

## Module I: FORCES AND MOMENT

### Session 3

#### Parallelogram Law of Forces

It states, “If two forces, acting simultaneously on a particle, be represented in magnitude and direction by the two adjacent sides of a parallelogram, their resultant may be represented in magnitude and direction by the diagonal of the parallelogram, which passes through their point of intersection.”

#### Triangle Law of Forces

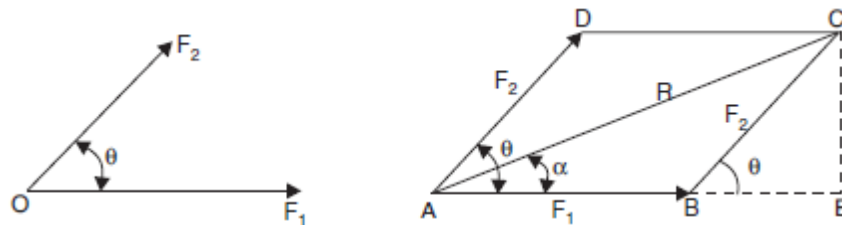
It states, “If two forces acting simultaneously on a particle, be represented in magnitude and direction by the two sides of a triangle, taken in order, their resultant may be represented in magnitude and direction by the third side of the triangle, taken in opposite order.”

#### Polygon Law of Forces

It is an extension of Triangle Law of Forces for more than two forces, which states, “If a number of forces acting simultaneously on a particle, be represented in magnitude and direction, by the sides of a polygon taken in order, then the resultant of all these forces may be represented, in magnitude and direction, by the closing side of the polygon, taken in opposite order.”

#### Cosine Law Method

Consider the two forces  $F_1$  and  $F_2$  acting on a particle as shown in Figure. Let the angle between the two forces be  $\theta$ . If parallelogram  $ABCD$  is drawn with  $AB$  representing  $F_1$  and  $AD$  representing  $F_2$  to some scale, according to parallelogram law of forces  $AC$  represents the resultant  $R$ . Drop perpendicular  $CE$  to  $AB$ .



$$\begin{aligned} R &= \sqrt{(F_1 + F_2 \cos \theta)^2 + (F_2 \sin \theta)^2} \\ &= \sqrt{F_1^2 + 2F_1 F_2 \cos \theta + F_2^2 \cos^2 \theta + F_2^2 \sin^2 \theta} \\ &= \sqrt{F_1^2 + 2F_1 F_2 \cos \theta + F_2^2} \end{aligned}$$

$$\alpha = \tan^{-1} \frac{F_2 \sin \theta}{F_1 + F_2 \cos \theta}$$

Particular cases:

1. When  $\theta = 90^\circ$

$$R = \sqrt{F_1^2 + F_2^2}$$

2. When  $\theta = 0^\circ$

$$R = \sqrt{F_1^2 + 2F_1F_2 + F_2^2} = F_1 + F_2$$

3. When  $\theta = 180^\circ$

$$R = \sqrt{F_1^2 - 2F_1F_2 + F_2^2} = F_1 - F_2$$

### Method of Resolution for the Resultant Force

1. Resolve all the forces horizontally and find the algebraic sum of all the horizontal components (*i.e.*,  $\Sigma H$ ).
2. Resolve all the forces vertically and find the algebraic sum of all the vertical components (*i.e.*,  $\Sigma V$ ).
3. The resultant  $R$  of the given forces will be given by the equation:

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$$

4. The resultant force will be inclined at an angle  $\theta$  with the horizontal, such that

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