# ENGG. MECHANICS

# $1^{ST}$ & 2nd SEM

## All Branch

## Under SCTE&VT,Odisha

## PREPARED BY


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# Mechanics :-

Engineering mechanics is the branch of science which deals with the laws and principles of mechanics, alongwith their applications to engineering problems.

* It is classified into following two types.

(I) static
(II) Dynamic

## (I) Statics :-

It is the branch of Engineering mechanics, which deals with the forces and their effects while acting upon a bodies at rest.

## (II) Dynamics :-

It is the branch of engg. mechanics which deals with the forces and their effects, while acting upon a bodies in motion.

# It is of two types;

(a) Kinetics
(b) Kinematics

## (a) Kinetics :-

It is the branch of dynamics, which deals with the bodies in motion due to the application of forces.

(b) Kinematics :-

It is the branch of Dynamics which deals with the bodies in motion, without any reference to the forces which are responsible for motion.

Rigid body :-

Rigid body is a solid body in which deformation is zero or negligible.

Force :-

Force is defined as an external agent which produces or tends to produce, destroy or tends to destroy the motion of a body.

Effects of a force :-

-> It may change the motion of a body.
-> It may retard the motion of a body.
-> It balance the forces already acting on a body.
-> It may give rise to the internal stresses in the body.

Characteristics of Force :-

-> Magnitude of forces
-> The direction of the line, along which the force acts. (It is also known as line of action)

→ Nature of the force (i.e Push or Pull)

→ The point at which (

## Units of force :-

In M.K.S system = Kilogram - Force (kgf)

In S.I System = Newton (N)

In C.G.S system = Dyne

$1N = 10^5 dyn$ ⇒ $1 dyn = 10^{-5} N$

## System of forces :-

When two or more forces act on a body, they are called to form a system of forces.

1. **Coplaner forces :-**

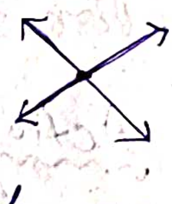
The forces, whose line of action lie on the same plane, are known as coplaner forces.

2. **Colinear Forces :-**

The forces, whose lines of action lie on the same line, are known as colinear forces.

(3) **Curcurrent forces :-**

The forces, which meet at one point are known as curcurrent forces.



(4) **Coplanner concurrent forces :-**

The forces which meet at one point and their line of action also lie on the same plane.

(5) coplaner non concurrent :-

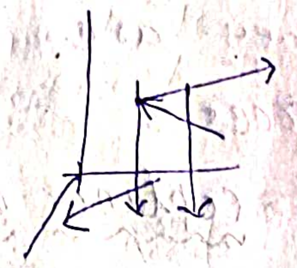
The forces which don't meet at one point, but their lines of action also lie on the same plane.

(6) Non coplaner concurrent forces :-

The forces, which meet at one point but their lines of action don't lie on the same plane.

(7) Non- coplaner non- concurrent forces :-

The forces, which don't meet at one Point and their lines of action don't lie on the same plane.



Principle of superposition :-

The principle of super position of forces ~~states~~ states that the combained effect of a force system acting on a particle or a rigid body is the sum of the ~~effects~~ effects of individual forces.


Freebody Diagram :- (FBD)

Freebody diagram is a sketch of an object of interest with all the surrounding objects stripped away and all of these forces acting on the body shown.

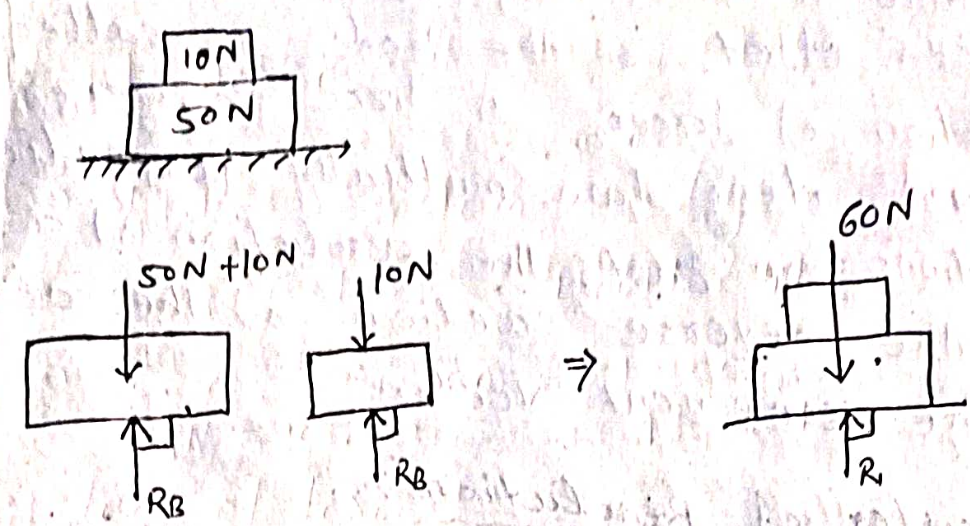
Action and Reaction of forces :-

An action force is a force that is applied to an object

-> A reaction force is a consequence of an action force which is opposite in direction

# Example of FBD :-

(1)

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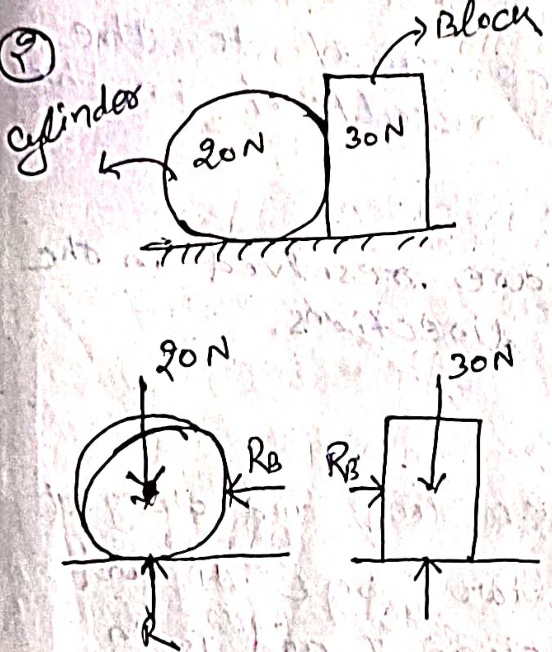
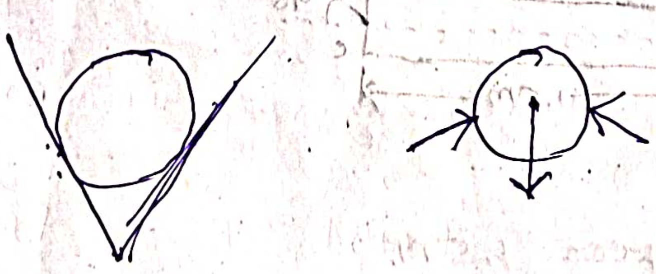



(3)


(4)



## Resolution of forces:

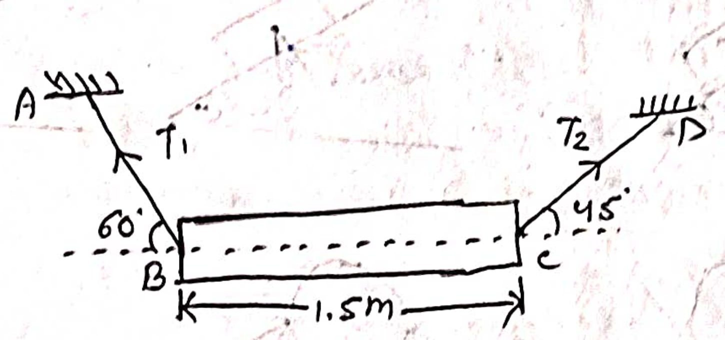
The process of spliting up the given force into a no. of components, without changing it's effect on the body is called Resolution of forces. A force is generally resolved along two mutually perpendicular directions. In fact, the resolution of a force is the reverse action of the addition of the component vectors.

## Principles of Resolution:

It states that, "The algebraic sum of the resolved parts of a no. of forces in a given direction, is equal to the resolved part of their resultant in the same direction.

* In general, the forces are resolved in the vertical and horizontal directions.

Q. A machine component 1.5m long and weight 1000N is supported by two rope AB and CD. Calculate the tensions $T_1$ and $T_2$ in the ropes AB and CD.



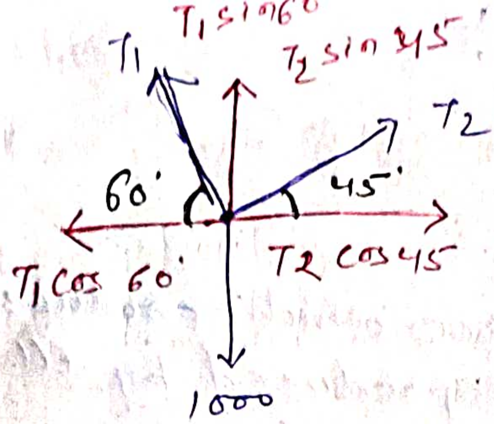

Sol?

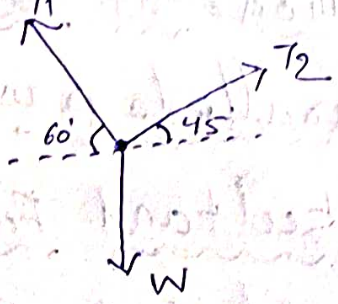
Given data,

length = ~~1000~~ 1.5m.

weight = 1000 N

$T_1 = ?$ , $T_2 = ?$




(F.B.D)

Resolving the forces horizontally, and equating the same,

$$T_1 \cos 60° = T_2 \cos 45°$$

$$\Rightarrow T_1 = T_2 \times \frac{\cos 45°}{\cos 60°} = T_2 \times \frac{0.707}{0.5}$$

$$\Rightarrow T_1 = 1.414\, T_2 \quad \text{— (1)}$$

Now, Resolving the forces vertically,

$$T_1 \sin 60° + T_2 \cos 45° = 1000$$

$$\Rightarrow 1.414\, T_2 \sin 60° + T_2 \cos 45° = 1000$$

(From eqn (1) we get $T_1$)

$$\Rightarrow (1.414 \times 0.866)\, T_2 + (0.707)\, T_2 = 1000$$

$$\Rightarrow 1.224\, T_2 + 0.707\, T_2 = 1000$$

$$\Rightarrow T_2 (1.224 + 0.707) = 1000$$

$$\Rightarrow \cancel{T_2} \Rightarrow T_2 \times 1.93 = 1000$$

$$\Rightarrow T_2 = \frac{1000}{1.93} = 518.1\, N$$

From eqn (1)

$$T_1 = 1.414\, T_2$$

$$= 1.414 \times 518.1$$

$$T_1 = 732.6\, N$$

(Ans)

## Method of Resolution :

## Parallelogram law :-

### Resultant Force :-

It is a single force which produces the same effect as produced by all the given forces acting on a body.

→ The resultant force may be determined by the following three laws of forces

(I) Parallelogram law

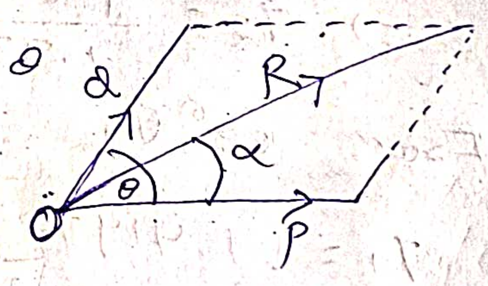
(II) Triangle law

(III) Polygon law

### (I) Parallelogram law :-

It states that, If two forces acting simultaneously on a particle, be represented in magnitude and direction by the two adjacent sides of a parallelogram, then their resultant may be represented in magnitude and direction by the diagonal of a parallelogram which passes through their point of intersection.

Let us consider two forces 'P' and 'Q' acting at angle $\theta$ at point 'O'.




The resultant is given by

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

If the resultant (R) makes an angle $\alpha$ with the force P, then.

$$\boxed{\tan\alpha = \frac{Q\sin\theta}{P+Q\cos\theta}}$$

where, P, Q = Forces whose resultant is required to be found out.

$\theta$ = Angle betn P and Q

$\alpha$ = Angle which the resultant Force makes with one of the forces.

<u>Note</u>:-

1. If $\theta = 0^\circ$ i.e when the forces act along the same line.

~~R = P+F~~

$$\boxed{R = P+Q} \quad (\because \cos 0^\circ = 1)$$

2. If $\theta = 90^\circ$ i.e when the forces at at right angle.

$$R = \sqrt{P^2+Q^2} \quad (\because \cos 90^\circ = 0)$$

3. If $\theta = 180^\circ$ i.e whe the forces act along the same straight line but in opposite direction.

$(\because \cos 180^\circ = -1)$

4. If the two forces are equal i.e $P = Q = $ Force

then, $R = \sqrt{F^2+F^2+2F^2\cos\theta}$

$$R = \sqrt{2F^2(1+\cos\theta)}$$

$$= \sqrt{2F^2 \times 2\cos^2\left(\frac{\theta}{2}\right)} \quad \left[\because 1+\cos\theta = 2\cos^2\left(\frac{\theta}{2}\right)\right]$$

$$= \sqrt{4F^2 \times \cos^2\left(\frac{\theta}{2}\right)}$$

$$\Rightarrow R = 2F\cos\frac{\theta}{2}$$

Q. Two forces of 100N and 150N are acting simultaneously at a point. What is the resultant forces, if the angle bet<sup></sup> them is 45°?

Sol$^n$: Given data,

$P = 100\,N$

$Q = 150\,N$

$\theta = 45°$

We know that,

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

$$= \sqrt{\{(100)^2 + (150)^2 + 2 \times 100 \times 150 \times \cos 45°\}}\,N$$

$$= 232\,N.$$ Ans

Q. Find the magnitude of two forces, such that if they act at right angles, their resultant is $\sqrt{10}$ N. But if they act at 60°, their resultant is $\sqrt{13}$ N.

~~Given data~~

First of all, consider the two forces acting at right angles. We know that when the angle bet$^n$ the two given Forces is 90°, then the resultant force (R)

$\sqrt{10} = \sqrt{P^2+Q^2}$

$10 = P^2+Q^2$ —(I) (∵ squaring both sides.

Similarly, when the angle betⁿ the two forces is 60°, then the resultant force (R)

$\sqrt{13} = \sqrt{P^2+Q^2+2PQ\cos 60°}$

$13 = P^2+Q^2+2PQ\times 0.5$ (∵ squaring both)

$PQ = 13-10 = 3$ (Put the value of $P^2+Q^2 = 10$)

We know that

$(P+Q)^2 = P^2+Q^2+2PQ$

$= 10+3\times 2$

$= 16$

$P+Q = \sqrt{16} = 4$ —(I)

Similarly

$(P-Q)^2 = P^2+Q^2-2PQ$

$= 10-2\times 3$

$= 4$

$\Rightarrow P-Q = \sqrt{4} = 2$ —(II)

Now solving the two eqⁿs

$P+\cancel{Q} = 4$

$P-\cancel{Q} = 2$

$2P = 6$

$\Rightarrow P = 3$

Now put the value of P in eqⁿ (1)

$$P + Q = 4$$

$$\Rightarrow Q = 4 - P$$

$$= 4 - 3$$

$$Q = 1N$$

$$\therefore P = 3N \; \& \; Q = 1N$$

## Triangle law :-

It state's that if two forces, acting simultaneously on a particle, be represented in magnitude and direction by the two sides of a triangle taken in order, then their resultant may be represented in magnitude and direction by the third side of the triangle, taken in opposite order.

## Polygon law :-

It states that if a no. of forces acting simultaneously on a particle, be represented in magnitude and direction by sides of a polygon taken in order, then their resultant is represented in magnitude and direction by the closing side of the polygon taken in opposite order.

## Method of Resolution for the resultant force:-

1. Resolve all the forces horizontally and find the algebric sum of all horizontal components. (i.e $\Sigma H$).

2. Resolve all the forces vertically and find the algebric sum of all the vertical components (i.e. $\Sigma V$).

3. The resultant 'R' of the given forces will be given by :

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$$

4. The resultant force will be inclined with the horizontal at an angle $\theta$, with the horizontal.

i.e.

$$\tan\theta = \frac{\Sigma V}{\Sigma H}$$

**Notes:-**

→ The value of angle $\theta$ will vary depending upon the values of $\Sigma V$ and $\Sigma H$.

→ $\Sigma V$ is +ve, the resultant makes an angle bet$^n$ 0° and 180°. But $\Sigma V$ is -ve when the the resultant makes an angle bet$^n$ ~~90° to 270°~~ 180° to 360°.

→ $\Sigma H$ is +ve, when the resultant makes an angle bet$^n$ 0° - 90° or 270° - 360°. But

$\Sigma H$ is -ve ; when resultant makes an angle betn $90° - 270°$.