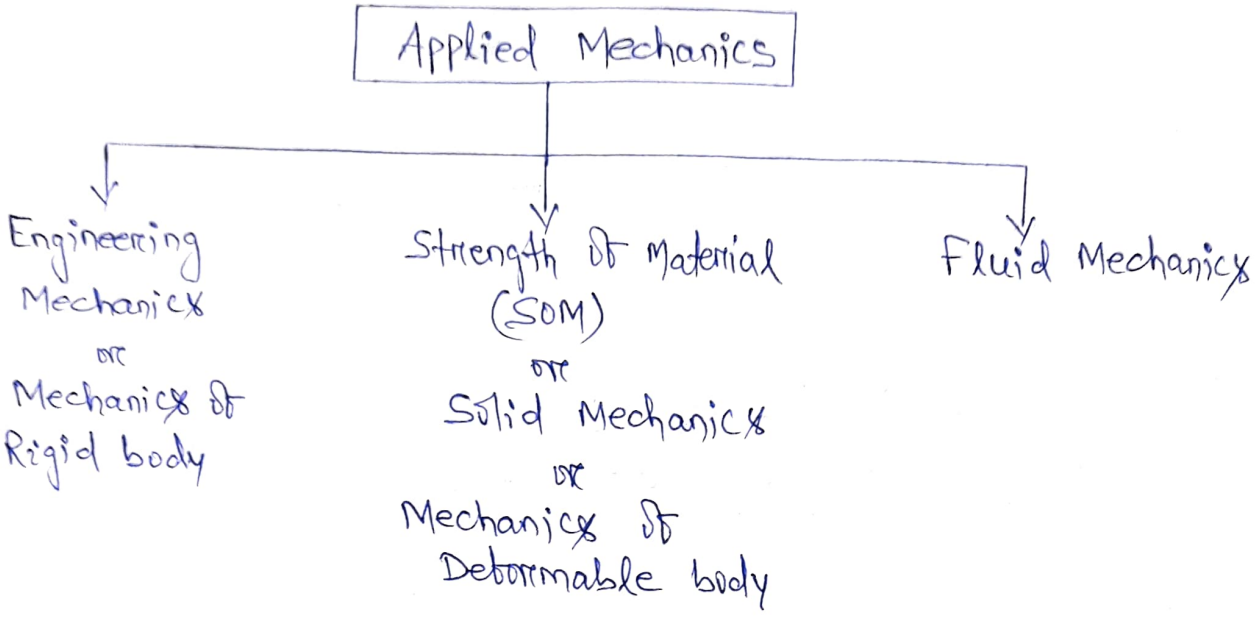
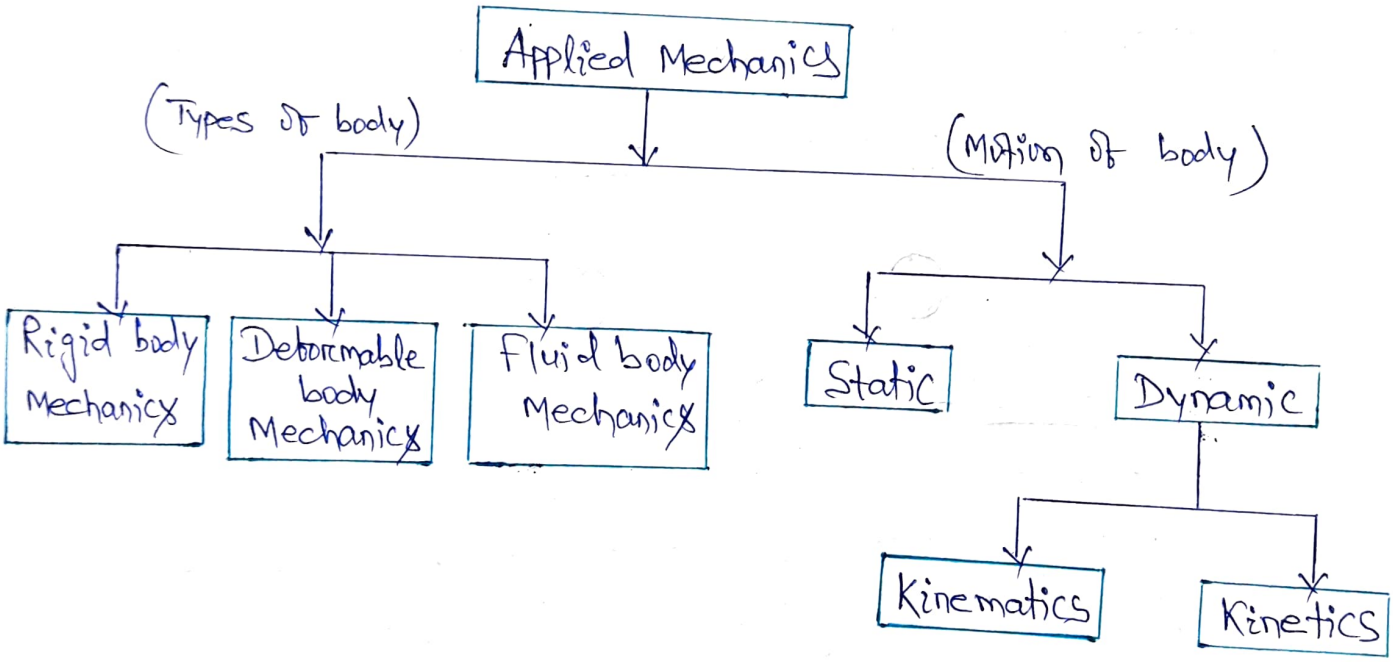
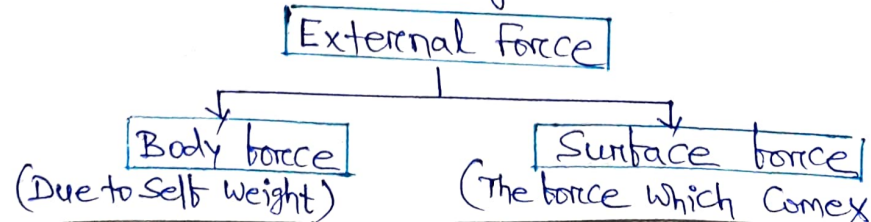
# Topic-01 [ Fundamentals of Engg. Mechanics ]




## Applied Mechanics :-

It is the branch of Science which deals with the study of forces (external & internal) and their effect over the bodies (rigid & deformable).



## Engineering Mechanics :-

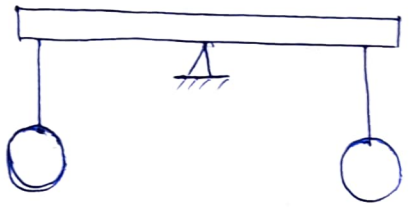
It is the branch of applied mechanics which deals with study of behaviour of the rigid body upon the application of external force system, such that the bodies assume to be rigid.

Note :-

⇒ Engineering Mechanics applies the Principle of Mechanics to design, taking into account the effects of forces.

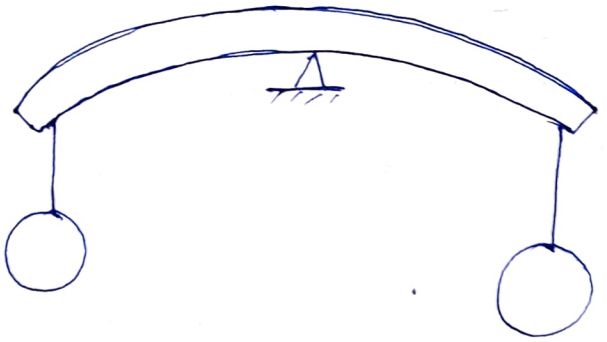
## Rigid body :-

A rigid body is one which does not change it's shape & size under the effect of force acting over it.



## Deformable body :-

A deformable body is one which undergoes deformation under the effect of forces acting on it and its return to it's original shape & size on removal of the forces acting on the body.



Note :-

⇒ The rigidity of a body depends upon the fact that how fare it undergoes deformation under effect of force.

## Statics :

Statics deals with the forces acting on a body under which the body is in rest.

## Dynamics :

Dynamics deals with the force acting on a body under which it is in motion.

## Kinematics :

Kinematics deals with the motion of the bodies in which the agents responsible for motion is not Considered.

## Kinetics :

Kinetics deals with the motion of the bodies in which the agents responsible for motion is considered. It deals with the relationship between force and the resulting motion of bodies on which they act.

## Force :

Force is something which changes or tends to change the state of rest or of uniform motion of a body in a straight line.

## Notes :

⇒ Force is the direct or indirect action of one body on another. It is a vector quantity.

⇒ There are different kinds of force such as

a) Gravitational
b) Frictional
c) Magnetic
d) Inertia [Caused by mass and acceleration]

## Characteristics of force :

The characteristics or elements of the force are the quantities by which a force is fully represented. There are

(i) Magnitude (i.e 500N, 1000N etc.)

(ii) Direction or Line of action (Angle relative to a coordinate system)

(iii) Sense or nature (Push or Pull)

(iv) Point of application

## Effects of Force :

When a force acts on a body, the effects produced in that body may be as follows.

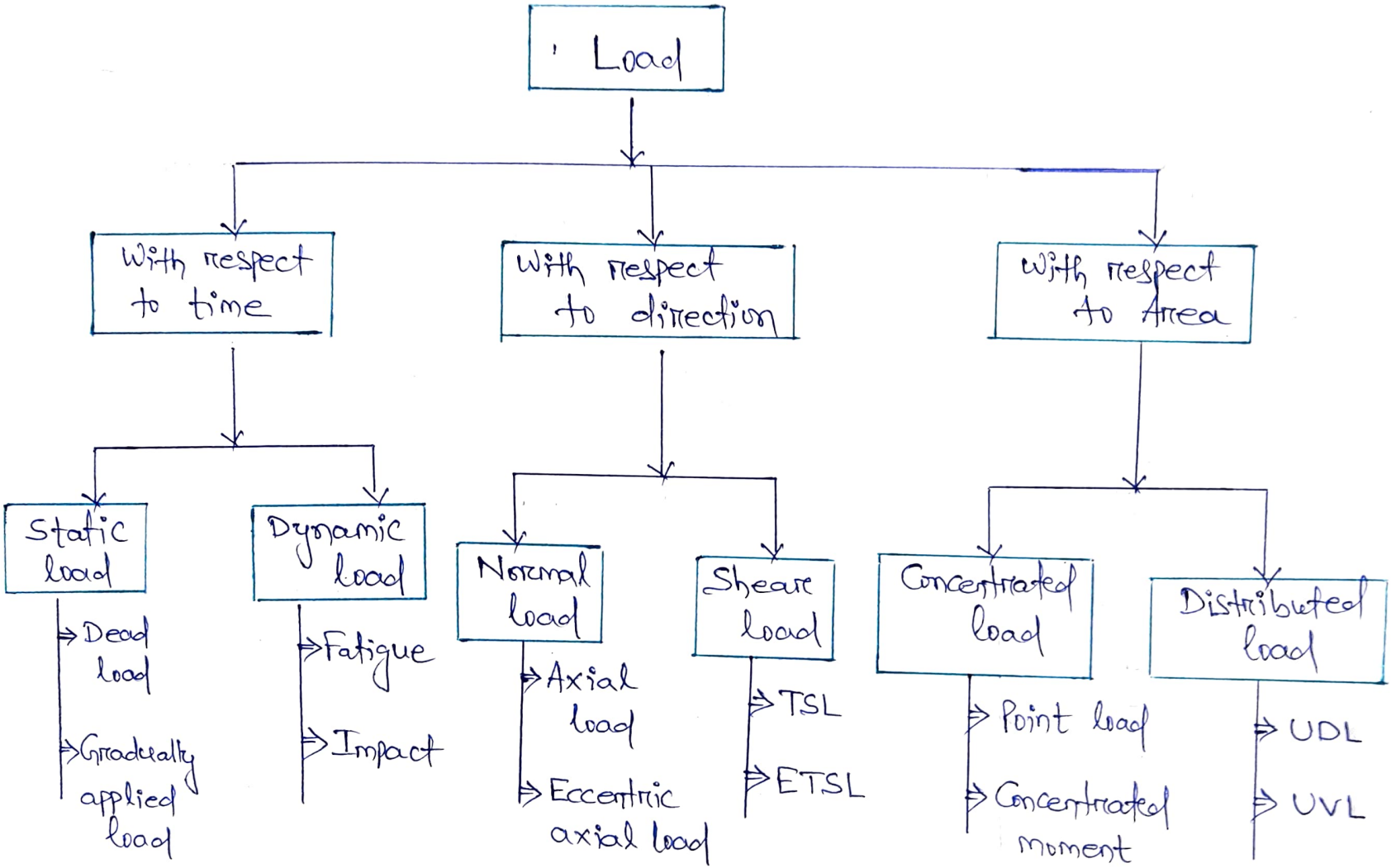
(i) It may bring a change in the motion of the body i.e the motion may be accelerated or retarded.

(ii) It may balance the force already acting on the body thus bringing the body to a state of rest or of equilibrium.

(iii) It may change the size or shape of the body i.e body may be twisted, bend, stretched, compressed or otherwise distorted by the action of force.

## Load :-

Load is any force or couple to which a member is subjected during it's functionality.




**Note**

TSL = Transverse Shear Load

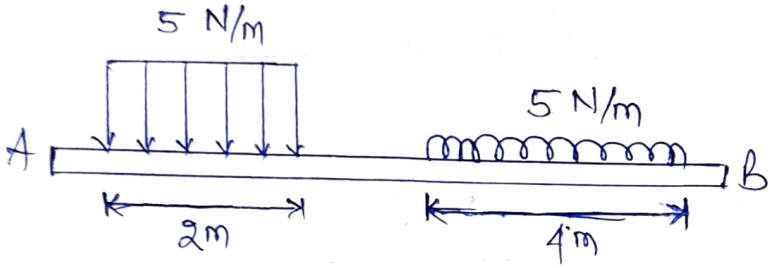
ETSL = Eccentric Transverse Shear Load

UDL = Uniform Distributed Load

UVL = Uniform Varying Load.

## ① Point Load ÷ (Concentrated Load)


## ② Uniform Distributed Load ÷

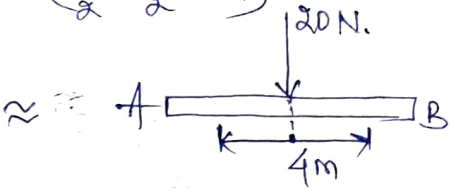



Note ÷ [Convert to Point load]

UDL = b × h = 4 × 5 = 20 N

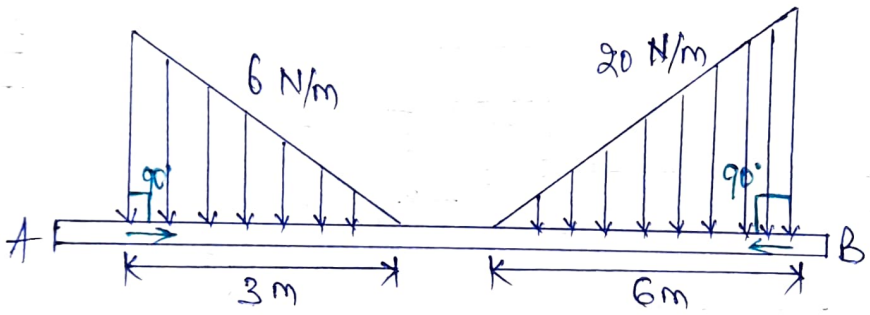
$\left(\frac{b}{2} = \frac{4}{2} = 2m\right)$

≈




## ③ Uniform Varing Load ÷

Note ÷ [Convert to point load]



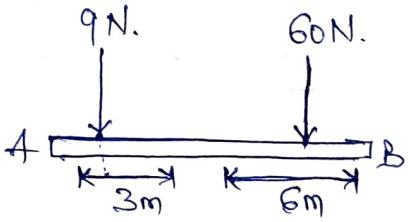

① UVL = $\frac{1}{2}$ b × h

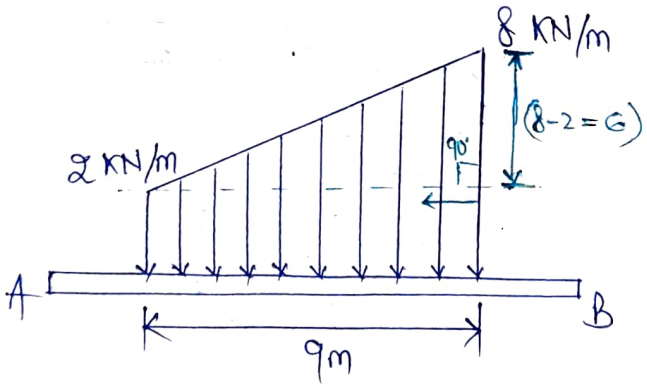
= $\frac{1}{2}$ × 3 × 6

= 9 N.

$\left(\frac{b}{3} = \frac{3}{3} = 1m\right)$

≈




② UVL = $\frac{1}{2}$ b × h

= $\frac{1}{2}$ × 6 × 20

= 60 N.

$\left(\frac{b}{3} = 6/3 = 2m\right)$

③ [UDL + UVL]

UDL = 18 KN. (at 4.5m)

UVL = $\frac{1}{2}$ b × h = $\frac{1}{2}$ × 9 × 6 = 27 KN. (at $\frac{9}{3}$ = 3m)

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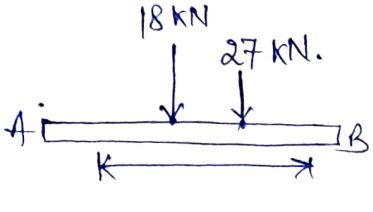
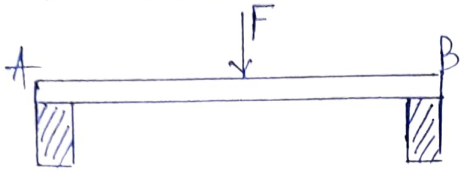
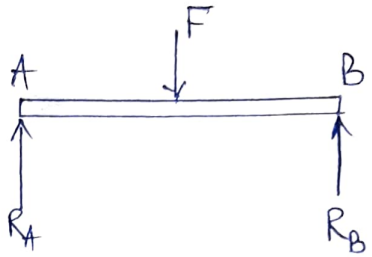


# Types of Supports :-

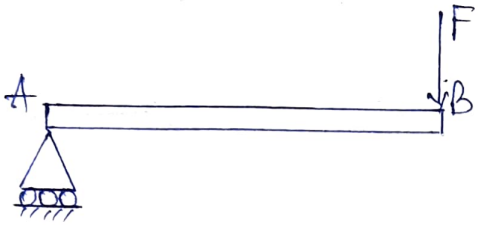
## ① Simple Support :-




FBD




## ② Roller Support :-

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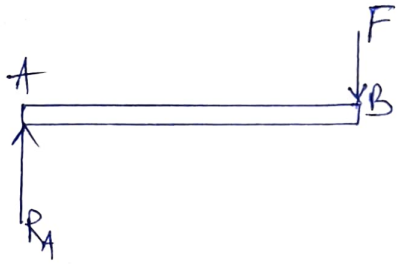
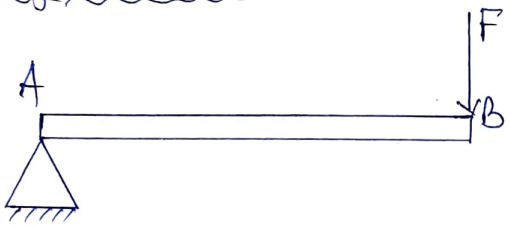



## ③ Hinge Support :-

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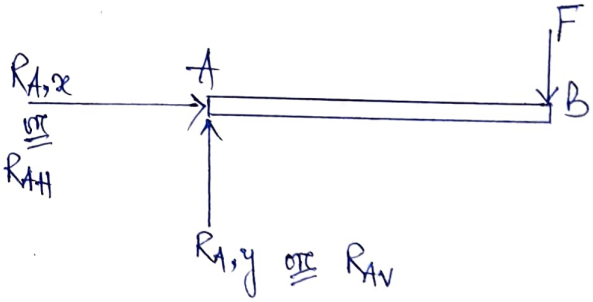
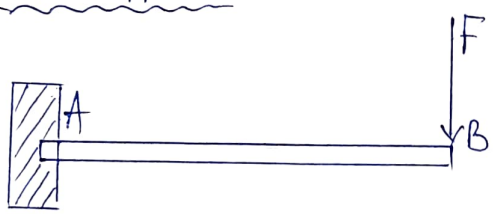



## ④ Fixed Support :-

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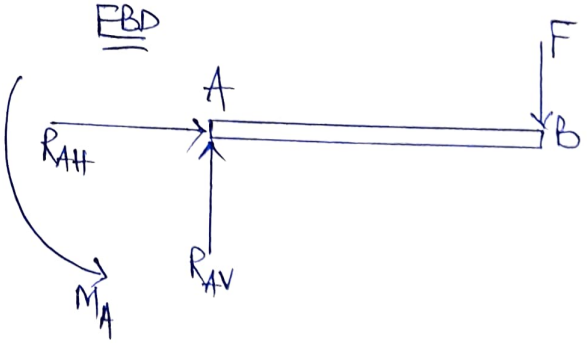


## Force System :-

⇒ A force system is a collection of force acting on a body in one or more planes.

⇒ According to relative position of the lines of action of the force, the force may be classified as follows.

① Coplanar force System

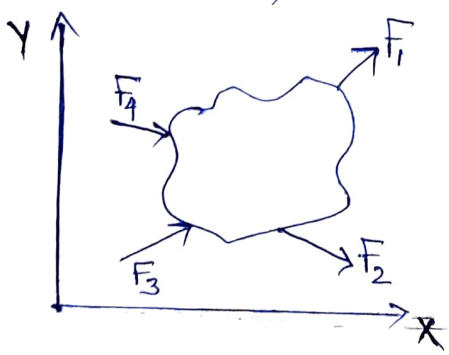
- a) Concurrent force System
- b) Parallel force System
- c) Non-Concurrent force System.

② Non-Coplanar force System.

- a) Concurrent force System.
- b) Parallel force System.
- c) Non-Concurrent force System.

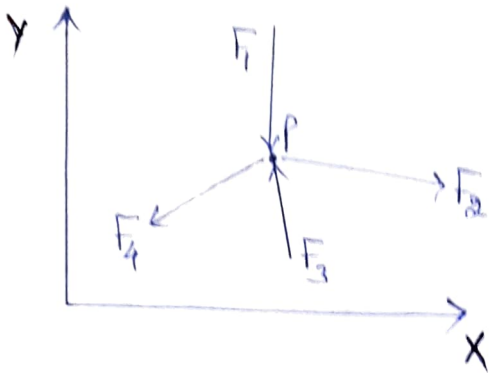
## Coplanar force system :-

Lines of action of the forces are lie on one plane (x-y plane).



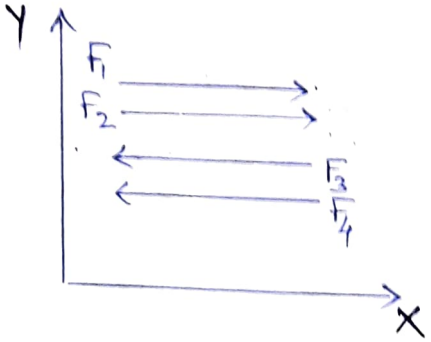

## Coplanar Concurrent force System :-

Lines of action of force are meeting at a common point.



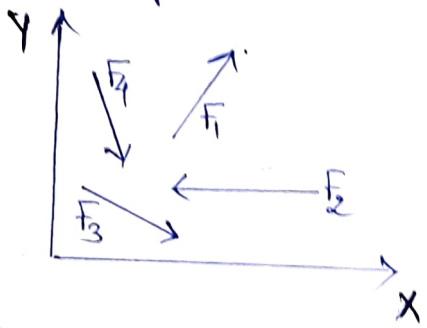

## Coplanar Parallel force System :-

Line action of forces are parallel to one another.

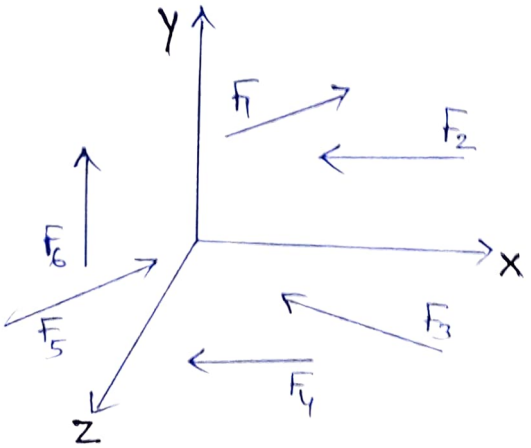



## Coplanar Non-Concurrent force System :-

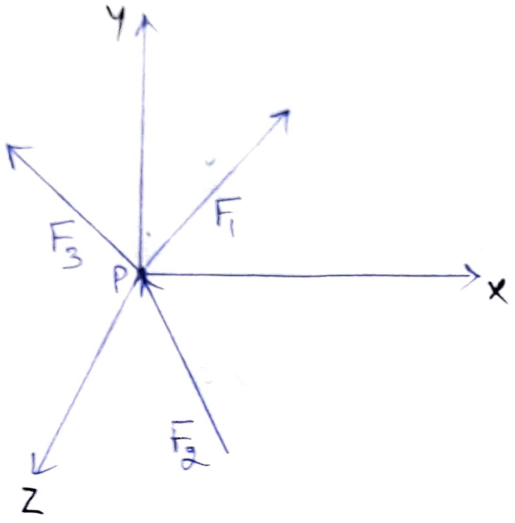
Line of action of forces are different & don't meet at common point.



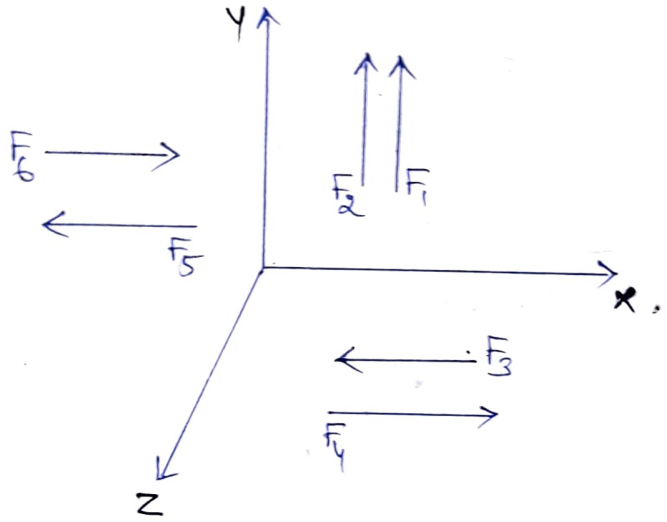

## Non-Coplanar force System :-



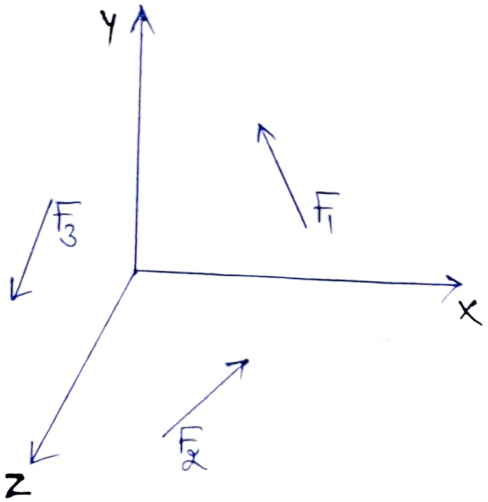
## Non-Coplanar Concurrent force System :-




## Non-Coplanar Parallel force System :-

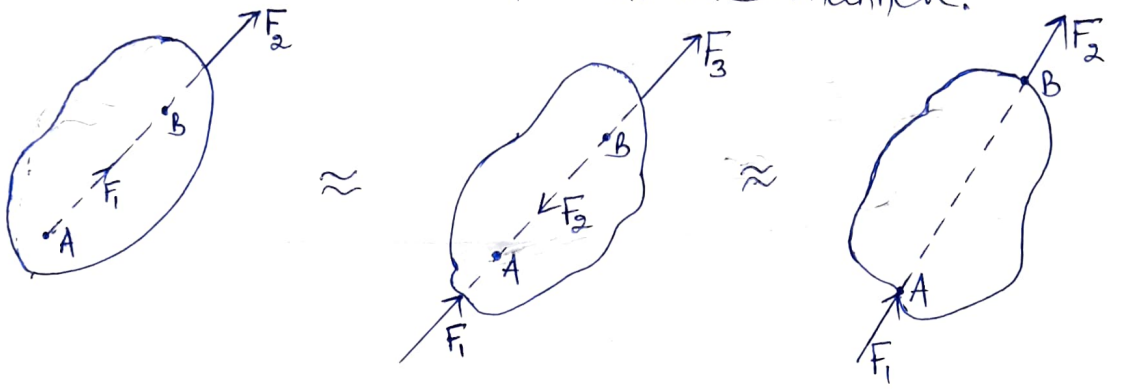



## Non-Coplanar Non-Concurrent force System :-



## Principle of Transmissibility :-

The Principle of transmissibility of force State that when a force acts upon a body, it's effects is same whatever point in it's line of action is taken as the point of application provided that the point is connected with the rest of the body in the same in variable manner.

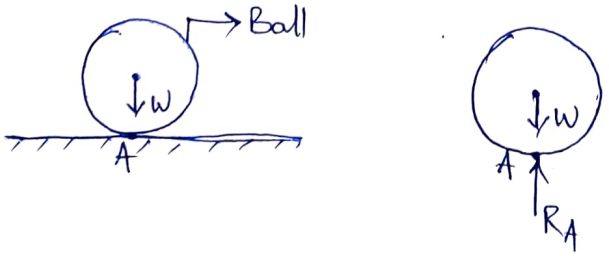



## Law of Superposition :-

The action of a given system of force on a rigid body will no way be changed if we add or Substract from them another System of force in equilibrium.

## Action & Reaction :-

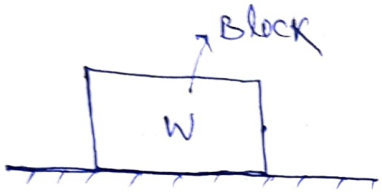
Whenever there are two bodies in Contact, each exert a force on other. Out of these force one is called action & other is called reaction. Action & reaction are equal & opposite.




[Self weight of the ball "W" is action and upward force exerted on the ball from the Surface "$R_A$" is reaction]

# Free Body Diagram (FBD) :-

Free body diagram is necessary to investigate the condition of equilibrium of a body or system. While drawing the FBD all supports of the body are removed and replaced with the reaction force acting on it.

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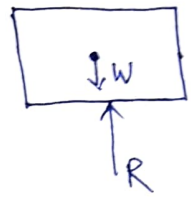


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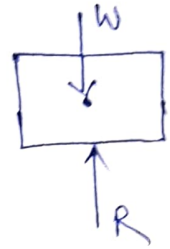


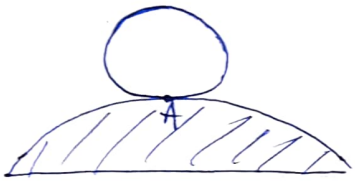


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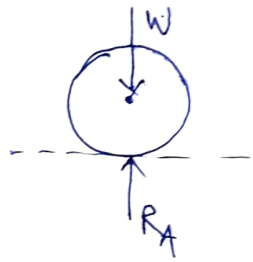


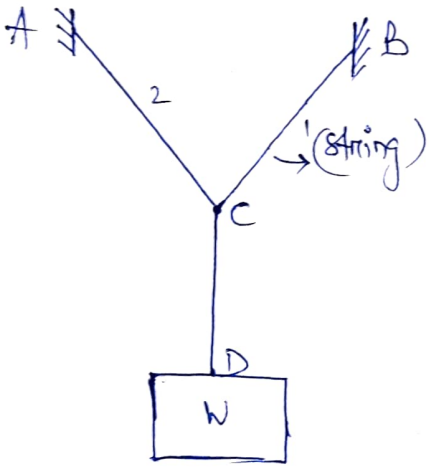


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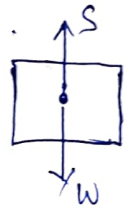


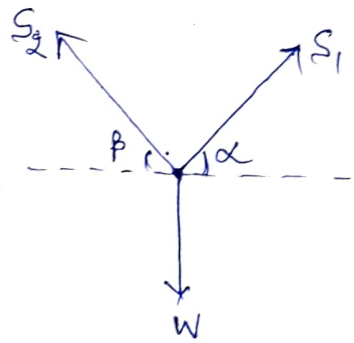


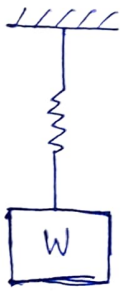


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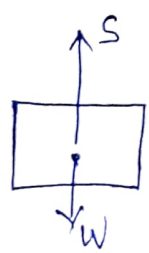

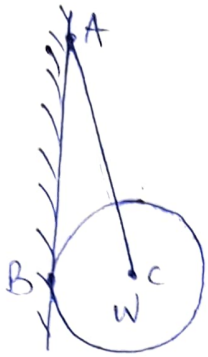


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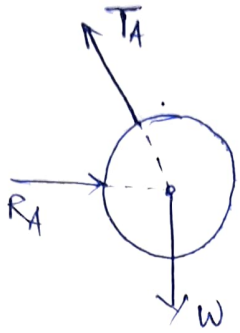
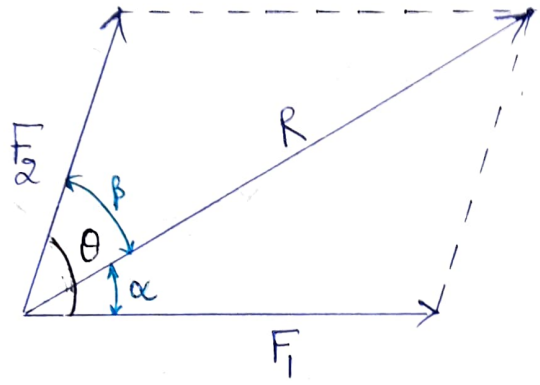


## Parallelogram Law of Force :-

If two no of forces acting on a body are represented by two adjacent sides of a parallelogram then the diagonal represence the resultant force in both direction & Magnitude.




$$\theta = \alpha + \beta$$

$$\text{Resultant}(R) = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

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

$$\Rightarrow \alpha = \tan^{-1}\left(\frac{F_2\sin\theta}{F_1 + F_2\cos\theta}\right)$$

$$\tan\beta = \frac{F_1\sin\theta}{F_2 + F_1\cos\theta}$$

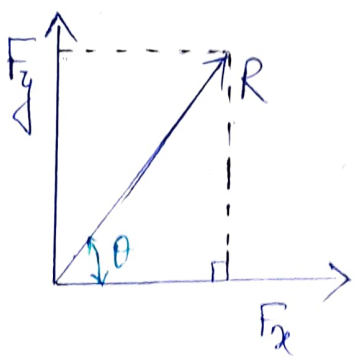
**Note :-**

① $\text{Resultant}(R) = \sqrt{F_x^2 + F_y^2}$

② $\tan\theta = \frac{F_y}{F_x}$

$$\cos\theta = \frac{F_x}{R}$$

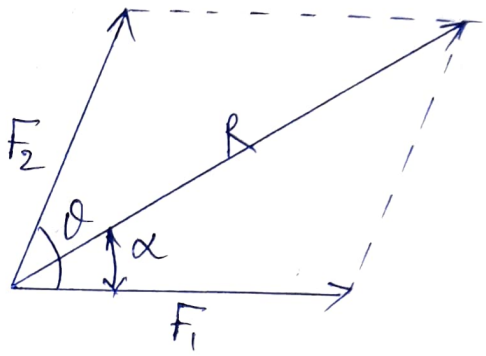
$$\sin\theta = \frac{F_y}{R}$$



Question :

Calculate the resultant of two forces having Magnitude 600 N & 400 N and acting at 60° to one another. Find out the resultant force & direction, when two forces have a) Same Sense b) Opposite Sense.

Ans a) Same Sense :




$F_1 = 600\ N$

$F_2 = 400\ N$

$\theta = 60°$

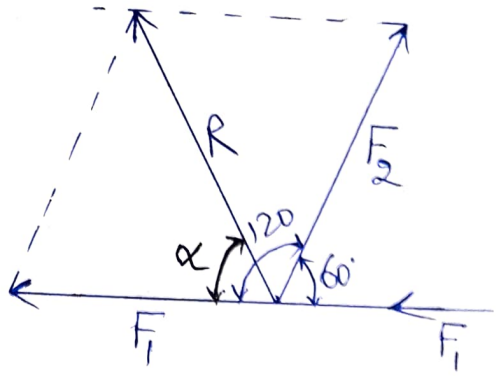
$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

$$= \sqrt{600^2 + 400^2 + 2\times600\times400\cos60} = 871.779\ N$$

$$\alpha = \tan^{-1}\left(\frac{F_2\sin\theta}{F_1 + F_2\cos\theta}\right) = \tan^{-1}\left(\frac{400\sin60}{600 + 400\cos60}\right)$$

$$= 23.413°$$

b) Opposite Sense :




$F_1 = 600\ N.$

$F_2 = 400\ N$

$\theta = 120°$

$$R = \sqrt{600^2 + 400^2 + 2\times600\times400\times\cos120}$$

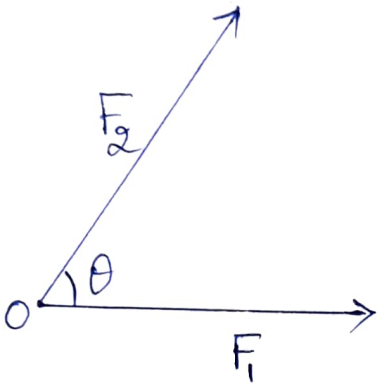
$$= 529.15\ N$$

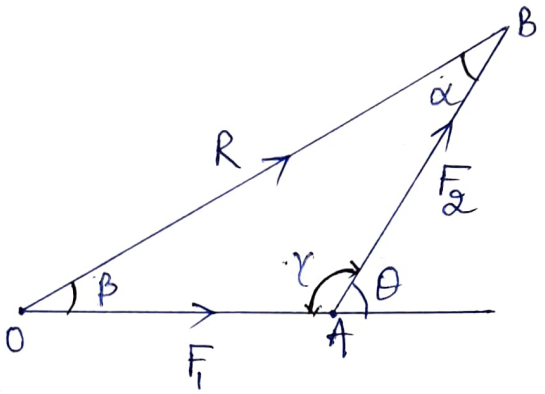
$$\alpha = \tan^{-1}\left(\frac{400\sin120}{600 + 400\cos120}\right)$$

$$= 40.89°$$

## Triangle Law of Forces :

The triangle law of forces states that "If two forces are acting as the adjacent sides of a triangle taken in order then the closing sides of a triangle represents the resultant in opposite direction.




$F_1 \propto \sin\alpha \Rightarrow F_1 = K\sin\alpha \Rightarrow \frac{F_1}{\sin\alpha} = K$

$F_2 \propto \sin\beta \Rightarrow F_2 = K\sin\beta \Rightarrow \frac{F_2}{\sin\beta} = K$

$R \propto \sin\gamma \Rightarrow R = K\sin\gamma \Rightarrow \frac{R}{\sin\gamma} = K$

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{R}{\sin\gamma}$$ → Sine Rule.