MIMLI DAS

Lecturer, Mechanical Engineering

ENGINEERING MECHANICS

CHAPTER 2: COPLANAR CONCURRENT FORCES

Lecture 7:

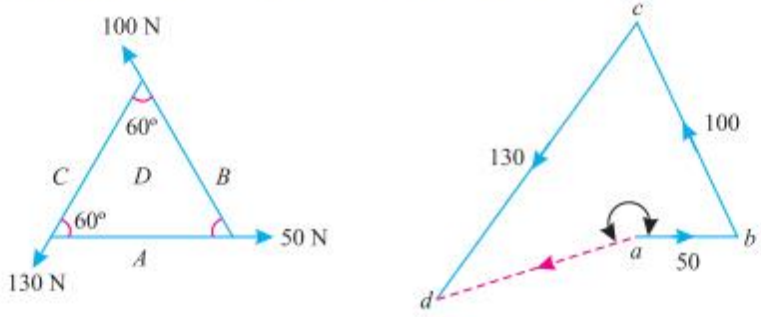
Graphical (Vector) method to find the resultant force:
(Using Polygon Law of forces)
The magnitude and direction of the resultant force can also be found out as discussed below:

- **Construction of space diagram (position diagram):** It means the construction of a diagram showing the various forces (or loads) alongwith their magnitude and lines of action.
- **Use of Bow's notations:** All the forces in the space diagram are named by using the Bow's notations. It is a convenient method in which every force (or load) is named by two capital letters, placed on its either side in the space diagram.
- **Construction of vector diagram (force diagram):** It means the construction of a diagram starting from a convenient point and then go on adding all the forces vectorially one by one (keeping in view the directions of the forces) to some suitable scale. Now the closing side of the polygon, taken in opposite order, will give the magnitude of the resultant force (to the scale) and its direction.

Example 2.10. *A particle is acted upon by three forces equal to 50 N, 100 N and 130 N, along the three sides of an equilateral triangle, taken in order. Find graphically the magnitude and direction of the resultant force.*

Solution. The system of given forces is shown in Fig. 2.8 (*a*)

First of all, name the forces according to Bow's notations as shown in Fig. 2.8 (*a*). The 50 N force is named as *AD*, 100 N force as *BD* and 130 N force as *CD*.



(*a*) Space diagram (*b*) Vector diagram

Fig. 2.8.

Now draw the vector diagram for the given system of forces as shown in Fig. 2.8 (*b*) and as discussed below :

1. Select some suitable point *a* and draw *ab* equal to 50 N to some suitable scale and parallel to the 50 N force of the space diagram.
2. Through *b*, draw *bc* equal to 100 N to the scale and parallel to the 100 N force of the space diagram.
3. Similarly through *c*, draw *cd* equal to 130 N to the scale and parallel to the 130 N force of the space diagram.
4. Join *ad*, which gives the magnitude as well as direction of the resultant force.
5. By measurement, we find the magnitude of the resultant force is equal to 70 N and acting at an angle of 200° with *ab*. **Ans.**

Example 2.11. *The following forces act at a point :*

(*i*) *20 N inclined at 30° towards North of East.*

(*ii*) *25 N towards North.*

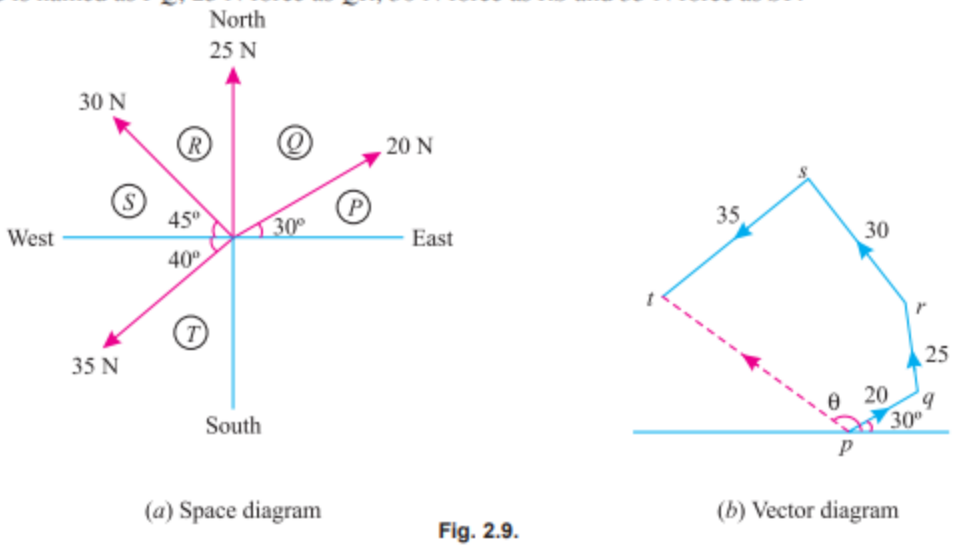
(*iii*) *30 N towards North West and*

(*iv*) *35 N inclined at 40° towards South of West.*

Find the magnitude and direction of the resultant froce.

***Solution.** The system of given forces is shown in Fig. 2.9 (*a*).

First of all, name the forces according to Bow's notations as shown in Fig. 2.9 (*a*). The 20 N force is named as *PQ*, 25 N force as *QR*, 30 N force as *RS* and 35 N force as *ST*.



(*a*) Space diagram (*b*) Vector diagram

Fig. 2.9.

Now draw the vector diagram for the given system of forces as shown in Fig. 2.9 (*b*) and as discussed below :

1. Select some suitable point *p* and draw *pq* equal to 20 N to some suitable scale and parallel to the force *PQ*.
2. Through *q*, draw *qr* equal to 25 N to the scale and parallel to the force *QR* of the space diagram.
3. Now through *r*, draw *rs* equal to 30 N to the scale and parallel to the force *RS* of the space diagram.
4. Similarly, through *s*, draw *st* equal to 35 N to the scale and parallel to the force *ST* of the space diagram.
5. Joint *pt*, which gives the magnitude as well as direction of the resultant force.
6. By measurement, we find that the magnitude of the resultant force is equal to 45.6 N and acting at an angle of 132° with the horizontal *i.e.* East–West line. **Ans.**

OBJECTIVE TYPE QUESTIONS

1. Which of the following statement is correct?
   (*a*) A force is an agent which produces or tends to produce motion.
   (*b*) A force is an agent which stops or tends to stop motion.
   (*c*) A force may balance a given number of forces acting on a body.
   (*d*) Both (*a*) and (*b*).

2. In order to determine the effects of a force acting on a body, we must know
   (*a*) Its magnitude and direction of the line along which it acts.
   (*b*) Its nature (whether push or pull).
   (*c*) Point through which it acts on the body.
   (*d*) All of the above.

3. If a number of forces are acting simultaneously on a particle, then the resultant of the forces will have the same effect as produced by the all the forces. This is known as
   (*a*) Principle of physical independence of forces.
   (*b*) Principle of transmissibility of forces.
   (*c*) Principle of resolution of forces.
   (*d*) None of the above.

4. The vector method, for the resultant force, is also called polygon law of forces
   (*a*) Correct (*b*) Incorrect

5. The resultant of two forces P and Q acting at an angle θ is equal to
   (*a*) $\sqrt{P^2 + Q^2 + 2PQ\sin\theta}$ (*b*) $\sqrt{P^2 + Q^2 + 2PQ\cos\theta}$
   (*c*) $\sqrt{P^2 + Q^2 - 2PQ\sin\theta}$ (*d*) $\sqrt{P^2 + Q^2 - 2PQ\cos\theta}$

6. If the resultant of two forces P and Q acting at an angle (α) with P, then
   (*a*) $\tan\alpha = \dfrac{P\sin\theta}{P + Q\cos\theta}$ (*b*) $\tan\alpha = \dfrac{P\cos\theta}{P + Q\cos\theta}$
   (*c*) $\tan\alpha = \dfrac{Q\sin\theta}{P + Q\cos\theta}$ (*d*) $\tan\alpha = \dfrac{Q\cos\theta}{P + Q\cos\theta}$

ANSWERS

1. (*d*) 2. (*d*) 3. (*a*) 4. (*b*) 5. (*b*) 6. (*c*)