2.6. POLYGON LAW OF FORCES

"If a number of concurrent forces acting simultaneously on a body are represented in magnitude and direction by the sides of a polygon, taken in order, then the resultant is represented in magnitude and direction by the closing side of the polygon, taken in opposite order."

Consider force P_1, P_2, P_3, and P_4 acting on the body at point O as shown Fig. 2.39 (*a*). Line AB is drawn to represent force P_1, line BC to represent P_2, line CD to represent P_3 and line DE to represent P_4. The polygon is completed by drawing the closing line AE. This closing line AE represents the resultant of the given system in magnitude, line of action and direction.

The polygon law of forces follows from the triangle law of forces as is evident from the steps outline below:

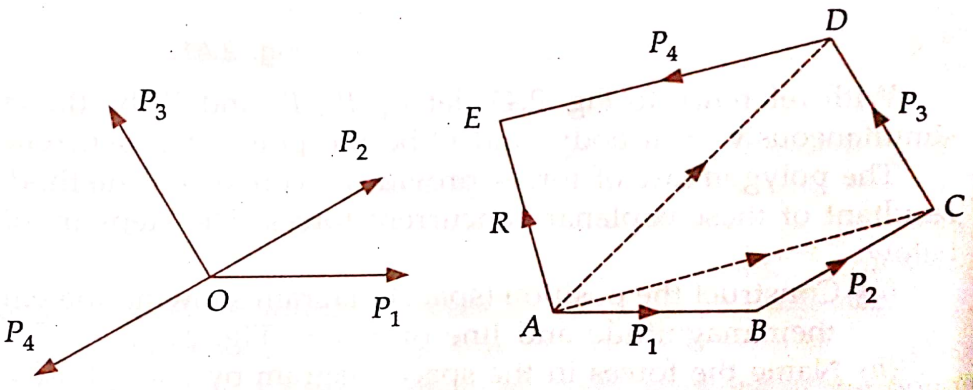

Fig. 2.39

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$$\vec{AC} = \vec{AB} + \vec{BC}$$
$$\vec{AD} = \vec{AC} + \vec{CD} = \vec{AB} + \vec{BC} + \vec{CD}$$
$$\vec{AE} = \vec{AD} + \vec{DE} = \vec{AB} + \vec{BC} + \vec{CD} + \vec{DE}$$

or $$R = P_1 + P_2 + P_3 + P_4.$$

Sometimes the polygon law of forces is stated as follows:

"If any number of forces acting at a point can be represented in magnitude and direction by the sides of a polygon taken in order, then the system of forces is in equilibrium."

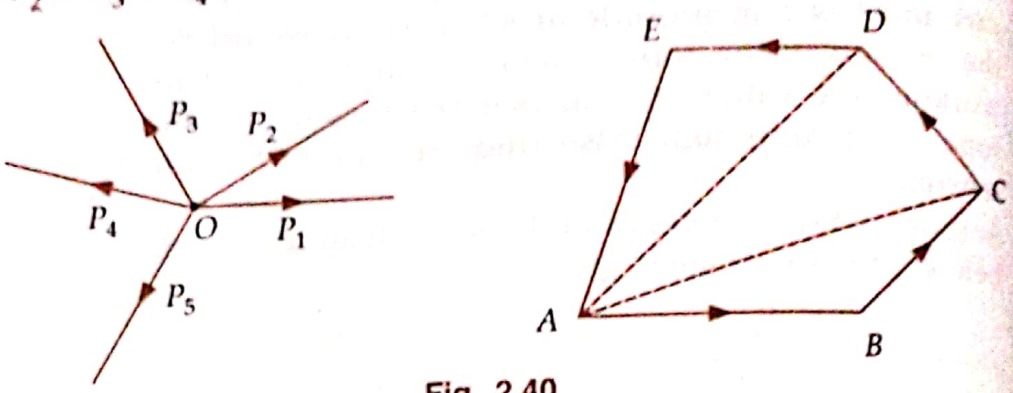

Fig. 2.40

Let the forces P_1, P_2, P_3, P_4 and P_5 acting at point O be represented in magnitude by the sides AB, BC, CD, DE and EA of the polygon $ABCDE$. Join AC and BD.

By the triangle law of forces.

$$\vec{AC} = \vec{AB} + \vec{BC}$$
$$\vec{AD} = \vec{AC} + \vec{CD} = \vec{AB} + \vec{BC} + \vec{CD}$$
$$\vec{AE} = \vec{AD} + \vec{DE} = \vec{AB} + \vec{BC} + \vec{CD} + \vec{DE}$$

i.e., $\vec{AE}$ represents the resultant of forces P_1, P_2, P_3, and P_4.

$\therefore$ Vector sum of all the forces $= \vec{AE} + \vec{EA} = 0$

and hence the system is in equilibrium.

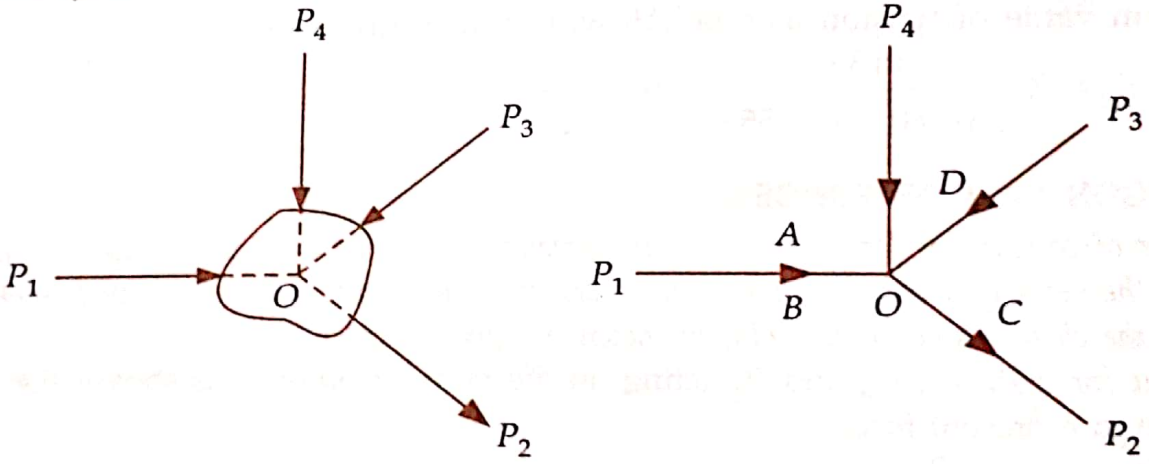

Fig. 2.41.

With reference to Fig. 2.41, let P_1, P_2, P_3 and P_4 be the coplanar concurrent forces acting simultaneously on a body, and O be the point of concurrency of three forces.

The polygon law of forces provides a convenient method for determining graphically the resultant of these coplanar concurrent forces. The steps involved in the method are outlined below:

(*a*) Construct the position (space) diagram showing the various forces (or loads) along with their magnitude and line of action (Fig. 2.41).

(*b*) Name the forces in the space diagram by using Bow's notation by which each force is named by two capital letters placed on its either side.

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(*c*) Construct the force diagram by starting from a convenient point. Go on adding all the forces vectorially one by one to some suitable scale.

In the context of the force system indicated, draw vector *ab* equal to force P_1 to some suitable scale and parallel to the line of action of P_1. From point *b*, draw vector *bc* to represent P_2 in magnitude and direction. From point *c*, draw vector *cd* to represent force P_3 in magnitude and direction. Then from point draw vector *de* equal and parallel to force P_4.

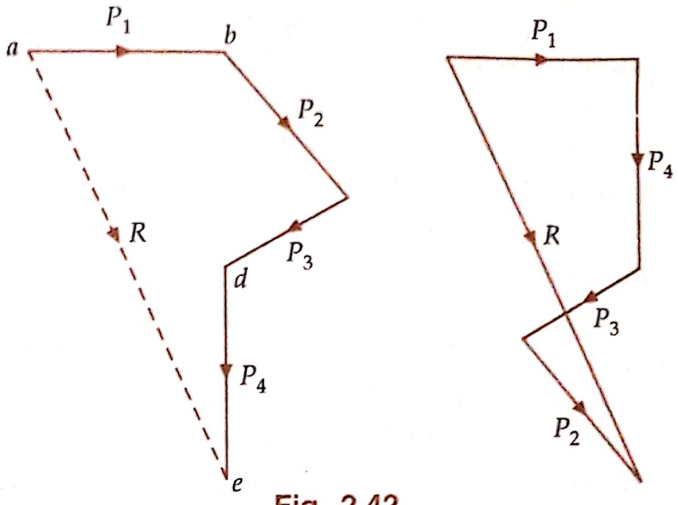

Fig. 2.42

The closing side *ae* of the polygon (Fig. 2.42) gives the required resultant in magnitude and direction. The direction is from *a* to *e* as shown in the vector diagram.

It is to be noted that the order of taking the forces does change the shape of the polygon. However, the resultant remains the same in magnitude, direction and sense.

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