

# VECTORS

## 12<sup>th</sup> Math - Chapter 10

This is Problem-16 from Exercise 10.5

1. If  $\theta$  is the angle between two vectors  $\vec{\mathbf{a}}$  and  $\vec{\mathbf{b}}$ , then  $\vec{\mathbf{a}} \cdot \vec{\mathbf{b}} \geq 0$ .

(a)  $0 < \theta < \frac{\pi}{2}$

(b)  $0 \leq \theta \leq \frac{\pi}{2}$

(c)  $0 < \theta < \pi$

(d)  $0 \leq \theta \leq \pi$

**Solution:** Given

$$\mathbf{a}, \mathbf{b} \text{ are two vectors} \quad (1)$$

$$\mathbf{a}^\top \mathbf{b} \geq 0 \quad (2)$$

Assume that  $\mathbf{a}, \mathbf{b}$  are ,

$$\mathbf{a} = \begin{pmatrix} 4 \\ 3 \end{pmatrix} \quad (3)$$

$$\mathbf{b} = \begin{pmatrix} 5 \\ 12 \end{pmatrix} \quad (4)$$

We know that

$$\theta = \cos^{-1} \left( \frac{\mathbf{a}^\top \mathbf{b}}{\|\mathbf{a}\| \|\mathbf{b}\|} \right) \quad (5)$$

$$\Rightarrow \mathbf{a}^\top \mathbf{b} = \cos \theta \|\mathbf{a}\| \|\mathbf{b}\| \quad (6)$$

$$\|\mathbf{a}\| = \sqrt{\mathbf{a}_1^2 + \mathbf{a}_2^2} \quad (7)$$

Verification:

$$\|\mathbf{a}\| = \sqrt{4^2 + 3^2} \quad (8)$$

$$\Rightarrow = 5 \quad (9)$$

$$\|\mathbf{b}\| = \sqrt{5^2 + 12^2} \quad (10)$$

$$\Rightarrow = 13 \quad (11)$$

(a) for  $\theta = 0$

$$\mathbf{a}^\top \mathbf{b} = \cos(0)(5)(13) \quad (12)$$

$$\implies = 65 \quad (13)$$

$$\implies \mathbf{a}^\top \mathbf{b} \geq 0$$

(b) for  $\theta = \frac{\pi}{2}$

$$\mathbf{a}^\top \mathbf{b} = \cos\left(\frac{\pi}{2}\right)(5)(13) \quad (14)$$

$$\implies = 0 \quad (15)$$

$$\implies \mathbf{a}^\top \mathbf{b} \geq 0$$

(c) for  $\theta = \pi$

$$\mathbf{a}^\top \mathbf{b} = \cos(\pi)(5)(13) \quad (16)$$

$$\implies = -65 \quad (17)$$

$$\implies \mathbf{a}^\top \mathbf{b} < 0$$

Therefore, the  $\theta$  is  $0 \leq \theta \leq \frac{\pi}{2}$ . So, option (b) is correct.