

# Force Systems

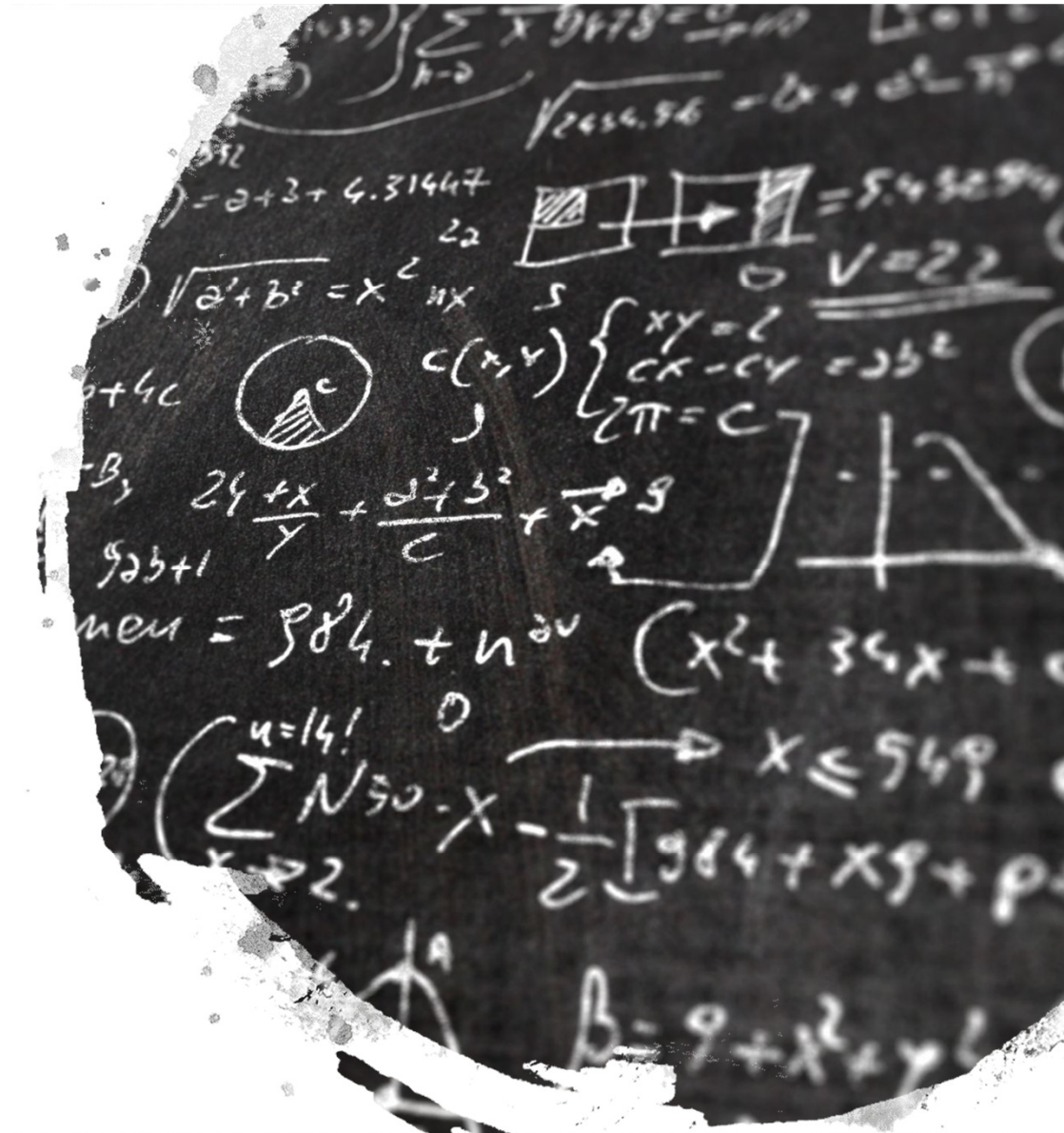
## (CAM ES1103)

AMIT KUMAR

- Syllabus:
- Vectors Algebra: basics of vector algebra, resultant vector, Application of vector equilibrium on structures.
- Force systems basic concepts, equilibrium of system of forces, free body diagrams, equations of equilibrium of coplanar systems, structures (trusses), analysis of structures, method of joints, method of section, friction, virtual work, work energy principle, impulse-momentum (linear, angular).
- Function of several variables, functions of one and several variables, partial differentiation, maxima-minima.
- Vector Differentiation: Vector functions and derivatives, Arc length and unit tangent vector, Curvature and unit normal vector, Directional derivative and gradient vectors, Tangent plane, Divergence and curl of a vector field
- Integral Calculus, area under curve, arc length, double integral, change of order and triple integrals, surface and volume integrals, solids of revolution, moment of inertia, floatation, buoyancy, centroid

# INTRODUCTION

- Definition of 'force' can be given in several ways. Most simply it can be defined as 'the cause of change in the state of motion of a particle or body'. It is of course, the product (multiplication) of mass of the particle and its acceleration.
- It is a vector quantity.



# CHARACTERISTICS OF A FORCE

A Force has following basic characteristics

i) Magnitude

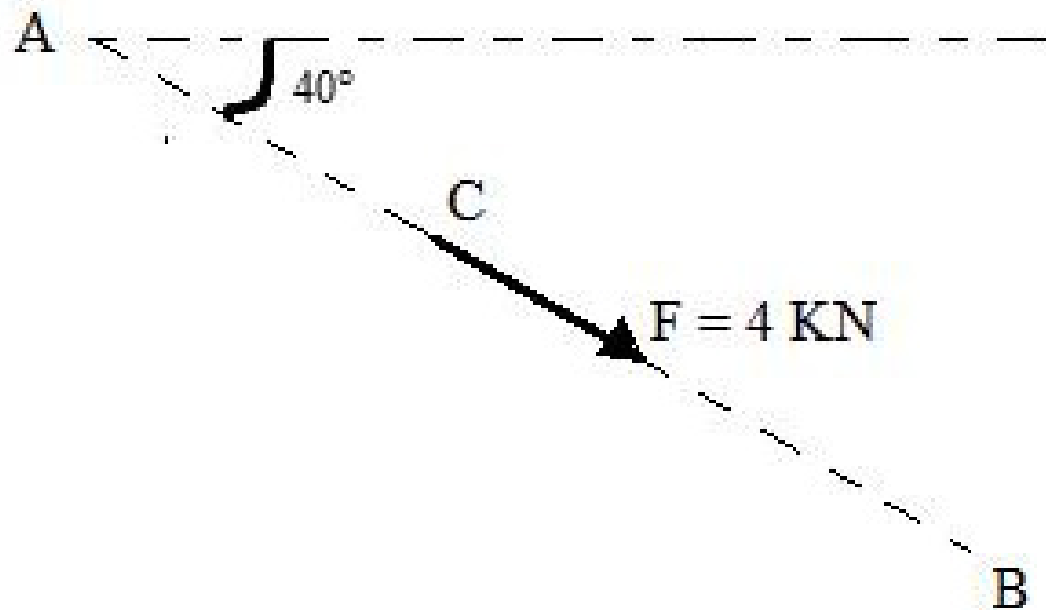
ii) Direction

iii) Point of application

iv) Line of action

Force is represented as a vector .i.e an arrow with its magnitude.

e.g. for the force shown in Figure, magnitude of force is 4KN, direction is  $40^\circ$  with the horizontal in fourth quadrant, point of application is C and line of action is AB.



# ***TYPES OF FORCES***

- *Contact Force*
- *Body Force*
- *Point Force*
- *Distributed Force*
- *External Force*
- *Internal Force*
- *Frictional Force*
- *Wind Force*
- *Hydrostatic Force*
- *Cohesive & Adhesive Force etc.*

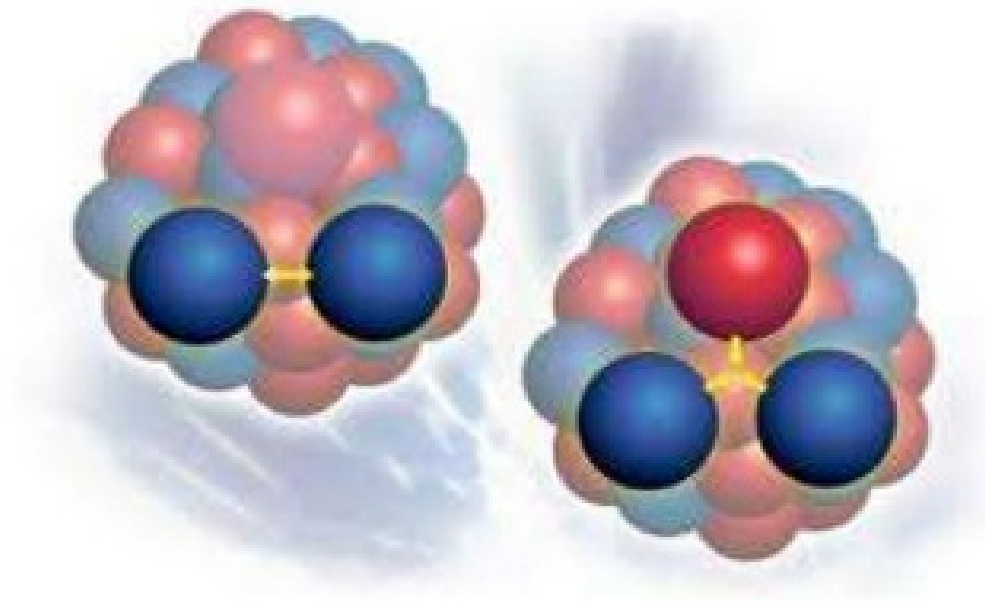
# CONTACT FORCES

- Force produced by direct contact of bodies is known as contact force.
- It may be of pull type or push type.



# **BODY FORCES**

- *Forces produced without contact of the bodies is called body force.*
- *It is the force holds together the particles forming the rigid bodies.*



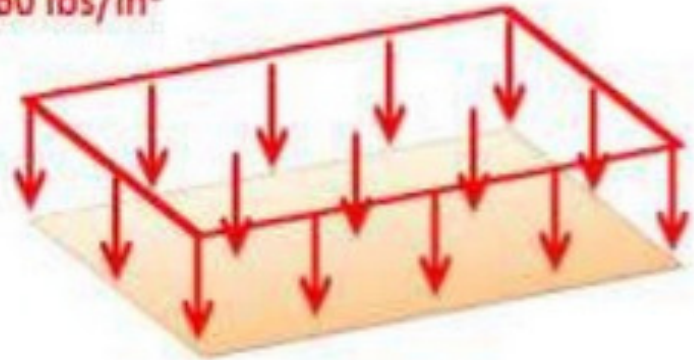


# ***DISTRIBUTED FORCE***

- *When force is distributed over large area it is called distributed force.*

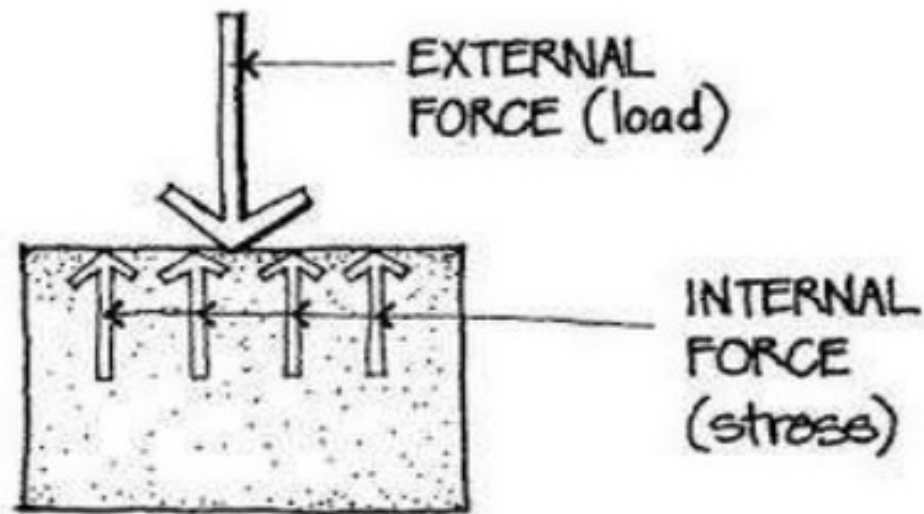


60 lbs/in<sup>2</sup>



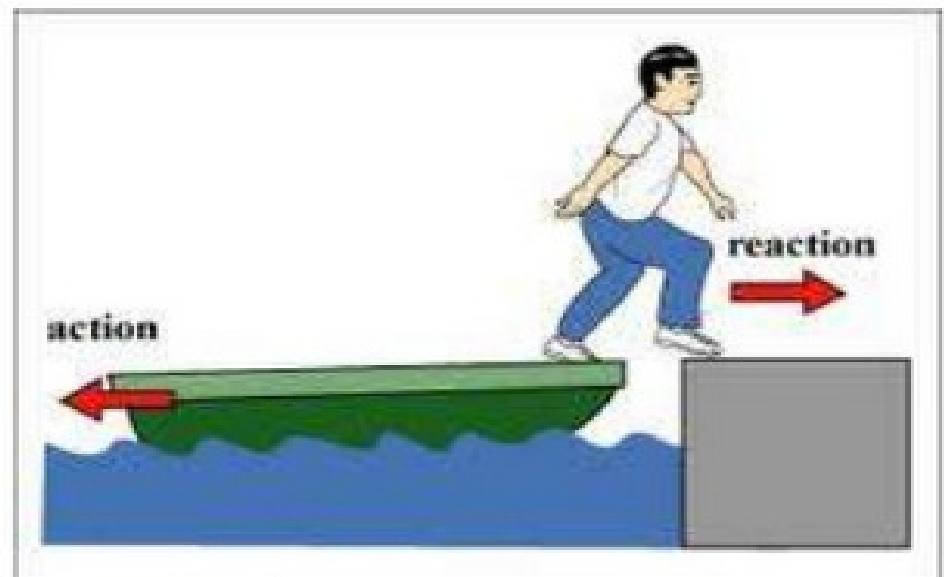
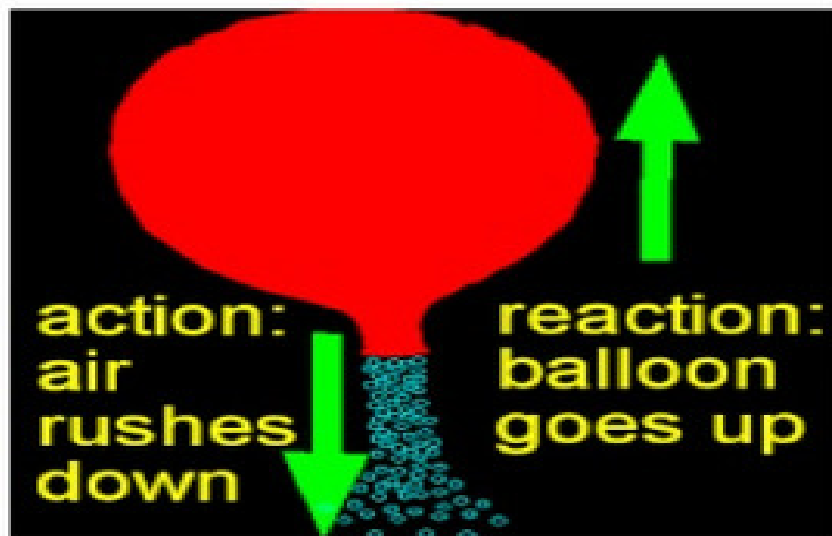
# EXTERNAL & INTERNAL FORCE

- *The force exerted by weight on a body is external force, while the resistance offered to retain its shape is called internal force.*



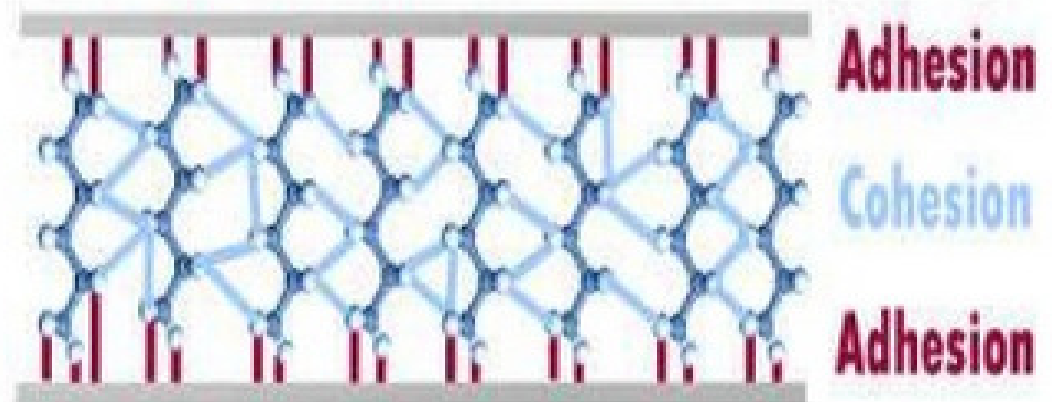
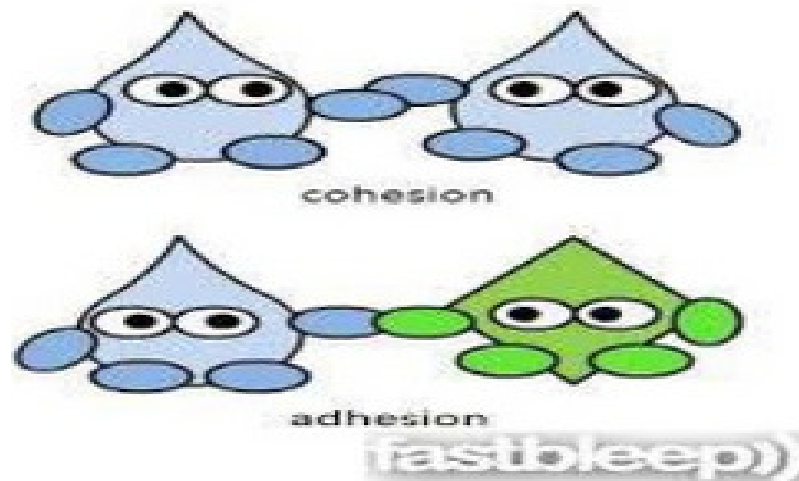
# ACTION & REACTION

- *As per Newton's third law, whenever a body exerts force (action) on other body. The other body exerts similar force on the former body known as reaction.*
- *Action= Reaction*



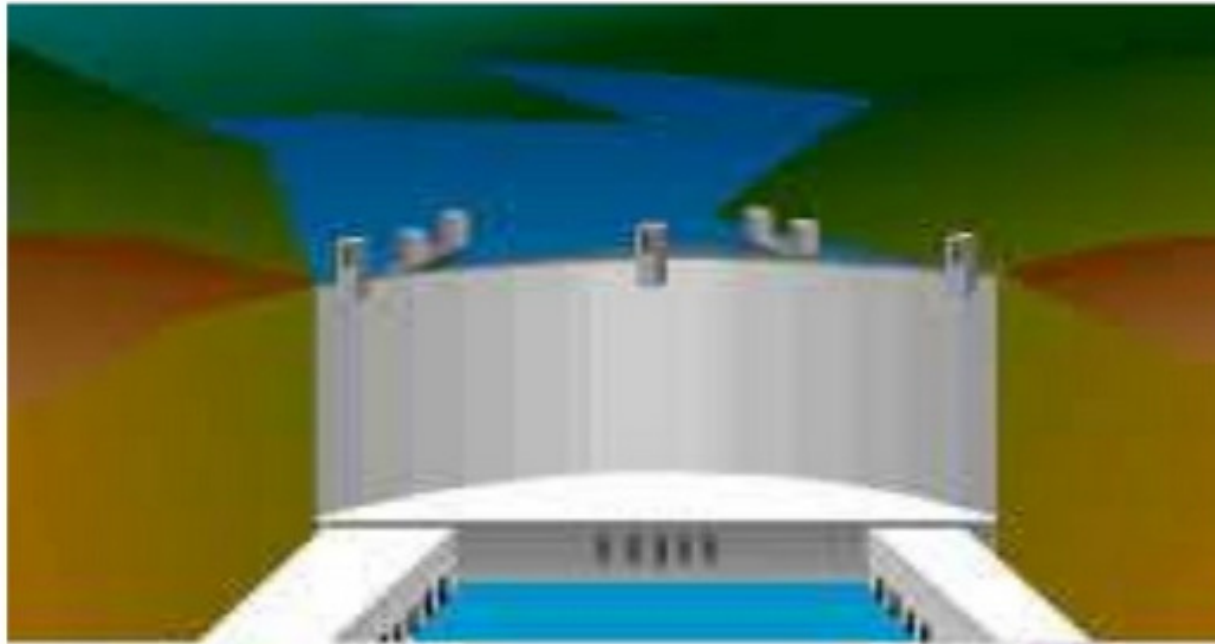
# COHESION & ADHESION

- Force developed between molecules of same material is called cohesive forces.
- Force developed between molecules of different materials is called adhesive force.

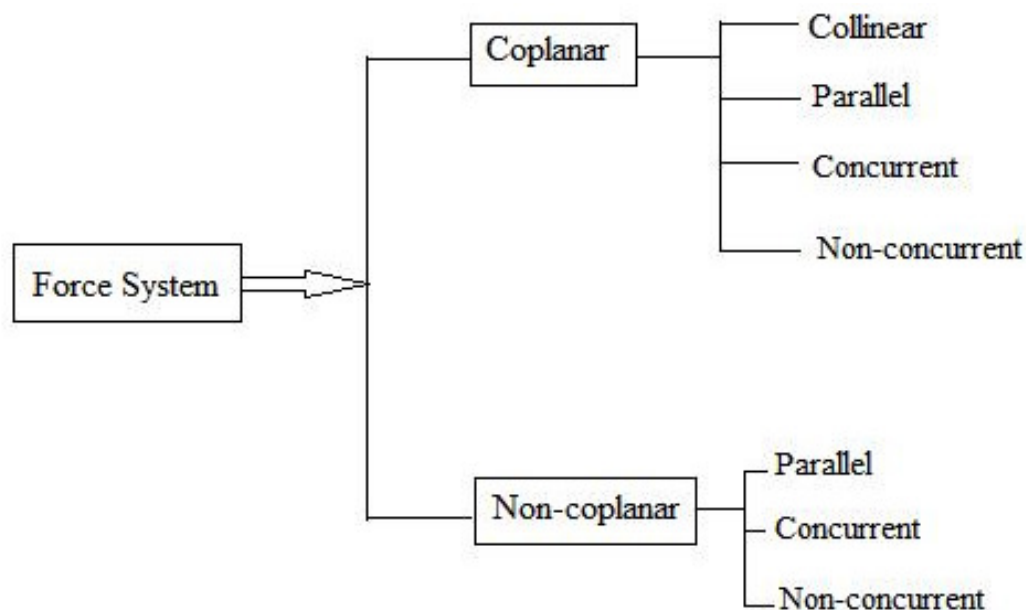


# HYDROSTATIC FORCE

- *Force exerted by water on a body when it is obstructed by a body.*



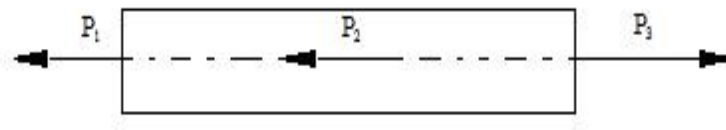
# SYSTEMS OF FORCES



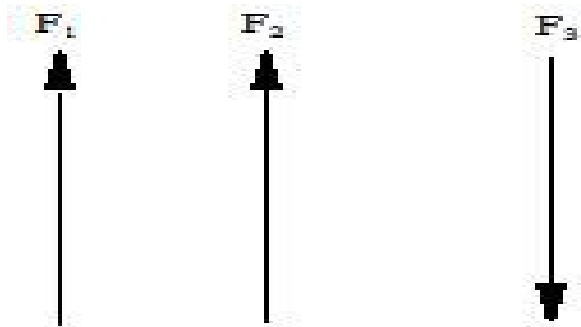
- When a mechanics problem or system has more than one force acting, it is known as a 'force system' or 'system of force'.

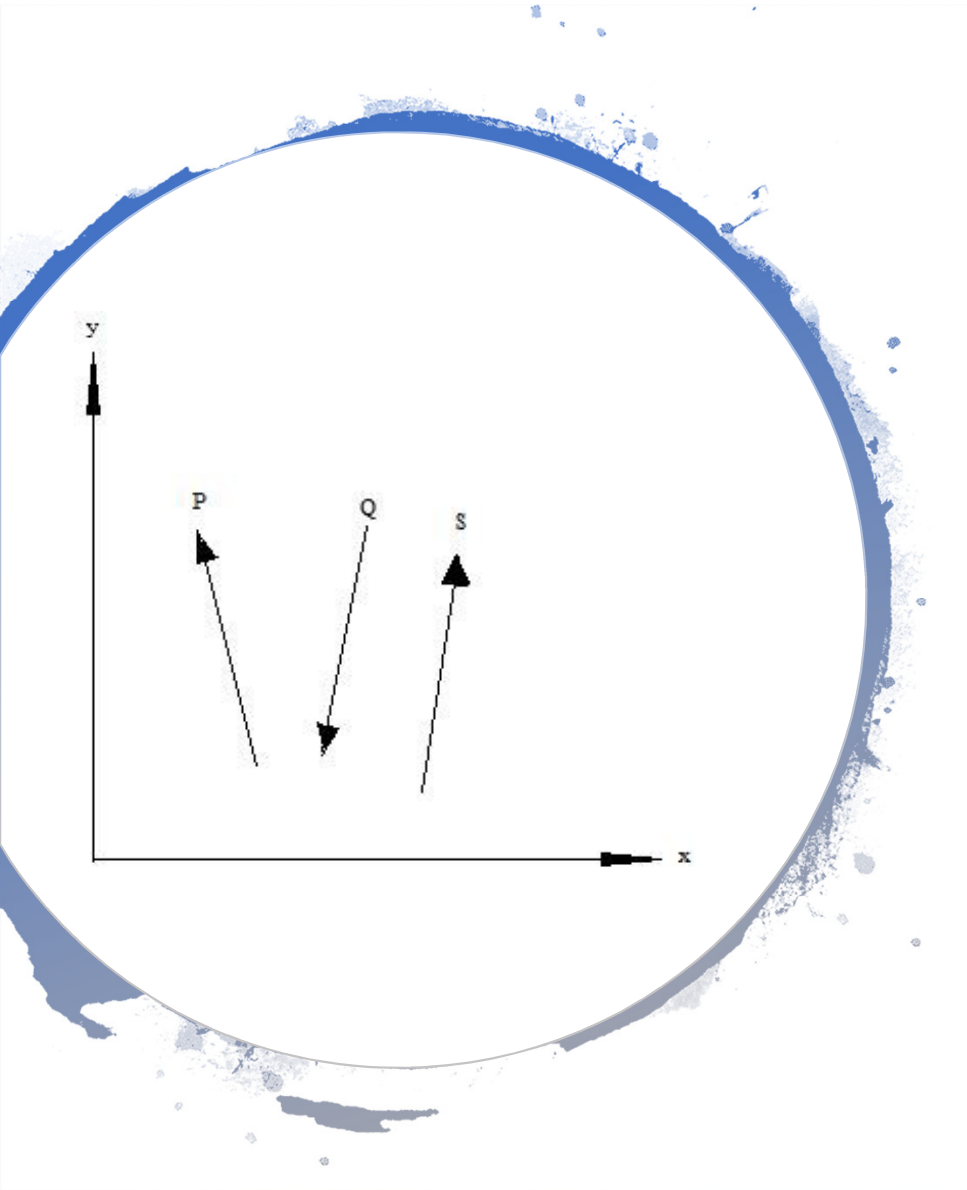
- **Collinear Force System**

When the lines of action of all the forces of a system act along the same line, this force system is called collinear force system.



- **Parallel Forces**





### **Coplanar Force System**

When the lines of action of a set of forces lie in a single plane is called coplanar force system.

- **Non-Coplanar Force System**

When the line of action of all the forces do not lie in one plane, is called Non-coplanar force system



## **Concurrent Force System**

The forces when extended pass through a single point and the point is called point of concurrency. The lines of actions of all forces meet at the point of concurrency. Concurrent forces may or may not be coplanar.

## **Non-concurrent Force System**

When the forces of a system do not meet at a common point of concurrency, this type of force system is called non-concurrent force system. Parallel forces are the example of this type of force system. Non-concurrent forces may be coplanar or non-coplanar.

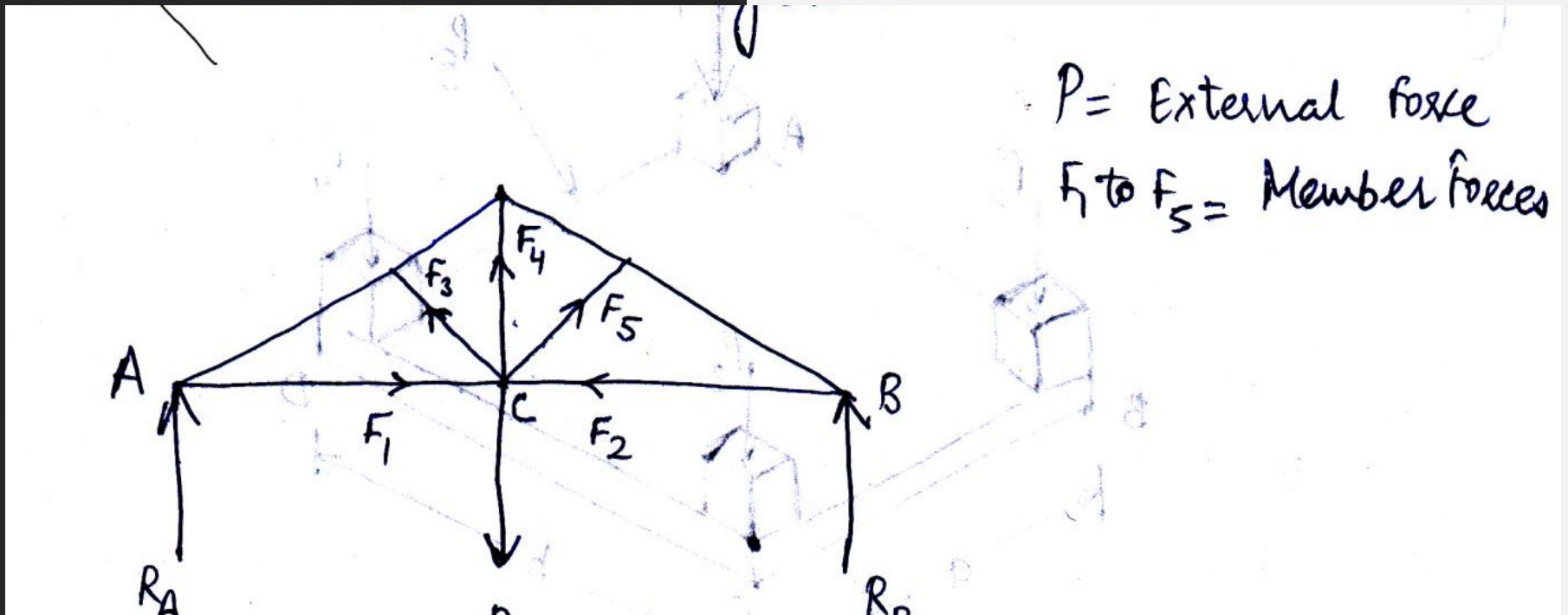
### Coplanar and concurrent force system

A force system in which all the forces lie in a single plane and meet at one point, For example, forces acting at a joint of a roof truss

$P$  = External force

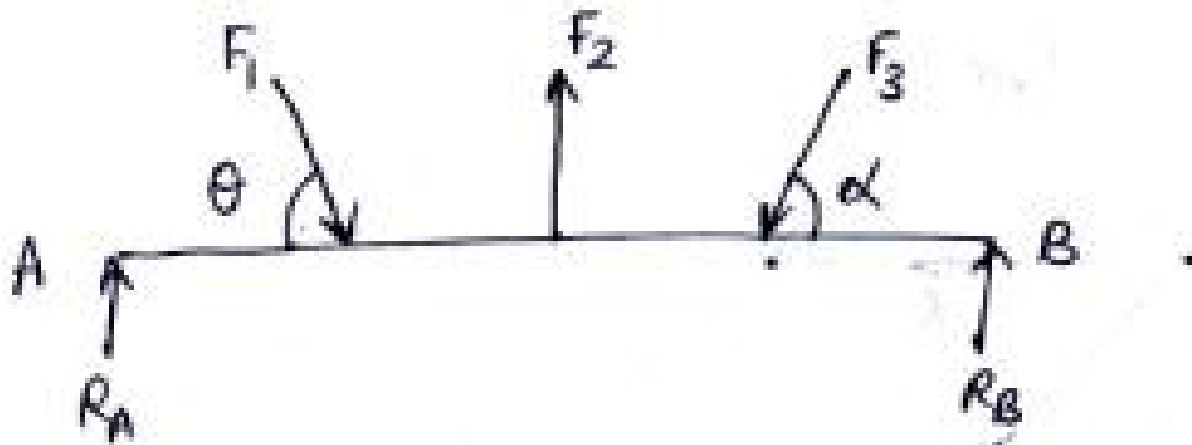
$F_1$  to  $F_5$  = Member forces (internal)  $R_A$  and  $R_B$  = Reactions

$C$  = Point of concurrency

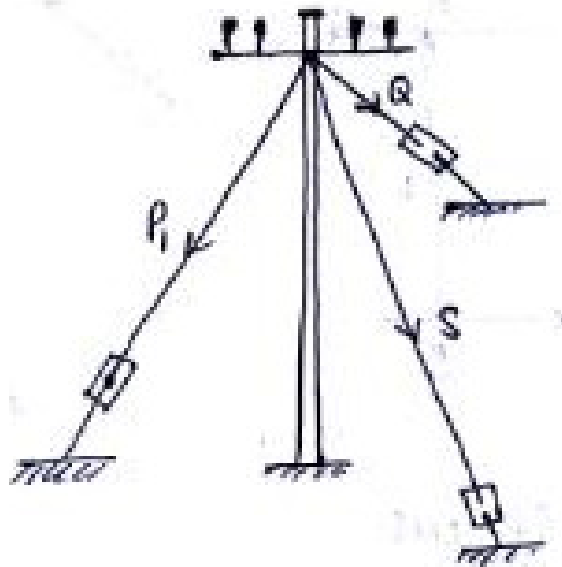


# Coplanar and non-concurrent force system

- These forces do not meet at a common point; however, they lie in a single plane, for example, forces acting on a beam as shown in Fig.



## Non-coplanar and concurrent force system



- In this system, the forces lie in a different plane but pass through a single point. Example is forces acting at the top end of an electrical pole.