8 \left( \frac{5\vec{i} - \vec{j} + 2\vec{k}}{\sqrt{30}} \right) \\ &= \frac{40}{\sqrt{30}}\vec{i} - \frac{8}{\sqrt{30}}\vec{j} + \frac{16}{\sqrt{30}}\vec{k} \end{aligned}$$

### Question 11:

Show that the vectors  $2\hat{i} - 3\hat{j} + 4\hat{k}$  and  $-4\hat{i} + 6\hat{j} - 8\hat{k}$  are collinear.

### Answer 11:

Let  $\vec{a} = 2\hat{i} - 3\hat{j} + 4\hat{k}$  and  $\vec{b} = -4\hat{i} + 6\hat{j} - 8\hat{k}$ .

It is observed that  $\vec{b} = -4\hat{i} + 6\hat{j} - 8\hat{k} = -2(2\hat{i} - 3\hat{j} + 4\hat{k}) = -2\vec{a}$

$$\therefore \vec{b} = \lambda\vec{a}$$

where,

$$\lambda = -2$$

Hence, the given vectors are collinear.

### Question 12:

Find the direction cosines of the vector  $\hat{i} + 2\hat{j} + 3\hat{k}$

### Answer 12:

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$$\text{Let } \vec{a} = \hat{i} + 2\hat{j} + 3\hat{k}.$$

$$\therefore |\vec{a}| = \sqrt{1^2 + 2^2 + 3^2} = \sqrt{1+4+9} = \sqrt{14}$$

Hence, the direction cosines of  $\vec{a}$  are  $\left(\frac{1}{\sqrt{14}}, \frac{2}{\sqrt{14}}, \frac{3}{\sqrt{14}}\right)$ .

#### Question 13:

Find the direction cosines of the vector joining the points A (1, 2, -3) and B (-1, -2, 1) directed from A to B.

#### Answer 13:

The given points are A (1, 2, -3) and B (-1, -2, 1).

$$\therefore \vec{AB} = (-1-1)\hat{i} + (-2-2)\hat{j} + \{1-(-3)\}\hat{k}$$

$$\Rightarrow \vec{AB} = -2\hat{i} - 4\hat{j} + 4\hat{k}$$

$$\therefore |\vec{AB}| = \sqrt{(-2)^2 + (-4)^2 + 4^2} = \sqrt{4+16+16} = \sqrt{36} = 6$$

Hence, the direction cosines of  $\vec{AB}$  are  $\left(-\frac{2}{6}, -\frac{4}{6}, \frac{4}{6}\right) = \left(-\frac{1}{3}, -\frac{2}{3}, \frac{2}{3}\right)$ .

#### Question 14:

Show that the vector  $\hat{i} + \hat{j} + \hat{k}$  is equally inclined to the axes OX, OY, and OZ.

#### Answer 14:

$$\text{Let } \vec{a} = \hat{i} + \hat{j} + \hat{k}.$$

Then,

$$|\vec{a}| = \sqrt{1^2 + 1^2 + 1^2} = \sqrt{3}$$

Therefore, the direction cosines of  $\vec{a}$  are  $\left(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}\right)$ .

Now, let  $\alpha$ ,  $\beta$ , and  $\gamma$  be the angles formed by  $\vec{a}$  with the positive directions of x, y, and z axes.

Then, we have

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$$\cos \alpha = \frac{1}{\sqrt{3}}, \cos \beta = \frac{1}{\sqrt{3}}, \cos \gamma = \frac{1}{\sqrt{3}}.$$

Hence, the given vector is equally inclined to axes OX, OY, and OZ.

#### Question 15:

Find the position vector of a point R which divides the line joining two points P and Q whose position vectors are  $\hat{i} + 2\hat{j} - \hat{k}$  and  $-\hat{i} + \hat{j} + \hat{k}$  respectively, in the ratio 2:1

(i) internally

(ii) externally

#### Answer 15:

The position vector of point R dividing the line segment joining two points P and Q in the ratio m: n is given by:

- i. Internally:  $\frac{m\vec{b} + n\vec{a}}{m+n}$
- ii. Externally:  $\frac{m\vec{b} - n\vec{a}}{m-n}$

Position vectors of P and Q are given as:

$$\overrightarrow{OP} = \hat{i} + 2\hat{j} - \hat{k} \text{ and } \overrightarrow{OQ} = -\hat{i} + \hat{j} + \hat{k}$$

(i) The position vector of point R which divides the line joining two points P and Q internally in the ratio 2:1 is given by,

$$\begin{aligned} \overrightarrow{OR} &= \frac{2(-\hat{i} + \hat{j} + \hat{k}) + 1(\hat{i} + 2\hat{j} - \hat{k})}{2+1} = \frac{(-2\hat{i} + 2\hat{j} + 2\hat{k}) + (\hat{i} + 2\hat{j} - \hat{k})}{3} \\ &= \frac{-\hat{i} + 4\hat{j} + \hat{k}}{3} = -\frac{1}{3}\hat{i} + \frac{4}{3}\hat{j} + \frac{1}{3}\hat{k} \end{aligned}$$

(ii) The position vector of point R which divides the line joining two points P and Q externally in the ratio 2:1 is given by,

$$\begin{aligned} \overrightarrow{OR} &= \frac{2(-\hat{i} + \hat{j} + \hat{k}) - 1(\hat{i} + 2\hat{j} - \hat{k})}{2-1} = (-2\hat{i} + 2\hat{j} + 2\hat{k}) - (\hat{i} + 2\hat{j} - \hat{k}) \\ &= -3\hat{i} + 3\hat{k} \end{aligned}$$

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## Question 16:

Find the position vector of the mid point of the vector joining the points P (2, 3, 4) and Q (4, 1, - 2).

## Answer 16:

The position vector of mid-point R of the vector joining points P (2, 3, 4) and Q (4, 1, - 2) is given by,

$$\begin{aligned}\overline{OR} &= \frac{(2\hat{i} + 3\hat{j} + 4\hat{k}) + (4\hat{i} + \hat{j} - 2\hat{k})}{2} = \frac{(2+4)\hat{i} + (3+1)\hat{j} + (4-2)\hat{k}}{2} \\ &= \frac{6\hat{i} + 4\hat{j} + 2\hat{k}}{2} = 3\hat{i} + 2\hat{j} + \hat{k}\end{aligned}$$

## Question 17:

Show that the points A, B and C with position vectors,

$$\vec{a} = 3\hat{i} - 4\hat{j} - 4\hat{k}, \vec{b} = 2\hat{i} - \hat{j} + \hat{k} \text{ and } \vec{c} = \hat{i} - 3\hat{j} - 5\hat{k},$$

respectively form the vertices of a right angled triangle.

## Answer 17:

Position vectors of points A, B, and C are respectively given as:

$$\vec{a} = 3\hat{i} - 4\hat{j} - 4\hat{k}, \vec{b} = 2\hat{i} - \hat{j} + \hat{k} \text{ and } \vec{c} = \hat{i} - 3\hat{j} - 5\hat{k}$$

$$\vec{a} = 3\hat{i} - 4\hat{j} - 4\hat{k}, \vec{b} = 2\hat{i} - \hat{j} + \hat{k} \text{ and } \vec{c} = \hat{i} - 3\hat{j} - 5\hat{k}$$

$$\therefore \overline{AB} = \vec{b} - \vec{a} = (2-3)\hat{i} + (-1+4)\hat{j} + (1+4)\hat{k} = -\hat{i} + 3\hat{j} + 5\hat{k}$$

$$\overline{BC} = \vec{c} - \vec{b} = (1-2)\hat{i} + (-3+1)\hat{j} + (-5-1)\hat{k} = -\hat{i} - 2\hat{j} - 6\hat{k}$$

$$\overline{CA} = \vec{a} - \vec{c} = (3-1)\hat{i} + (-4+3)\hat{j} + (-4+5)\hat{k} = 2\hat{i} - \hat{j} + \hat{k}$$

$$\therefore |\overline{AB}|^2 = (-1)^2 + 3^2 + 5^2 = 1+9+25 = 35$$

$$|\overline{BC}|^2 = (-1)^2 + (-2)^2 + (-6)^2 = 1+4+36 = 41$$

$$|\overline{CA}|^2 = 2^2 + (-1)^2 + 1^2 = 4+1+1 = 6$$

$$\therefore |\overline{AB}|^2 + |\overline{CA}|^2 = 35+6 = 41 = |\overline{BC}|^2$$

Hence, ABC is a right-angled triangle.

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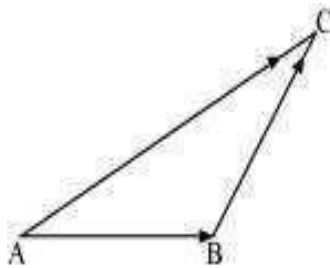
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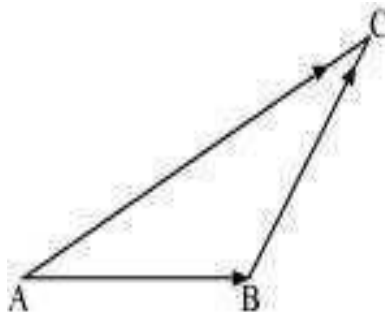
**Question 18:**

In triangle ABC which of the following is not true:



- A.  $\vec{AB} + \vec{BC} + \vec{CA} = \vec{0}$
- B.  $\vec{AB} + \vec{BC} - \vec{AC} = \vec{0}$
- C.  $\vec{AB} + \vec{BC} - \vec{CA} = \vec{0}$
- D.  $\vec{AB} - \vec{CB} + \vec{CA} = \vec{0}$

**Answer 18:**



On applying the triangle law of addition in the given triangle, we have:

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$$\overrightarrow{AB} + \overrightarrow{BC} = \overrightarrow{AC} \quad \dots(1)$$

$$\Rightarrow \overrightarrow{AB} + \overrightarrow{BC} = -\overrightarrow{CA}$$

$$\Rightarrow \overrightarrow{AB} + \overrightarrow{BC} + \overrightarrow{CA} = \vec{0} \quad \dots(2)$$

∴ The equation given in alternative A is true.

$$\overrightarrow{AB} + \overrightarrow{BC} = \overrightarrow{AC}$$

$$\Rightarrow \overrightarrow{AB} + \overrightarrow{BC} - \overrightarrow{AC} = \vec{0}$$

∴ The equation given in alternative B is true.

From equation (2), we have:

$$\overrightarrow{AB} - \overrightarrow{CB} + \overrightarrow{CA} = \vec{0}$$

∴ The equation given in alternative D is true.

Now, consider the equation given in alternative C:

$$\overrightarrow{AB} + \overrightarrow{BC} - \overrightarrow{CA} = \vec{0}$$

$$\Rightarrow \overrightarrow{AB} + \overrightarrow{BC} = \overrightarrow{CA} \quad \dots(3)$$

From equations (1) and (3), we have:

$$\overrightarrow{AC} = \overrightarrow{CA}$$

$$\Rightarrow \overrightarrow{AC} = -\overrightarrow{AC}$$

$$\Rightarrow \overrightarrow{AC} + \overrightarrow{AC} = \vec{0}$$

$$\Rightarrow 2\overrightarrow{AC} = \vec{0}$$

$$\Rightarrow \overrightarrow{AC} = \vec{0}, \text{ which is not true.}$$

Hence, the equation given in alternative C is incorrect.

The correct answer is C.

#### Question 19:

If  $\vec{a}$  and  $\vec{b}$  are two collinear vectors, then which of the following are incorrect:

A.  $\vec{b} = \lambda\vec{a}$ , for some scalar  $\lambda$

B.  $\vec{a} = \pm\vec{b}$

C. the respective components of  $\vec{a}$  and  $\vec{b}$  are proportional

D. both the vectors  $\vec{a}$  and  $\vec{b}$  have same direction, but different magnitudes

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### Answer 19:

If  $\vec{a}$  and  $\vec{b}$  are two collinear vectors, then they are parallel.

Therefore, we have:

$$\vec{b} = \lambda \vec{a} \text{ (For some scalar } \lambda \text{)}$$

If  $\lambda = \pm 1$ , then  $\vec{a} = \pm \vec{b}$ .

If  $\vec{a} = a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$  and  $\vec{b} = b_1\hat{i} + b_2\hat{j} + b_3\hat{k}$ , then

$$\vec{b} = \lambda \vec{a}.$$

$$\Rightarrow b_1\hat{i} + b_2\hat{j} + b_3\hat{k} = \lambda(a_1\hat{i} + a_2\hat{j} + a_3\hat{k})$$

$$\Rightarrow b_1\hat{i} + b_2\hat{j} + b_3\hat{k} = (\lambda a_1)\hat{i} + (\lambda a_2)\hat{j} + (\lambda a_3)\hat{k}$$

$$\Rightarrow b_1 = \lambda a_1, b_2 = \lambda a_2, b_3 = \lambda a_3$$

$$\Rightarrow \frac{b_1}{a_1} = \frac{b_2}{a_2} = \frac{b_3}{a_3} = \lambda$$

Thus, the respective components of  $\vec{a}$  and  $\vec{b}$  are proportional.

However, vectors  $\vec{a}$  and  $\vec{b}$  can have different directions.

Hence, the statement given in D is incorrect.

The correct answer is D.