Lecture -4

Engineering Mechanics

QUESTION:

The following forces act at a point :

(i) 20 N inclined at 30° towards North of East,

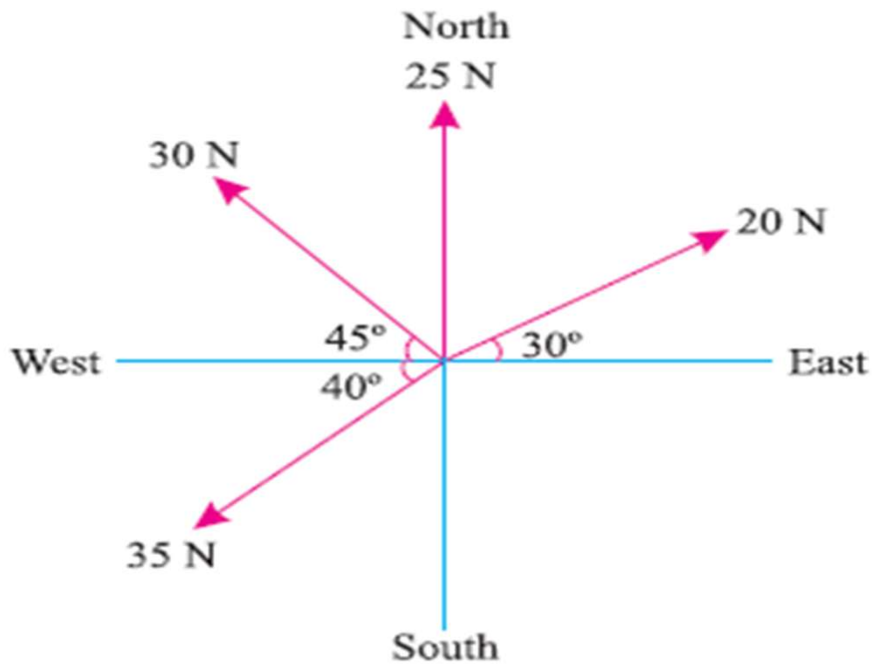
(ii) 25 N towards North,

(iii) 30 N towards North West, and

(iv) 35 N inclined at 40° towards South of West.

Find the magnitude and direction of the resultant force.

Conti…



Solution:

Magnitude of the resultant force

Resolving all the forces horizontally *i.e.*, along East-West line,

$$\Sigma H = 20 \cos 30° + 25 \cos 90° + 30 \cos 135° + 35 \cos 220° \text{ N}$$
$$= (20 \times 0.866) + (25 \times 0) + 30\,(-0.707) + 35\,(-0.766) \text{ N}$$
$$= -30.7 \text{ N} \qquad ...(i)$$

and now resolving all the forces vertically *i.e.*, along North-South line,

$$\Sigma V = 20 \sin 30° + 25 \sin 90° + 30 \sin 135° + 35 \sin 220° \text{ N}$$
$$= (20 \times 0.5) + (25 \times 1.0) + (30 \times 0.707) + 35\,(-0.6428) \text{ N}$$
$$= 33.7 \text{ N} \qquad ...(ii)$$

We know that magnitude of the resultant force,

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{(-30.7)^2 + (33.7)^2} = 45.6 \text{ N} \quad \textbf{Ans.}$$

Direction of the resultant force

Let θ = Angle, which the resultant force makes with the East.

We know that

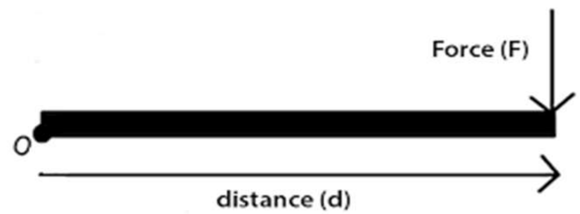
$$\tan\theta = \frac{\Sigma V}{\Sigma H} = \frac{33.7}{-30.7} = -1.098 \quad \text{or} \quad \theta = 47.7°$$

Since ΣH is negative and ΣV is positive, therefore resultant lies between 90° and 180°. Thus actual angle of the resultant = 180° – 47.7° = 132.3° **Ans.**

Moments and Their Applications

MOMENT OF A FORCE

It is the turning effect produced by a force, on the body, on which it acts. The moment of a force is equal to the product of the force and the perpendicular distance of the point, about which the moment is required and the line of action of the force.



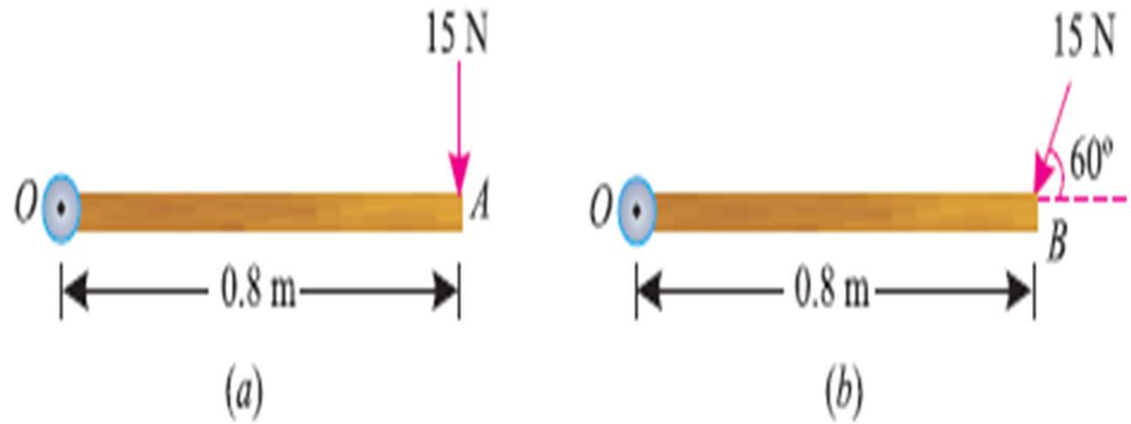
$$M = F * d$$

Where,

F = Force acting on the body, and

d = Perpendicular distance between the point, about which the moment is required and the line of action of the force.

Q. A force of 15 N is applied perpendicular to the edge of a door 0.8 m wide as shown in Fig. (a). Find the moment of the force about the hinge. If this force is applied at an angle of 60° to the edge of the same door, as shown in Fig. (b),find the moment of this force.



Conti…

Solution. Given : Force applied (P) = 15 N and width of the door (l) = 0.8 m

Moment when the force acts perpendicular to the door

We know that the moment of the force about the hinge,

$$= P \times l = 15 \times 0.8 = 12.0 \text{ N-m} \qquad \textbf{Ans.}$$

Moment when the force acts at an angle of 60° to the door

This part of the example may be solved either by finding out the perpendicular distance between the hinge and the line of action of the force as shown in Fig. 3.4 (a) or by finding out the vertical component of the force as shown in Fig. 3.4 (b).

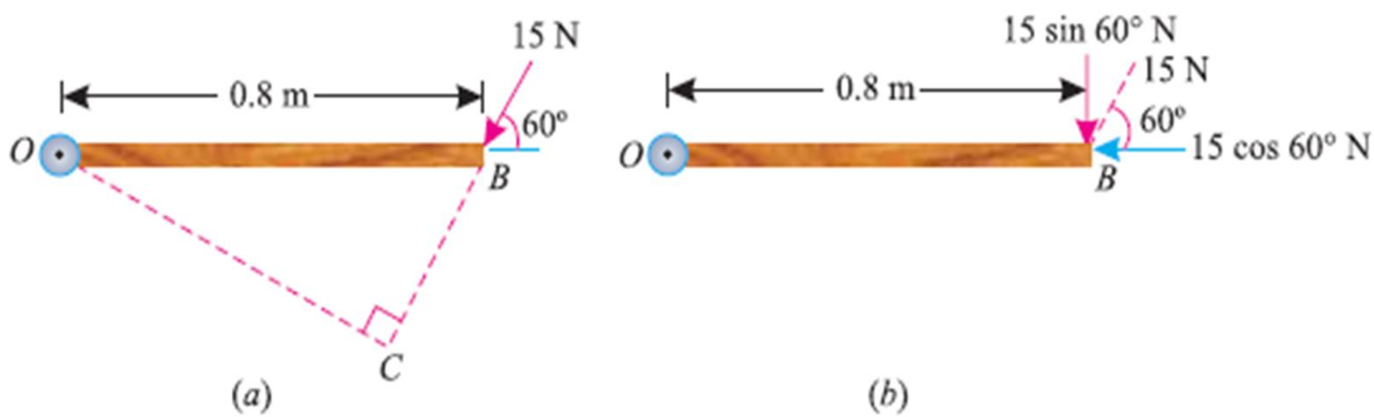


Fig. 3.4.

Conti…

From the geometry of Fig. 3.4 (*a*), we find that the perpendicular distance between the line of action of the force and hinge,

$$OC = OB \sin 60° = 0.8 \times 0.866 = 0.693 \text{ m}$$

$$\therefore \qquad \text{Moment} = 15 \times 0.693 = 10.4 \text{ N-m} \quad \textbf{Ans.}$$

In the second case, we know that the vertical component of the force

$$= 15 \sin 60° = 15 \times 0.866 = 13.0 \text{ N}$$

$$\therefore \qquad \text{Moment} = 13 \times 0.8 = 10.4 \text{ N-m} \quad \textbf{Ans.}$$