Engineering Mechanics Sample Paper

B. Tech II Semester

Example 1. A system of forces is acting at the corners of a rectangular block as shown in Fig. 2.4.

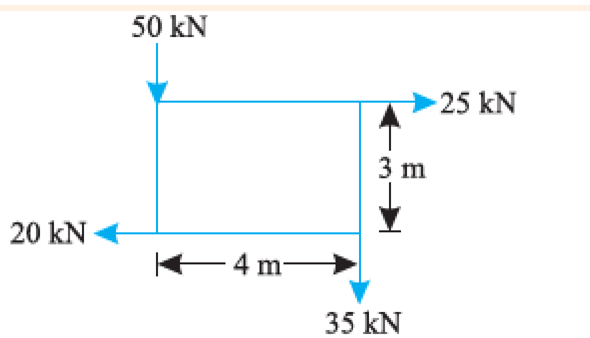


Fig.1

Determine the magnitude and direction of the resultant force.

Solution. Given: System of forces

Magnitude of the resultant force

Resolving forces horizontally,

$\Sigma H = 25 - 20 = 5$ kN

and now resolving the forces vertically

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

∴ Magnitude of the resultant force

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

Example 2. 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.

Solution. The system of given forces is shown in Fig. 2.

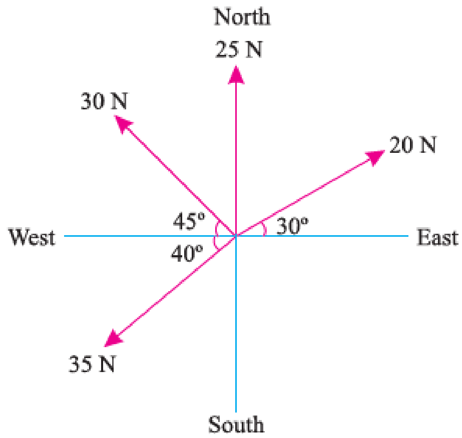


Fig.2

Magnitude of the resultant force

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

$\Sigma H = 20 \cos 30° + 25 \cos 90° + 30 \cos 135° + 35 \cos 220°$ N

$= (20 \times 0.866) + (25 \times 0) + 30 (-0.707) + 35 (-0.766)$ N

$= -30.7$ N ...(i)

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

$\Sigma V = 20 \sin 30° + 25 \sin 90° + 30 \sin 135° + 35 \sin 220°$ N

$= (20 \times 0.5) + (25 \times 1.0) + (30 \times 0.707) + 35 (-0.6428)$ N

$= 33.7$ N ...(ii)

We know that magnitude of the resultant force,

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

Direction of the resultant force

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

We know that

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

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°

Example 3. A horizontal line PQRS is 12 m long, where PQ = QR = RS = 4 m. Forces of 1000 N, 1500 N, 1000 N and 500 N act at P, Q, R and S respectively with downward direction. The lines of action of these forces make angles of 90°, 60°, 45° and 30° respectively with PS. Find the magnitude, direction and position of the resultant force.

Solution. The system of the given forces is shown in Fig. 3

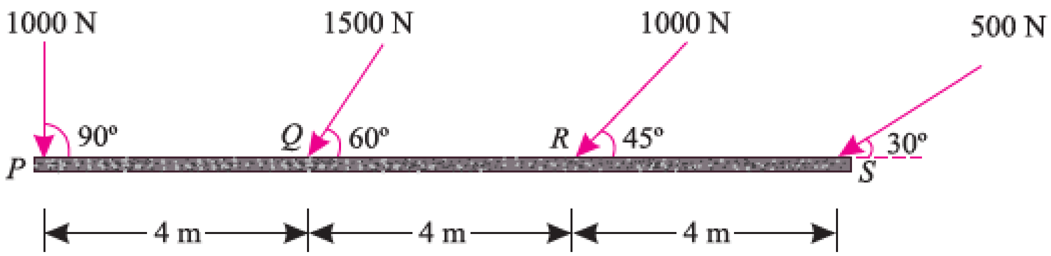


Fig 3.

Magnitude of the resultant force

Resolving all the forces horizontally,

ΣH = 1000 cos 90° + 1500 cos 60° + 1000 cos 45° + 500 cos 30° N

= (1000 × 0) + (1500 × 0.5) + (1000 × 0.707) + (500 × 0.866) N

= 1890 N ...(i)

and now resolving all the forces vertically,

ΣV = 1000 sin 90° + 1500 sin 60° + 1000 sin 45° + 500 sin 30° N

= (1000 × 1.0) + (1500 × 0.866) + (1000 × 0.707) + (500 × 0.5) N

= 3256 N ...(ii)

We know that magnitude of the resultant force,

R = (ΣH)2 + (ΣV)2 = (1890)2 + (3256)2 = 3765 N Ans.

Direction of the resultant force

Let θ = Angle, which the resultant force makes with PS

$$\tan\theta = \frac{\Sigma V}{\Sigma H} = \frac{3256}{1890} = 1.722 \text{ or } 59.8^{\circ}$$

Note. Since both the values of ΣH and ΣV are +ve. therefore resultant lies between 0° and 90°.

Position of the resultant force

Let x = Distance between P and the line of action of the resultant force.

Now taking moments of the vertical components of the forces and the resultant force about P, and equating the same,

$3256\ x = (1000 \times 0) + (1500 \times 0.866)\ 4 + (1000 \times 0.707)8 + (500 \times 0.5)12$

$= 13\ 852$

$$\therefore \qquad x = \frac{13852}{3256} = 4.25\,m$$

Example 4. A machine component 1.5 m long and weight 1000 N is supported by two ropes AB and CD as shown in Fig. 4 given below.

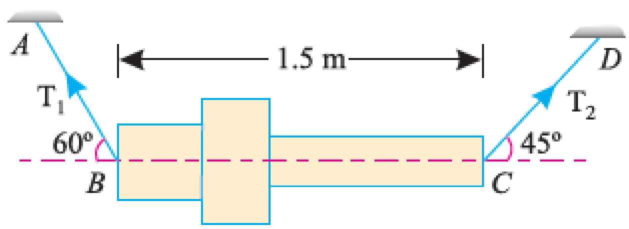


Fig. 4

Calculate the tensions T_1 and T_2 in the ropes AB and CD.

Solution. Given : Weight of the component = 1000 N

Resolving the forces horizontally (i.e., along BC) and equating the same,

$T_1 \cos 60° = T_2 \cos 45°$

$$T_1 = \frac{\cos 45°}{\cos 60°} \times T_2 \qquad \text{. ..(i)}$$

and now resolving the forces vertically,

$T_1 \sin 60° + T_2 \sin 45° = 1000$

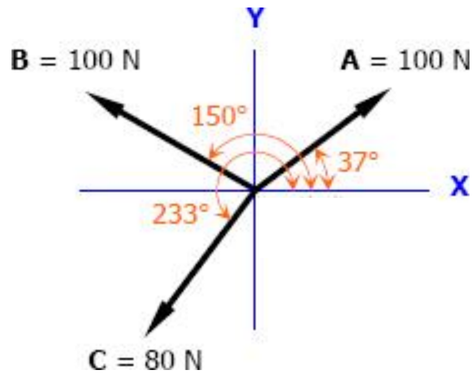
$(1.414\ T_2)\ 0.866 + T_2 \times 0.707 = 1000$

$1.93\ T_2 = 1000$

$$\therefore \quad T_2 = \frac{1000}{1.93} = 518.1\text{N}$$

and $T_1 = 1.414 \times 518.1 = 732.6$ N

Example 5. Three vectors A, B, and C are shown in the figure below. Find one vector (magnitude and direction) that will have the same effect as the three vectors shown in below.



Solution:

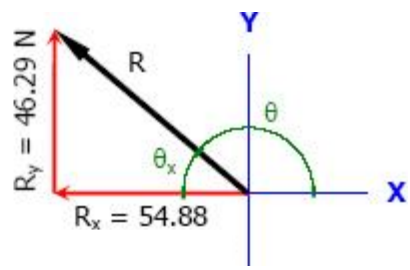
$R_x = 100\cos 37° + 100\cos 150° + 80\cos 233°$

$R_x = -54.88\ \text{ N}$

$R_x = 54.88\ \text{ N to the left}$

$R_y = 100\sin 37° + 100\sin 150° + 80\sin 233°$

$R_y = 46.29\ \text{ N}$



$R = \sqrt{{R_x}^2 + {R_y}^2}$

$R = \sqrt{54.88^2 + 46.29^2}$

$R = 71.79\ \text{ N}$

$\tan\theta_x = \dfrac{R_y}{R_x}$

$\tan\theta_x = \dfrac{46.29}{54.88}$

$\theta_x = 40.15°$

$\theta = 180° - \theta_x = 180° - 40.15°$

$\theta = 139.85°$

$R = 71.79\ \text{ N at }\ 139.85°$

Example 6. Determine the magnitude of P and F necessary to keep the concurrent force system in Fig. 6 in equilibrium.

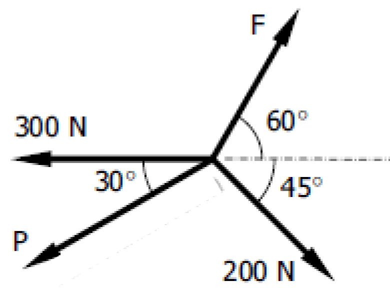


Fig.6

Solution: Because system of force is in equilibrium so sum of horizontal (ΣF_H) and vertical (ΣF_V) component of all forces will be zero.

$\Sigma F_H=0$

$F\cos60° +200\cos45° =300+P\cos30°$

$F=317.16+1.7320P$

$\Sigma F_V=0$

$F\sin60° =200\sin45° +P\sin30°$

$(317.16+1.7320P) \sin60° =200\sin45° +P\sin30°$

$274.67+1.5P=141.42+0.5P$

$P=-133.25$ N

$F=317.16+1.7320(-133.25)$

$F=86.37$ N