

MECHANICS FOR ENGINEERS

Lesson-2

Resultant Force

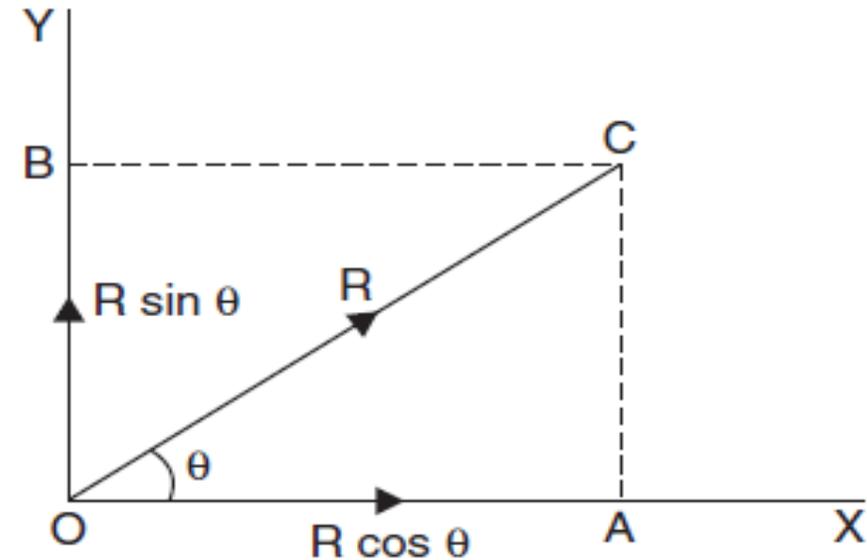
- If a number of forces are acting simultaneously on a particle, then it is possible to find out a single force which could replace them i.e., which would produce the same effect as produced by all the given forces. This single force is called *resultant force* and represented as \vec{R} etc.
- The individual forces are called component forces.

Composition and resolution of Forces

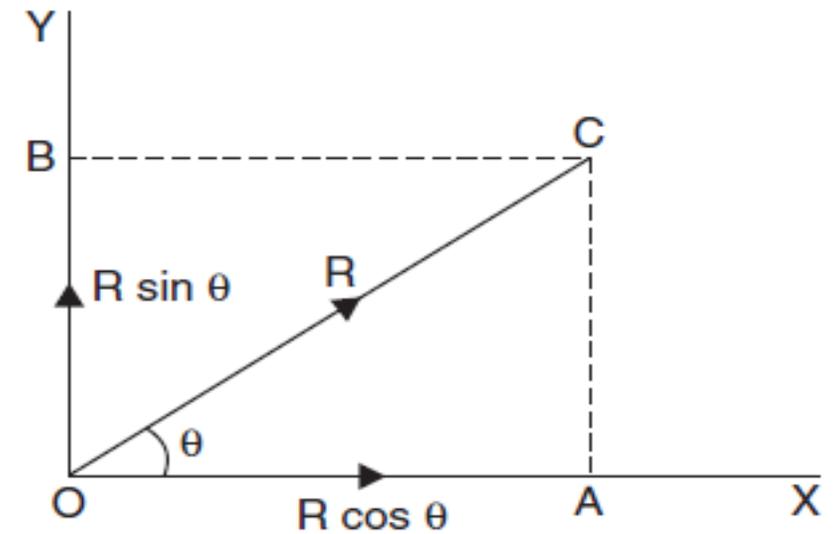
- The process of finding out the resultant force, of a number of given forces, is called composition of forces.
- The process of splitting up the given force into a number of components, without changing its effect on the body is called resolution of a force.
- A force is, generally, resolved along two mutually perpendicular directions.
- In fact, the resolution of a force is the reverse action of the addition of the component vectors.

Resolution of a Force into Rectangular Components

- Consider a force R acting on a particle O inclined at an angle θ as shown in Fig.1(a). Let x and y axes can be the two axes passing through O perpendicular to each other. These two axes are called rectangular axes or coordinate axes. They may be horizontal and vertical or inclined.



- The force R can now be resolved into two components R_x and R_y along the x and y axes and hence, the components are called rectangular components.
- Further, the polygon constructed with these two components as adjacent sides will form a rectangle $OACB$ and, therefore, the components are known as rectangular components.



- From the right angled triangle OAB, the trigonometrical functions can be used to resolve the force as follows:

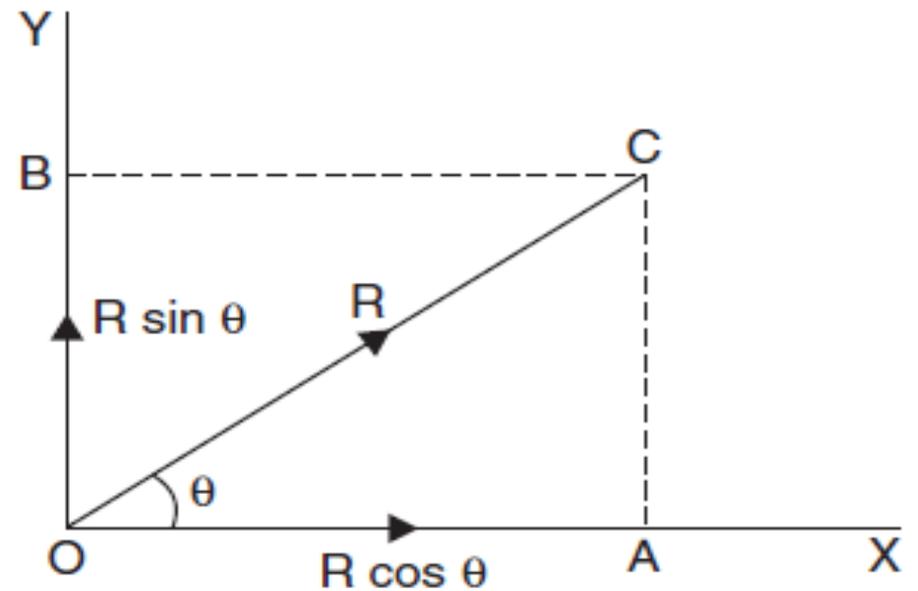
$$\cos \theta = \frac{OA}{OC}$$

Therefore,

$$OA = OC \times \cos \theta$$

Or,

$$R_x = R \cos \theta$$



- Similarly,

$$\sin \theta = \frac{AC}{OC}$$

Therefore,

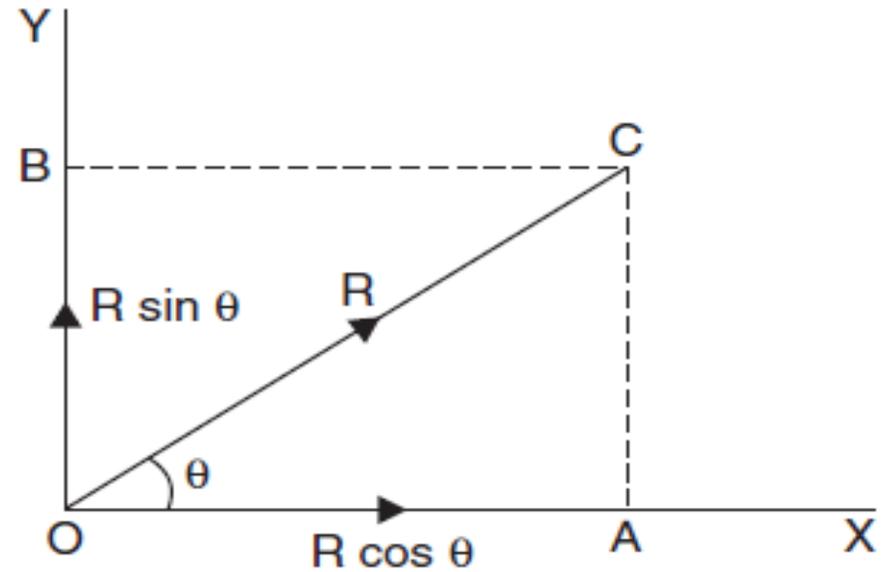
$$AC = OC \times \sin \theta$$

Or,

$$R_y = OB = AC = R \sin \theta$$

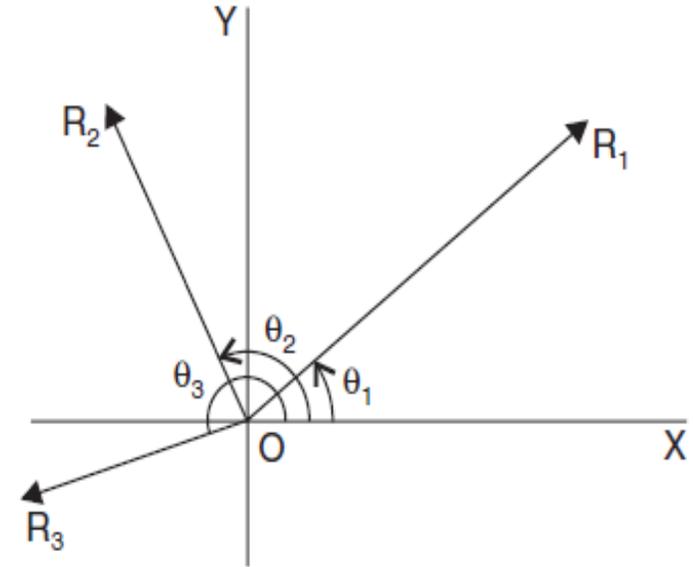
Therefore, the two rectangular components of the force F are:

$$R_x = R \cos \theta \quad \& \quad R_y = R \sin \theta$$



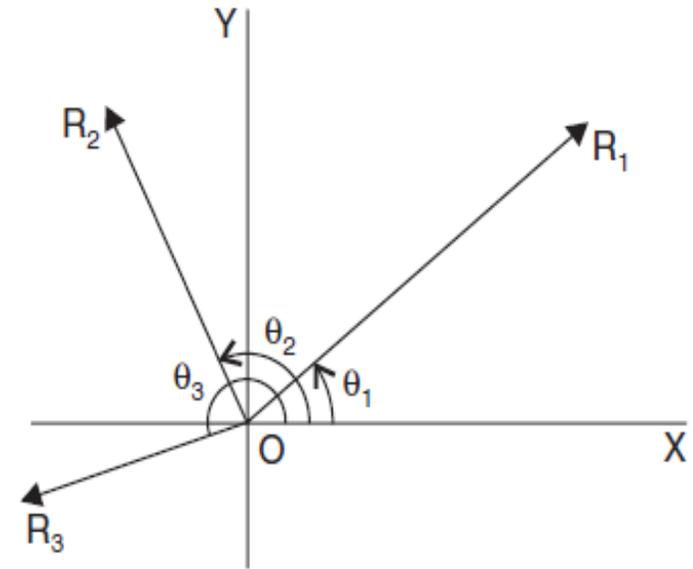
Resolution of a Number of Coplanar Forces

- Let a number of coplanar forces (forces acting in one plane are called coplanar forces) R_1, R_2, R_3, \dots are acting at a point as shown in figure.



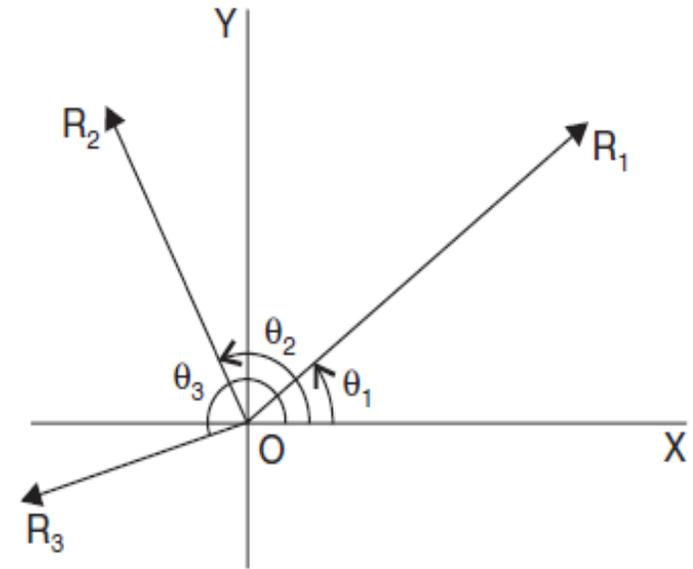
Resolution of a Number of Coplanar Forces

- Let θ_1 = Angle made by R_1 with X -axis θ_2 = Angle made by R_2 with X -axis , θ_3 = Angle made by R_3 with X -axis
- H = Resultant component of all forces along X -axis
- V = Resultant component of all forces along Y -axis
- R = Resultant of all forces
- θ = Angle made by resultant with X -axis.
- Each force can be resolved into two components, one along X -axis and other along Y -axis.



Resolution of a Number of Coplanar Forces

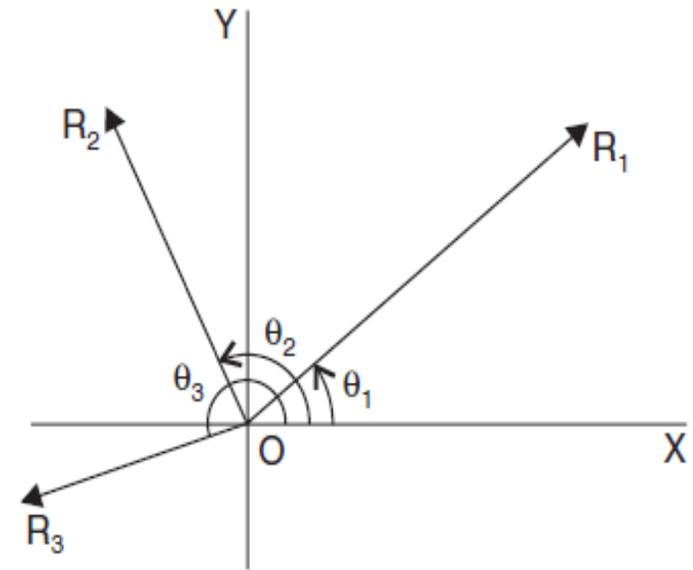
- Component of R_1 along X -axis = $R_1 \cos \theta_1$,
Component of R_1 along Y -axis = $R_1 \sin \theta_1$.
- Similarly, the components of R_2 and R_3 along X -axis and Y -axis are $(R_2 \cos \theta_2, R_2 \sin \theta_2)$ and $(R_3 \cos \theta_3, R_3 \sin \theta_3)$ respectively.
- Resultant components along X -axis = Sum of components of all forces along X -axis.
- $\therefore H = R_1 \cos \theta_1 + R_2 \cos \theta_2 + R_3 \cos \theta_3 + \dots$



Resolution of a Number of Coplanar Forces

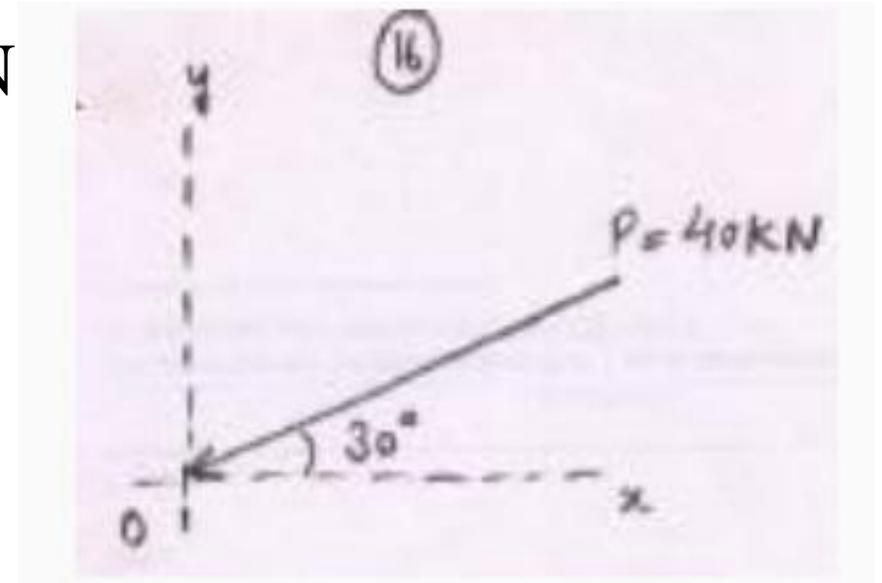
- Resultant component along Y -axis.= Sum of components of all forces along Y -axis.
- $\therefore V = R_1 \sin \theta_1 + R_2 \sin \theta_2 + R_3 \sin \theta_3 + \dots$
- Then resultant of all the forces, $R = (H^2 + V^2)^{1/2}$
- The angle made by R with X -axis is given by,

$$\tan \theta = V/H$$



- **Example**

- Determine the components of force $P = 40 \text{ kN}$ along x and y as shown in Fig



- **Solution:** Plot a rectangle OPSQ taking the force P (that is OS) as the diagonal as illustrated in Fig, the two components P_x and P_y can be obtained.

- Consider the right angle triangle OPQ in which

$$\cos 30^\circ = \frac{OP}{OS}$$

Or,

$$OP = OS \times \cos 30^\circ = 40 \times 0.866 = 34.64kN$$

Towards left.

$$OQ = OS \times \sin 30^\circ = 40 \times 0.5 = 20kN$$

Downward

