Engineering Mechanics

Module 1.1 – Resultant of forces

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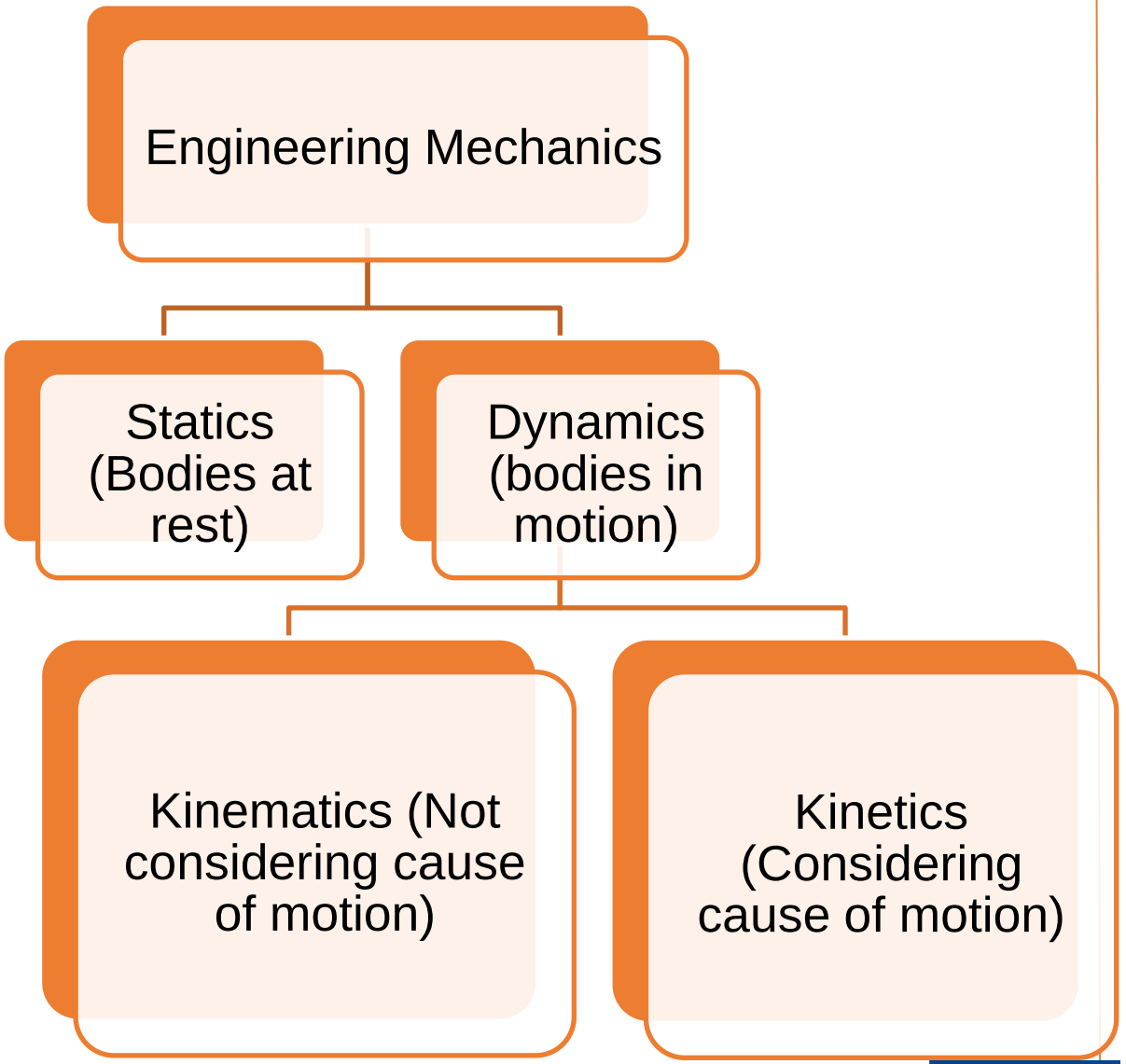
Engineering Mechanics

What is mechanics?

It is the branch of engineering science which deals with effect and analysis of forces acting on the body, which may be at rest or in the motion

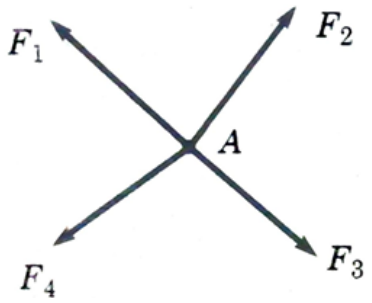


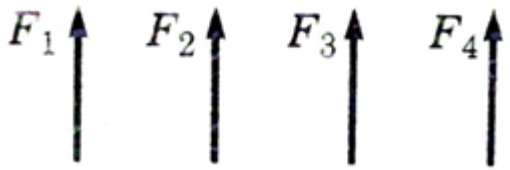
Contents

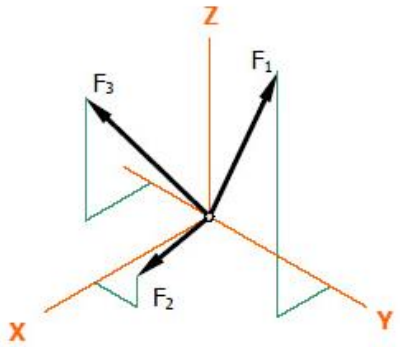
System of forces	
1.1	System of coplanar forces: Resultant of concurrent forces, parallel forces, non-concurrent non parallel system of forces, moment of force about a point, couples, Varignon's theorem, Principle of transmissibility of forces (Vector and analytical approach)

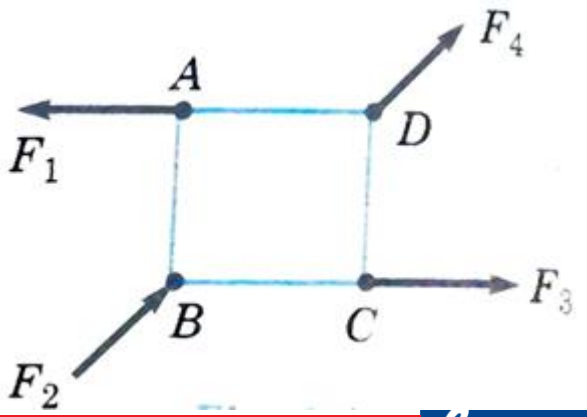
Types of different force system (F.S.) acting on a body

- Force systems
  - Co-planer force system
    - Concurrent F.S.
    - Non-concurrent F.S.
  - Non-co-planer force system
    - Concurrent F.S.
    - Non-concurrent F.S.









Resultant of a force system and its importance

Basic terminologies: Force and moment

Force: It is an external agency acting on the body which will cause the motion of the body from one location to another

Moment: The turning tendency of the body due to application of a force on it about a particular point is called moment. Moment magnitude is given by force * perpendicular distance

What is resultant?

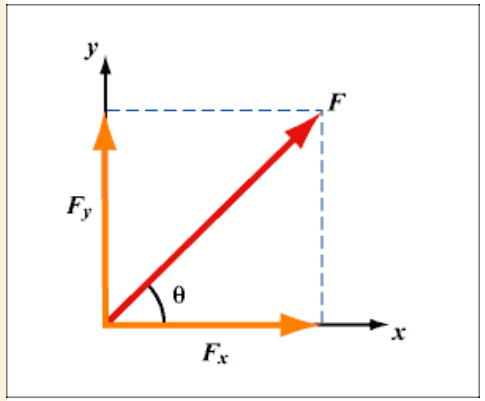
It is a single equivalent force acting on a body producing the same effect as that of multiple forces producing on it.

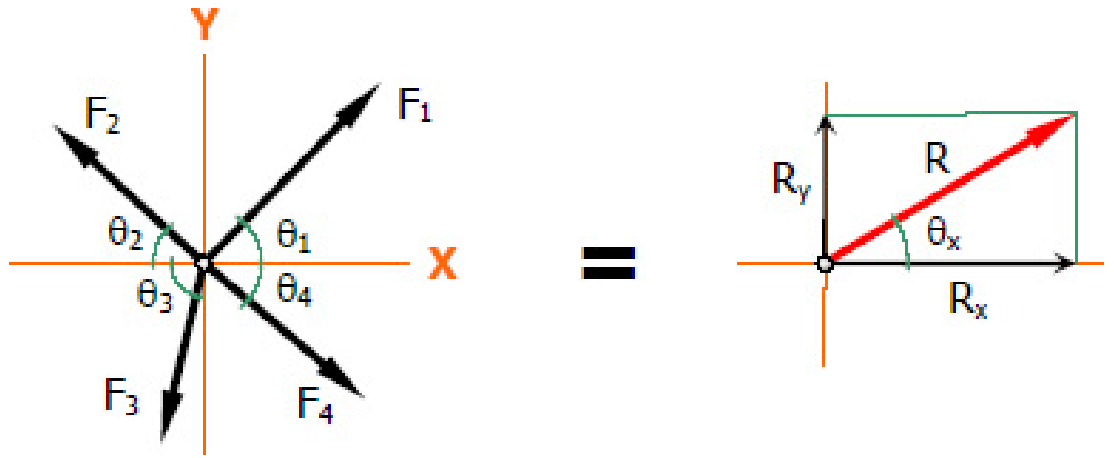
$$R_x = \Sigma F_x$$

$$R_y = \Sigma F_y$$

$$R = \sqrt{{R_x}^2 + {R_y}^2}$$

$$\tan\theta_x = \frac{R_y}{R_x}$$

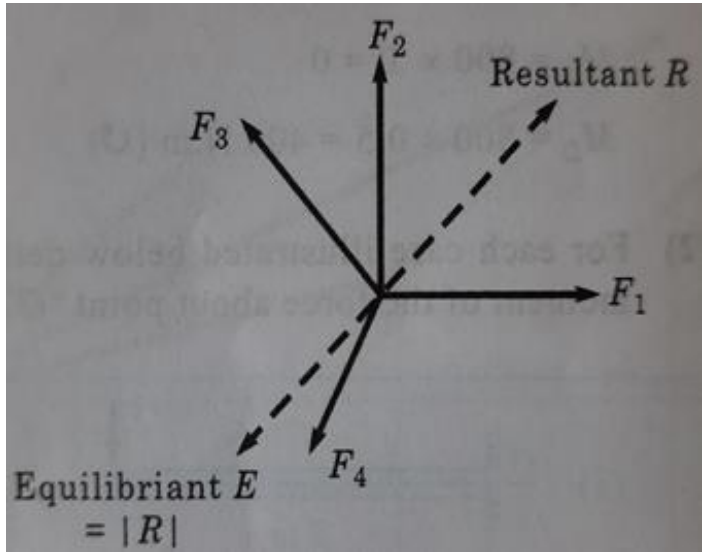




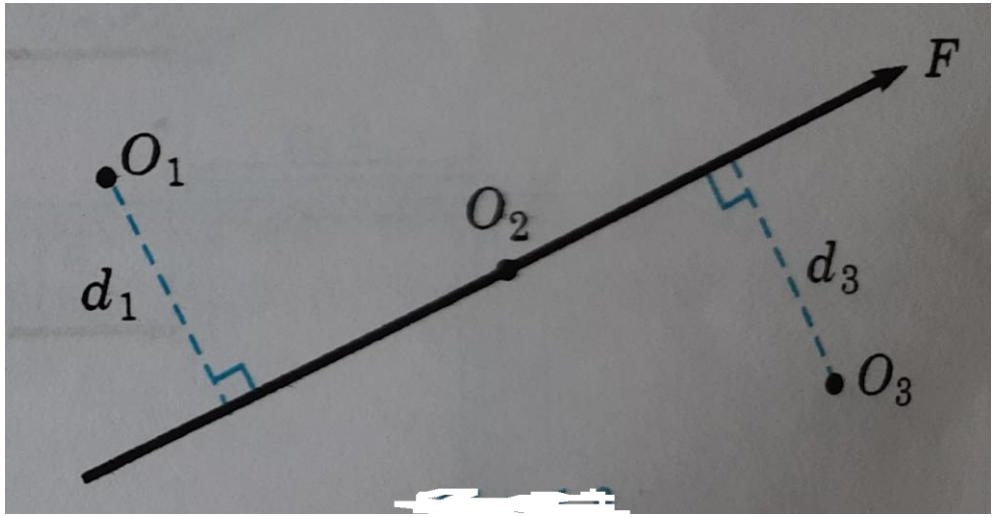
Composition of forces

- The process of addition of forces is called as composition of forces
- The forces cannot be added by a simple arithmetic procedure as they are vectors.
- Either graphical or analytical methods are used for composition of forces.

Resultant and Equilibriant



Moment of a force about a point



Moment of force F about O_1 $= F \times d_1$ (↺)

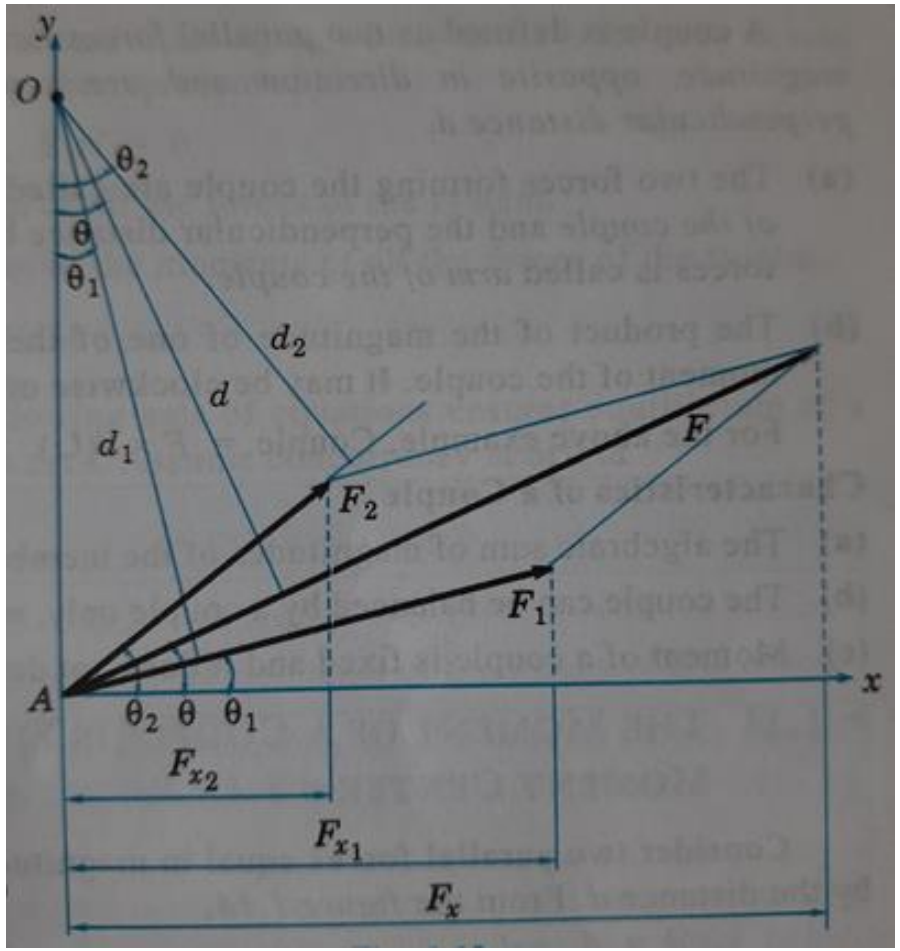
Moment of force F about O_2 $= F \times 0 = 0$

Moment of force F about O_3 $= F \times d_3$ (↻)

Varignon's theorem

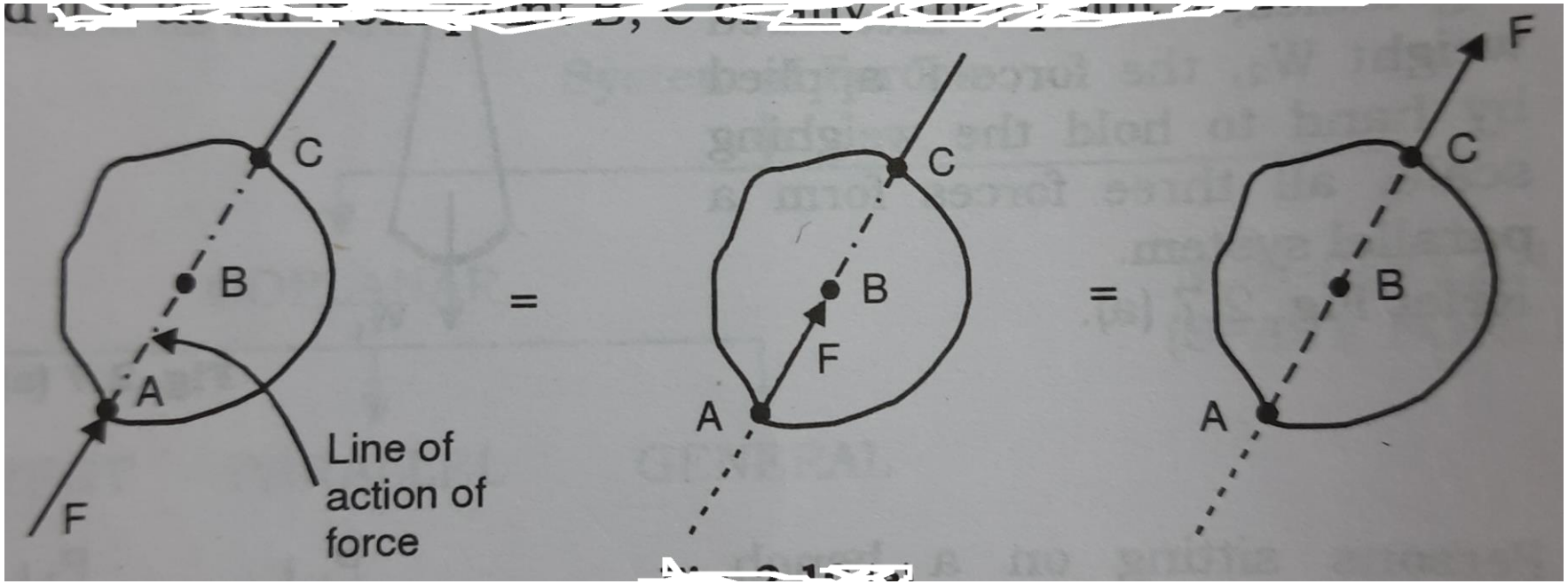
Statement: Moment of a resultant about any point is equal to the sum of the moments of the all forces about the same point. Mathematically,

$$\sum M_O^F = M_O^R$$

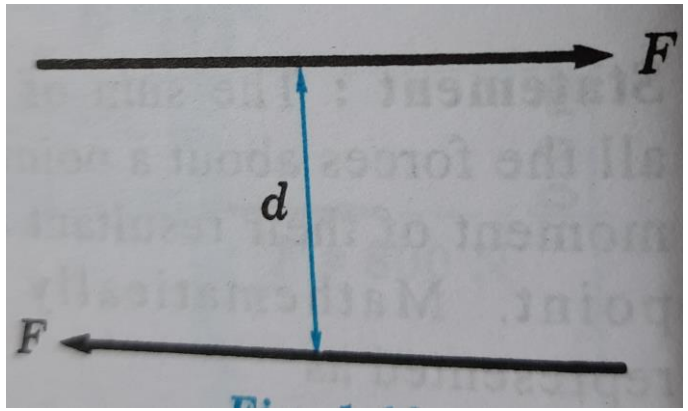


Principle of transmissibility of a force

- It states that the condition of equilibrium or motion of rigid body will remain unchanged if the point of application of force acting on the rigid body is transmitted to act at any other point along its line of action.

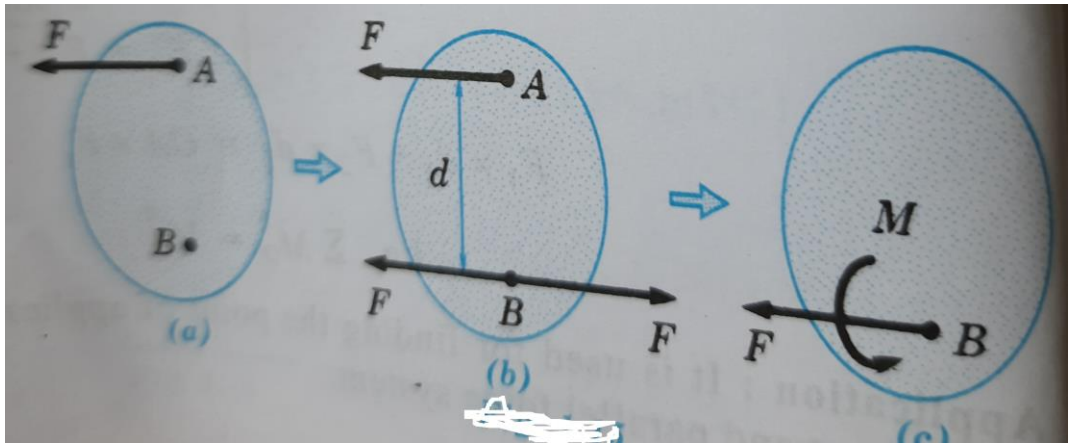


Couple



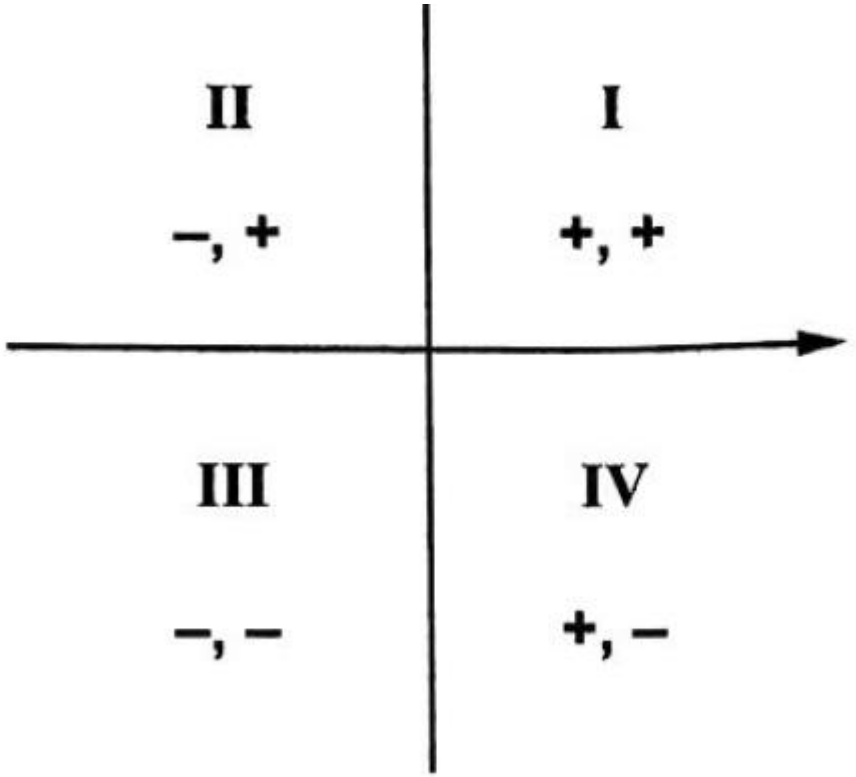
$$M = F \times d(\circlearrowleft)$$

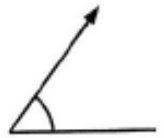
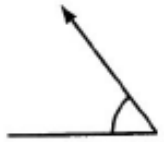
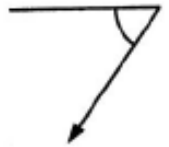
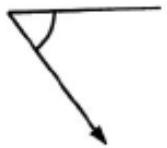
Resolution of a force into a force and couple

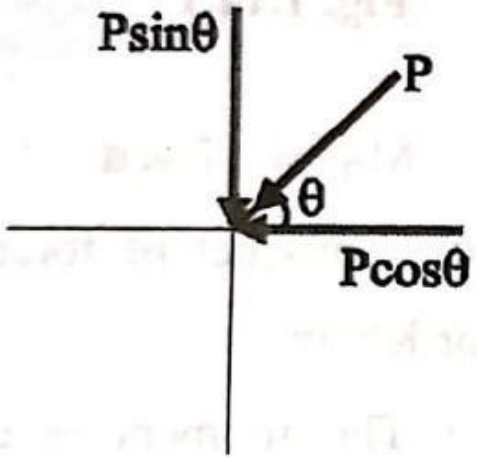


$$M = F \times d(\circlearrowleft)$$

Sign convention and symbolic representation of Resultant

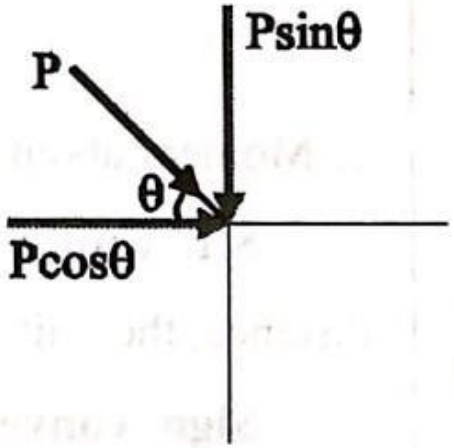


Quadrant	Symbol
I	
II	
III	
IV	



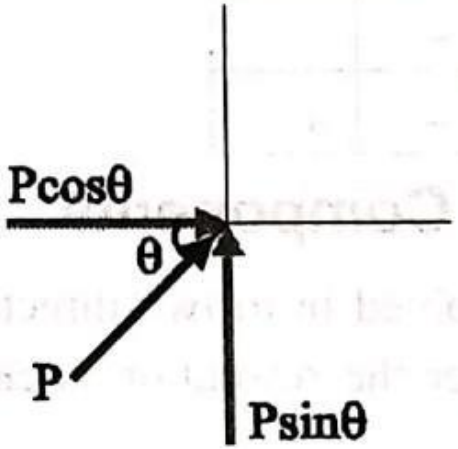
$P_x = -P\cos\theta$

$P_y = -P\sin\theta$



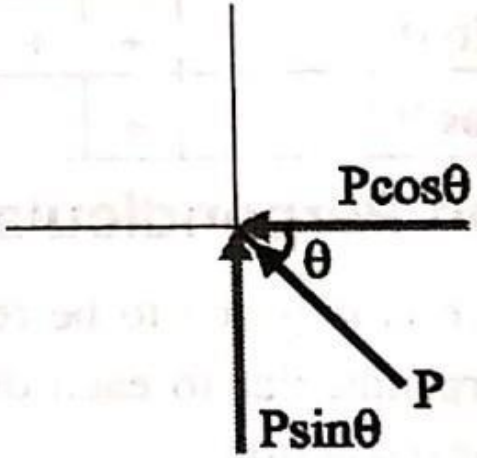
$P_x = P\cos\theta$

$P_y = -P\sin\theta$



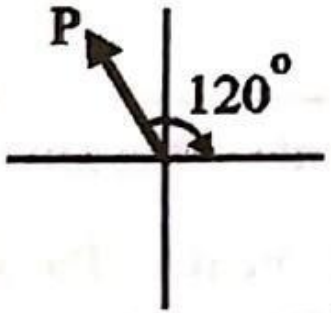
$P_x = P\cos\theta$

$P_y = P\sin\theta$



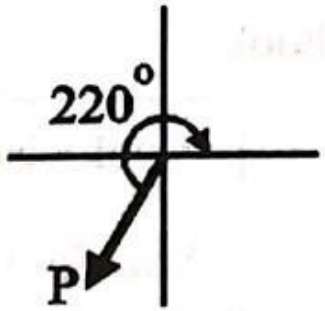
$P_x = -P\cos\theta$

$P_y = +P\sin\theta$



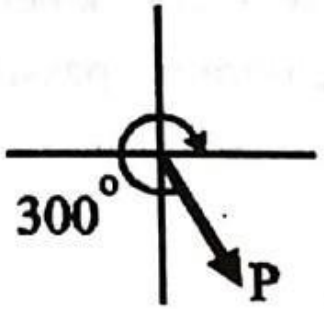
$P_x = +P\cos 120^\circ$

$P_y = +P\sin 120^\circ$



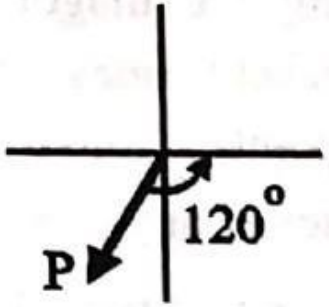
$P_x = +P\cos 220^\circ$

$P_y = +P\sin 220^\circ$



$P_x = +P\cos 300^\circ$

$P_y = +P\sin 300^\circ$

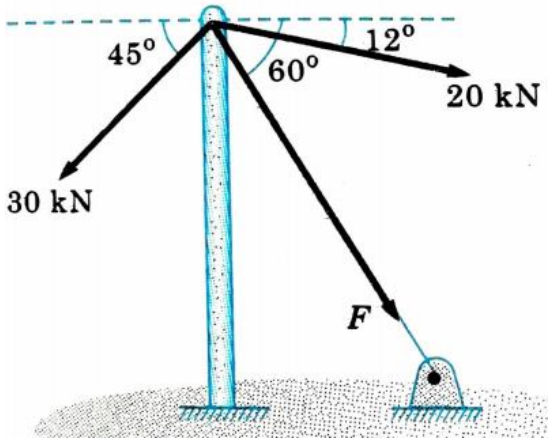


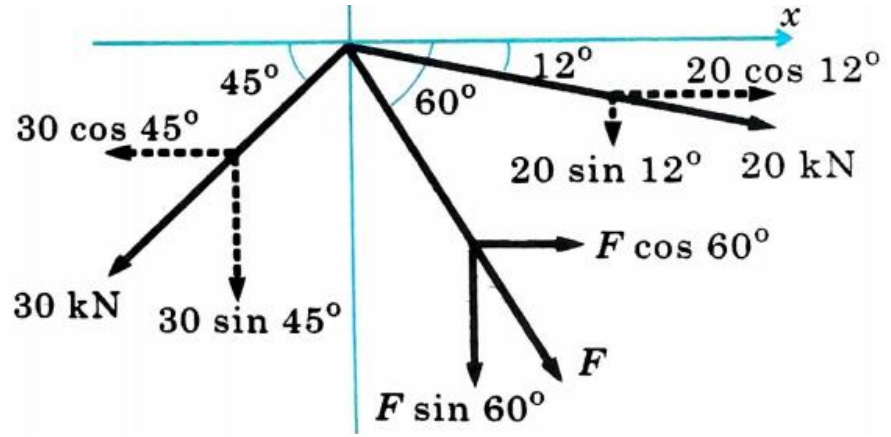
$P_x = +P\cos(-120^\circ)$

$P_y = +P\sin(-120^\circ)$

Resultant of coplanar concurrent force system

Problem 1 : For the force system shown in fig. determine the value of force F so that the resultant of the system is vertical. Also find the resultant.





$$\Sigma F_x = 20 \cos 12^\circ + F \cos 60^\circ - 30 \cos 45^\circ = 0$$

$$\therefore F = 3.3 \text{ kN}$$

$$R = \Sigma F_y = -30 \sin 45^\circ - F \sin 60^\circ - 20 \sin 12^\circ$$

$$= -30 \sin 45^\circ - 3.3 \sin 60^\circ - 20 \sin 12^\circ$$

$$= -28.23 \text{ kN} = 28.23 \text{ kN} (\downarrow)$$

Resultant of coplanar concurrent force system

Practise problem : Find the force F4 completely so that the resultant of the force system is as shown in fig.