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Lecturer, Mechanical Engineering

ENGINEERING MECHANICS

CHAPTER 2: COPLANAR CONCURRENT FORCES

Lecture 5:

HOME WORK: Find the magnitude of the two forces, such that if they act at right angles, their resultant is $\sqrt{10}$ N. But, if they act at 60°, their resultant is $\sqrt{13}$ N. (ANS- 3N and 1N)

Principle of Resolution of forces (Or Principle of Resolved parts):

It states, "The algebraic sum of the resolved parts of a number of forces, in a given direction is equal to the resolved parts of their resultant in the same direction."

NOTE- The force which is split into two parts is called the resolved force and the parts are called component forces or resolutes.

Method of resolution of forces:

The magnitude and direction of the resultant force can also be found out using the method of resolution of forces as discussed below:

- Resolve all the forces horizontally and find the algebraic sum of all the horizontal components (i.e., ∑H).
- Resolve all the forces vertically and find the algebraic sum of all the vertical components (i.e., ∑V).
- The resultant R of the given forces will be given by the equation :R= $\sqrt{(\sum H)^2 + (\sum V)^2}$
- The resultant force will be inclined at an angle θ, with the horizontal, such that

$$\tan\theta = \frac{\sum V}{\sum H}$$

Notes : The value of the angle θ will vary depending upon the values of ∑V and ∑H as discussed below :

1. When ∑V is +ve, the resultant makes an angle between 0° and 180°. But when ∑V is –ve, the resultant makes an angle between 180° and 360°.
2. When ∑H is +ve, the resultant makes an angle between 0° to 90° or 270° to 360°. But when ∑H is –ve, the resultant makes an angle between 90° to 270°.

Example 2.6. *A system of forces are acting at the corners of a rectangular block as shown in Fig.* 2.4.

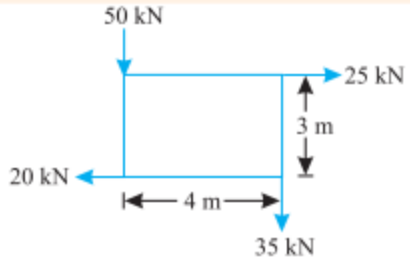

Fig. 2.4.

Determine the magnitude and direction of the resultant force.

Solution. Given : System of forces

Magnitude of the resultant force

Resolving forces horizontally,

$$\Sigma H = 25 - 20 = 5 \text{ kN}$$

and now resolving the forces vertically

$$\Sigma V = (-50) + (-35) = -85 \text{ kN}$$

$\therefore$ Magnitude of the resultant force

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{(5)^2 + (-85)^2} = 85.15 \text{ kN}$$ **Ans.**

Direction of the resultant force

Let θ = Angle which the resultant force makes with the horizontal.

We know that

$$\tan\theta = \frac{\Sigma V}{\Sigma H} = \frac{-85}{5} = -17 \quad \text{or} \quad \theta = 86.6°$$

Since ΣH is positive and ΣV is negative, therefore resultant lies between 270° and 360°. Thus actual angle of the resultant force

$$= 360° - 86.6° = 273.4°$$ **Ans.**

Example 2.7. *The forces 20 N, 30 N, 40 N, 50 N and 60 N are acting at one of the angular points of a regular hexagon, towards the other five angular points, taken in order. Find the magnitude and direction of the resultant force.*

Solution. The system of given forces is shown in Fig. 2.5

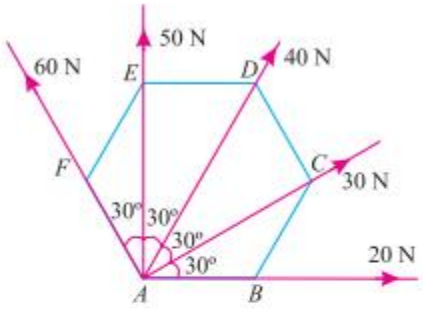

Fig. 2.5.

Magnitude of the resultant force

Resolving all the forces horizontally (*i.e.*, along *AB*),

$$\Sigma H = 20 \cos 0° + 30 \cos 30° + 40 \cos 60° + 50 \cos 90° + 60 \cos 120° \text{ N}$$
$$= (20 \times 1) + (30 \times 0.866) + (40 \times 0.5) + (50 \times 0) + 60 (-0.5) \text{ N}$$
$$= 36.0 \text{ N} \quad ...(i)$$

and now resolving the all forces vertically (*i.e.*, at right angles to *AB*),

$$\Sigma V = 20 \sin 0° + 30 \sin 30° + 40 \sin 60° + 50 \sin 90° + 60 \sin 120° \text{ N}$$
$$= (20 \times 0) + (30 \times 0.5) + (40 \times 0.866) + (50 \times 1) + (60 \times 0.866) \text{ N}$$
$$= 151.6 \text{ N} \quad ...(ii)$$

We know that magnitude of the resultant force,

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{(36.0)^2 + (151.6)^2} = 155.8 \text{ N}$$ **Ans.**

Direction of the resultant force

Let θ = Angle, which the resultant force makes with the horizontal (*i.e.*, *AB*).

We know that

$$\tan \theta = \frac{\Sigma V}{\Sigma H} = \frac{151.6}{36.0} = 4.211 \quad \text{or} \quad \theta = 76.6°$$ **Ans.**

HOMEWORK: Find the magnitude and direction of the resultant of the concurrent forces of 8N, 12N, 15N and 20N making angles 30°, 70°,120°,150° respectively from a fixed line. (2021-5 marks, same as the above sum)