SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35.

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DEPARTMENT OF AUTOMOBILE ENGINEERING

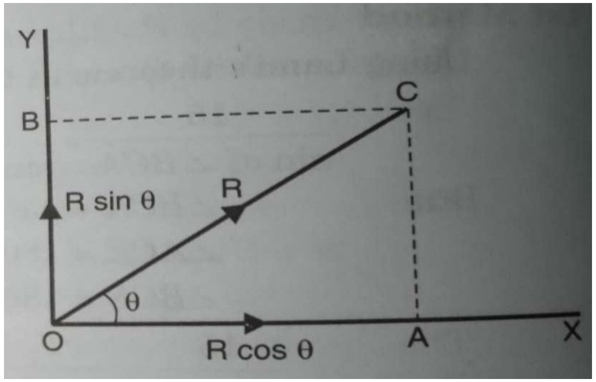
COURSE NAME : 23MET101 – ENGINEERING MECHANICS

I YEAR / I SEMESTER

Topic – Equilibrium of Particle

RESOLUTION OF FORCES

- It is defined as the process of splitting up the given force into a number of components , without changing its effect on the body is called resolution of a force.
- A force is, generally, resolved along two mutually perpendicular directions.



Components of R along x axis

Components of R along y axis

Conditions for equilibrium

$\Sigma H = 0$

$\Sigma V = 0$

$R = 0$

The forces 10N, 20N, 30N and 40N are acting on one of the vertices of a regular pentagon, towards the other four vertices taken in order. Find the Magnitude and direction of the resultant force R.

We know,

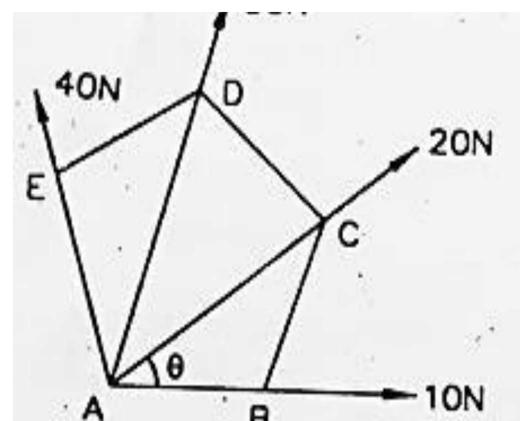
Sum of the interior angles of any regular polygon is $(2n - 4) \times 90°$, where n = number of sides. So, for Regular Pentagon,

$$\text{Sum of interior angles} = (2 \times 5 - 4) \times 90 = 540°$$

$$\therefore \text{Each included angle} = \frac{540}{5} = 108°$$

Joining the vertices B, C, D and E with the vertex A, we get 3 equal angles θ, as shown in fig 2.15. (a).

$$\therefore \text{angle } \theta = \frac{108°}{3} = 36°$$



Hence the forces and their corresponding angles with x axis are designated as below

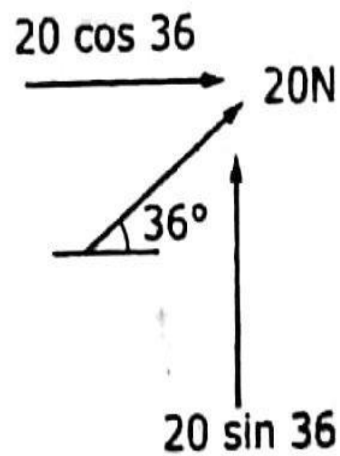
$F_1 = 10N; \quad \theta_1 = 0°$

$F_2 = 20N; \quad \theta_2 = 36°$

$F_3 = 30N; \quad \theta_3 = (2 \times 36) = 72°$

$F_4 = 40N; \quad \theta_4 = 180 - (3 \times 36) = 72°$

Resolved components of each force are given below:

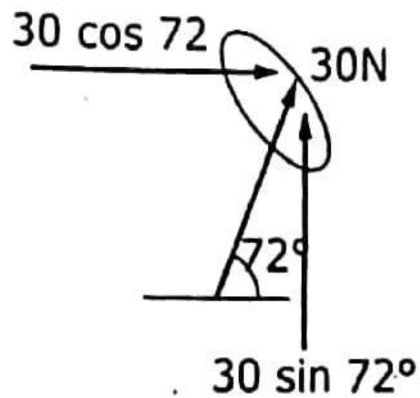


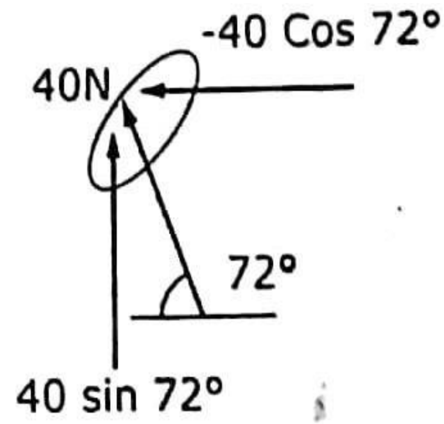
$F_h = 10\cos 0° = 10$

$F_v = 10\sin 0° = 0$

$F_h = 20\cos 36°$

$F_v = 20\sin 36°$





$F_h = 30 \cos 72°$ $\quad$ $F_h = -40 \cos 72°$

$F_v = 30 \sin 72°$ $\quad$ $F_v = 40 \sin 72°$

Resolving the forces horizontally,

$$\Sigma H = 10 + 20 \cos 36° + 30 \cos 72° - 40 \cos 72°$$
$$= 10 + 16.18 + 9.27 - 12.36$$
$$= 23.09 N$$

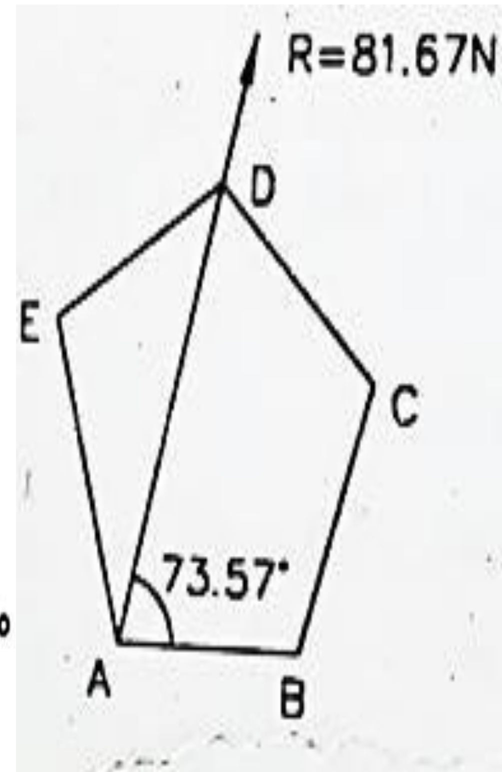
Resolving the forces vertically,

$$\Sigma V = 0 + 20 \sin 36° + 30 \sin 72° + 40 \sin 72°$$
$$= 0 + 11.76 + 28.53 + 38.04$$

Magnitude of Resultant force, $R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$

$$\therefore R = \sqrt{(23.09)^2 + (78.33)^2}$$

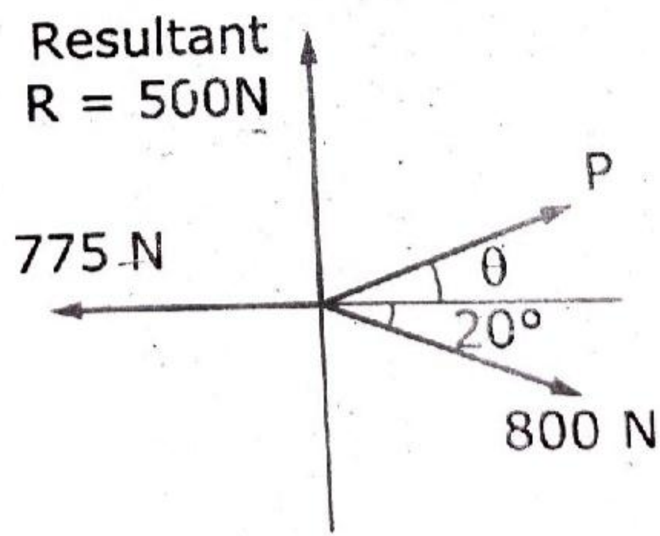
$$= 81.67N$$



Direction of Resultant force,

$$\alpha = \tan^{-1}\left(\frac{\Sigma V}{\Sigma H}\right) = \tan^{-1}\left(\frac{78.33}{23.09}\right) = 73.57^\circ$$

The three coplanar forces are acting at a point in the diagram. One of the forces is unknown and its magnitude is shown by P . The resultant is having a magnitude 500N and is acting along Y axis (positive direction) . Determine the unknown force P and its inclination with X -axis



It is given that the resultant force is 500N, acts in the positive direction of Y axis.

As Resultant force is a vertical force, it is equal to net vertical force and also the net horizontal force is zero.

i.e., $\Sigma V = R = 500N$ and $\Sigma H = 0$.

Using these two conditions, two unknowns P and θ are determined as follows.

Resolving the forces horizontally,

$$\Sigma H = P\cos\theta - 775\cos 0^\circ + 800\cos 20^\circ$$

$$0 = P\cos\theta - 775 + 751.75$$

$$\therefore\ P\cos\theta = 23.25N \qquad \text{--- (i)}$$

Resolving the forces vertically,

$$\Sigma V = P\sin\theta - 800\sin 20^\circ$$

$$500 = P\sin\theta - 273.61$$

$$\therefore\ P\sin\theta = 773.61N \qquad \text{--- (ii)}$$

Solving the equations (i) and (ii)

$$\frac{P\sin\theta}{P\cos\theta} = \frac{773.61}{23.25}$$

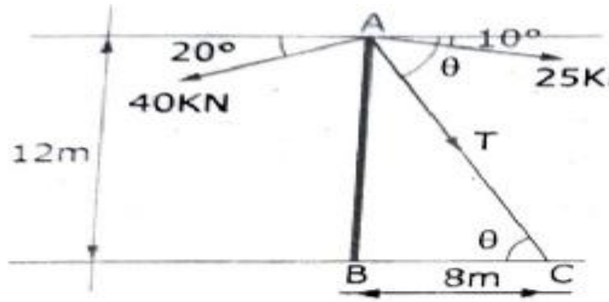
$$\tan\theta = 33.27$$

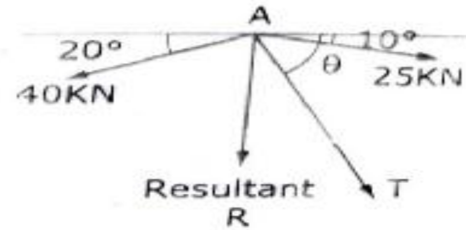
$$\theta = \tan^{-1}(33.27)$$

$$\theta = 88.27^\circ$$

Substituting $\theta = 88.27^\circ$ in equation (i), $\quad P = 770.13N$

Two cables which have known tensions are attached to the top of a tower AB .A third cable AC is used as a guy wire as shown in diagram. Determine the tension in AC if the resultant of the forces exerted at A by the three cables acts vertically downwards





It is given that the resultant force is acting vertically downwards. Hence, the net horizontal force is zero (i.e., $\Sigma H = 0$) and the resultant force is equal to the net vertical force.

Angle of inclination of Guy wire AC with reference to X axis can be determined from the available data.

In right angled triangle ABC,

$$\tan\theta = \frac{12}{8}$$

$$\theta = \tan^{-1}\left(\frac{12}{8}\right) = 56.30°.$$

Now, resolving the forces horizontally,

$$\Sigma H = 25\cos 10° - 40\cos 20° + T\cos\theta = 0,$$

$$0 = 25\cos 10° - 40\cos 20° + T\cos 56.3°$$

$$0 = 24.62 - 37.58 + 0.555T$$

here

$\Sigma H = 0$

$\Sigma V = R$

Solving, $T = 23.35N$.

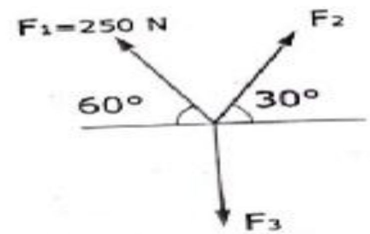
$\therefore$ The tension in the Guy wire is $23.35N$.

The forces shown in the figure are acting on a particle ,and keep the particle in equilibrium .The magnitude of F1 is 250N. Find the magnitude of F2and F3.

Method I (By Lami's theorem)

Here there are only three concurrent forces, acting outwards from a point. Hence, lami's theorem can be applied.

The angle opposite to F_1 force is $(90+30)=120°$ similarly, angles opposite to F_2 and F_3 forces are $(90+60)=150°$; and $(180-60-30)=90°$ respectively.



By lami's theorem,

$$\frac{F_1}{\sin 120} = \frac{F_2}{\sin 150} = \frac{F_3}{\sin 90}$$

or $$\frac{250}{\sin 120} = \frac{F_2}{\sin 150} = \frac{F_3}{\sin 90}$$

solving we get

$$F_2 = 144.33 \text{ N}; \quad F_3 = 288.67 \text{ N}$$

Method II (By equations of Equilibrium)

The given system of force is coplanar concurrent. Hence, equations of equilibrum satisfied in this particular force system are $\Sigma H = 0$ and $\Sigma V = 0$

Applying $\Sigma H = 0 \quad (\rightarrow +)$

$$F_2 \cos 30 - F_1 \cos 60 = 0 \qquad (F_3 \text{ force, has no horizandal component})$$

or $$F_2 \cos 30 = F_1 \cos 60$$

$$\therefore F_2 = \frac{250 \cos 60}{\cos 30} \qquad (\because F_1 = 250 \text{ N})$$

$$= 144.33\text{N}$$

Applying $\Sigma V = 0 \quad (\uparrow +)$

$$F_1 \sin 60 + F_2 \sin 30 - F_3 = 0$$

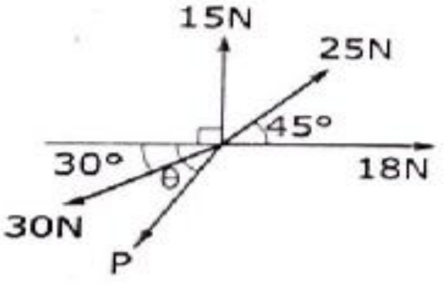
or $$250 \sin 60 + 144.33 \sin 30 = F_3$$

$$\therefore F_3 = 288.67 \text{ N}$$

The forces shown in diagram are in equilibrium . Find the magnitude and direction of ɵ(theta) of the unknown forces P

The inclined forces are resolved into two components in horizontal and vertical directions and the algebraic sum of horizantal components (i,e, ΣH) is equated to zero.

$\Sigma H = 0 \ (\rightarrow +)$



i.e, $25 \cos 45 + 18 - 30 \cos 30 - P \cos \theta = 0$

$$17.68 + 18 - 25.98 = P \cos \theta$$

$$\therefore \quad P \cos \theta = 9.7 \quad \text{----------- (i)}$$

$\Sigma V = 0 \quad (\uparrow +)$

i.e., $15 + 25 \sin 45 - 30 \sin 30 - P \sin \theta = 0$

$$15 + 17.68 - 15 = P \sin \theta$$

$$\therefore \quad P \sin \theta = 17.68 \quad \text{-----------(ii)}$$

Dividing eqn (ii) by eqn (i), we get

$$\frac{P \sin \theta}{P \cos \theta} = \frac{17.68}{9.7}$$

$$\text{or} \quad \tan \theta = 1.822$$

$$\theta = \tan^{1}(1.822)$$

$$= 61.24° \quad \textbf{(Ans)}$$

Substituing the value of θ in eqn (i), we get

$$P \cos (61.24)° = 9.7$$

$$\therefore \quad P = \frac{9.7}{\cos 61.24} = 20.16 \text{ N} \quad \textbf{(Ans)}$$

Thank You..