Unit-1

Introduction : Engineering Mechanics : The effect of external forces on the RIGID BODY.

Examples :

Statics : Body is at rest.

Daynamics :

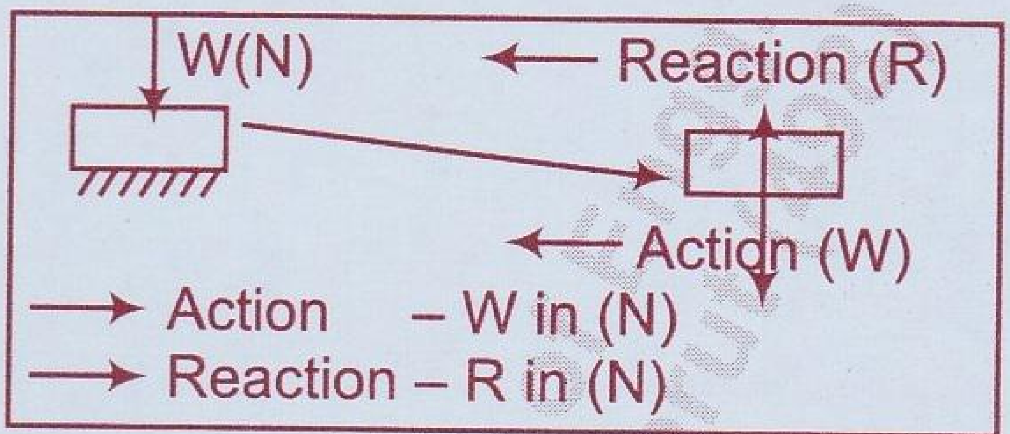
(a) Kinetics : Forces are considered by which motion takes place.

(b) Kinematics : Forces are not to be considered.

RIGID BODY :

(a) The Distance between two points never changes.

(iii) Newton's IIIrd law (Law of Action/Reaction)



(iv) Law of Parallelogram (To Find Resultant of two Concurrent force)

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

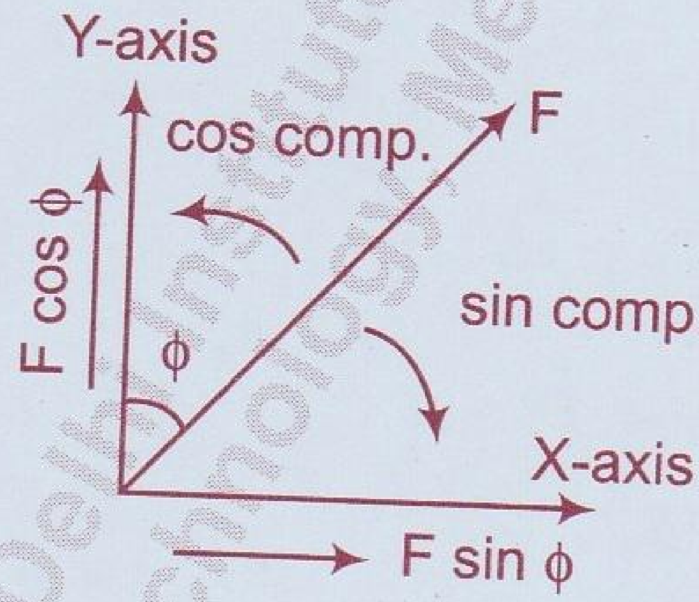
P, Q – Two concurrent force

$\phi \rightarrow$ angle b/w, P and Q.

RESOLUTION OF FORCES :

Every Inclined force gives two components

- Cos-Component (जिधर से कोण दिया हो)
- Sin-Component (जिधर से कोण ना दिया हो)



In Fig. (a)

$$\Sigma X = F_1 + F_5 - F_2$$

and $$\Sigma Y = F_4 + F_6 - F_3$$

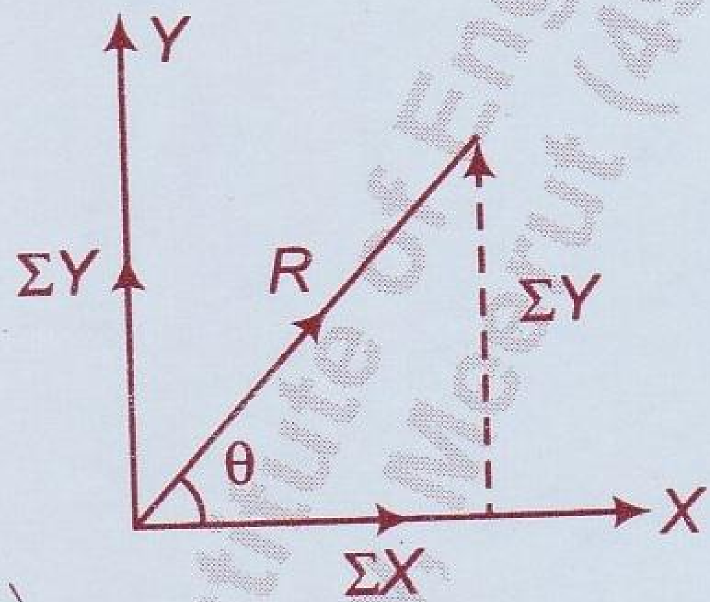


Fig. (b)

In Fig. (b)

$$R = \sqrt{\Sigma X^2 + \Sigma Y^2}$$

and $$\theta = \tan^{-1} \frac{\Sigma Y}{\Sigma X}$$

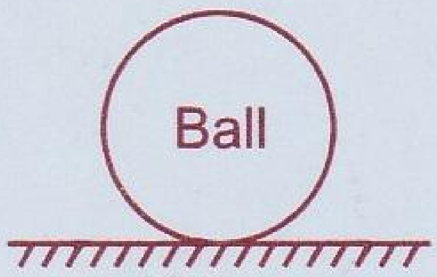
TYPES OF FORCES ON BODY :

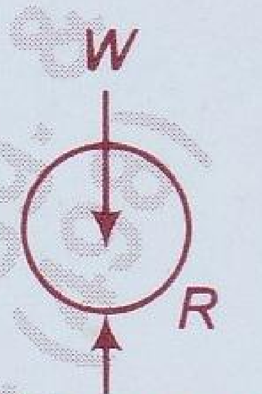
1. **Applied forces** (Forces applied externally to a body)
2. **Non-applied Forces**

   (a) Self Weight : Self weight ($w=mg$) always acts in vertically downward direction.

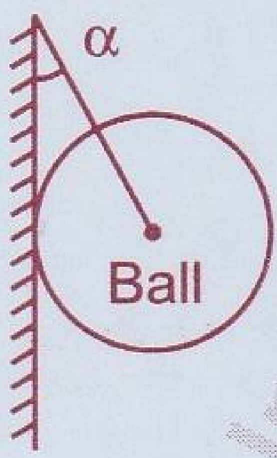
   (b) Reaction from surface of contact : It is always perpendicular to surface and towards the body.

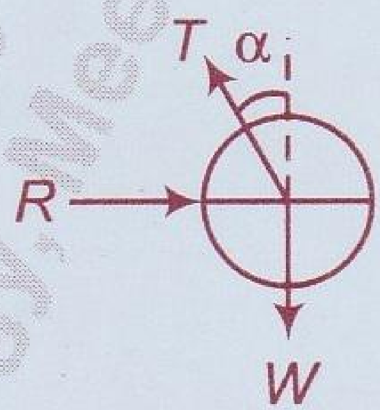
BODIES





F.B.D of Ball





F.B.D of Ball

$$\Sigma X = 0, \quad R - T \sin\alpha = 0$$

$$\Sigma Y = 0, \quad T \cos\alpha - W = 0$$

Unit-2

Truss : A structure made up of several bars (or members) are riveted or pin jointed together are called truss.

Types of Truss :

1. **Perfect Truss :** It satisfy the equation $M = 2J - 3$
2. **Imperfect Truss :**

   $$M \neq 2J - 3$$

   (a) Deficient truss :

   $$M < 2J - 3$$

   (b) Redundant truss :

   $$M > 2J - 3$$

where M = No. of memebrs

J = No. of joints

In figures, *AB, BC, CA* are the members.

A, B and *C* are the joints.

METHOD OF JOINTS

Step to Solved Truss Problems :

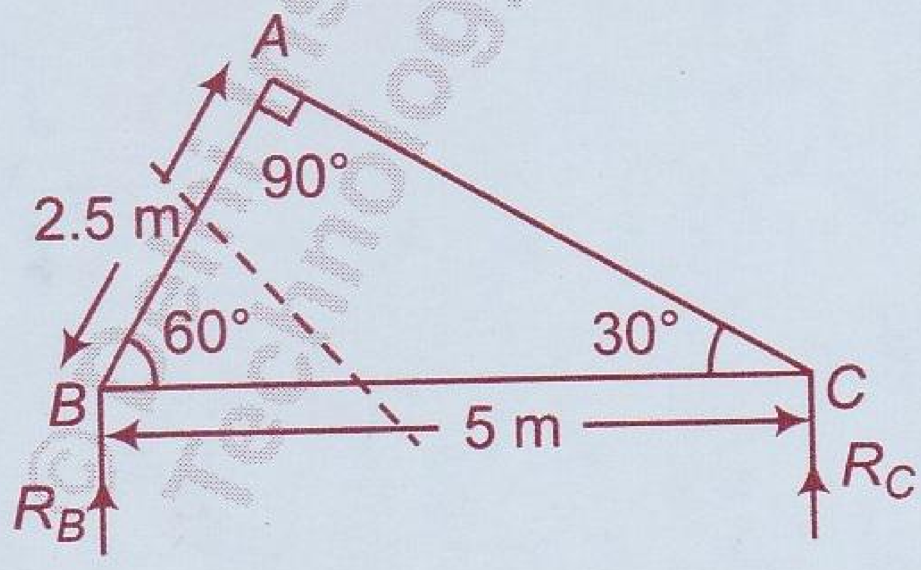
1. First we find all reactions by using equilibrium equations.
2. After that we select the joints at which two unknown quantity of force are acting.
3. Then we make the F.B.D. at the joint and find all forces in members by

- After cutting section consider one side of the section line and draw freebody diagram.
- Then the unknown forces in the members are determined by using :

$\Sigma x = 0, \Sigma y = 0$ and $\Sigma M = 0$

For Example :

Section cutting 2 Members



Unit-3

CENTROID :

It is the point of the body where total area of body is supposed to concentrated.

CENTRE OF GRAVITY :

Where total weight of the body is supposed to be concentrated.

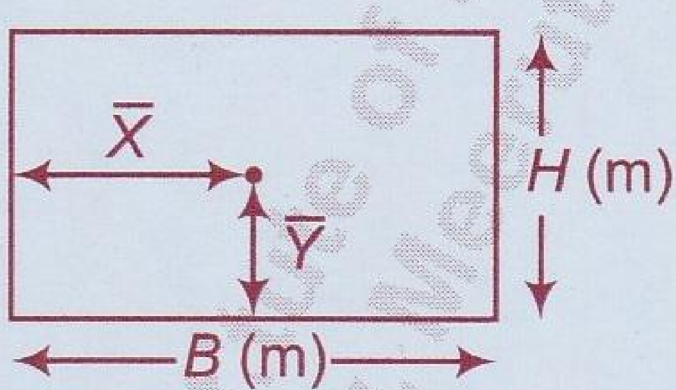
Formula Used to Determine Centroid or Centre of Gravity

$$\bar{X} = \frac{A_1 x_1 + A_2 x_2 + \ldots}{A_1 + A_2 + \ldots},$$

CENTROID OR CENTRE OF GRAVITY OF SOME FIGURE

1. Plane Figure : Rectangle

Figure :



Area : $A = B \times H\ \text{m}^2$

Co-ordinates :

$\overline{X} = B/2, \overline{Y} = H/2$

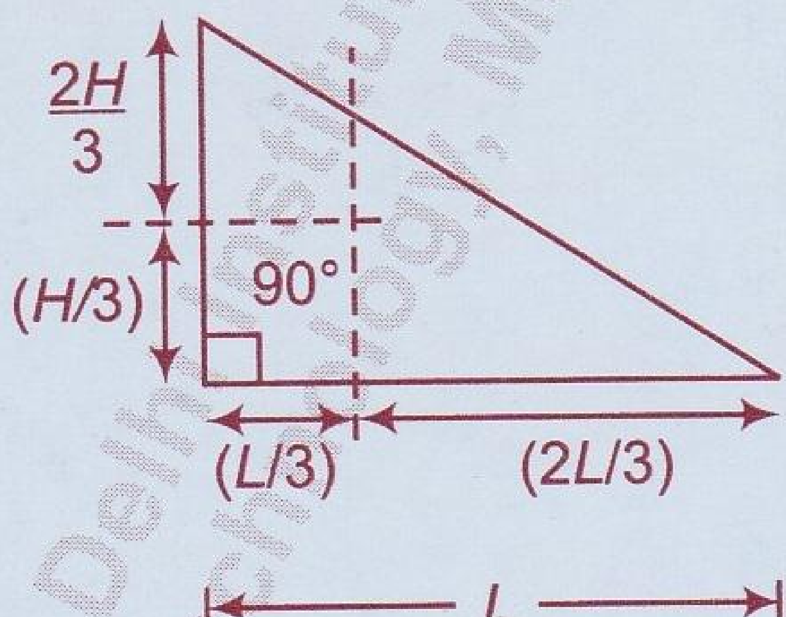
Area : $A = \dfrac{\pi R^2}{2}\ \text{m}^2$

Co-ordinates :

$$\bar{X} = R,\ \bar{Y} = \frac{4R}{3\pi}$$

4. Plane Figure : Triangle

Figure :



CENTROID BY VOLUME :

$$\bar{X} = \frac{V_1x_1 + V_2x_2 + \ldots}{V_1 + V_2 + \ldots},$$

$$\bar{Y} = \frac{V_1y_1 + V_2y_2 + \ldots}{V_1 + V_2 + \ldots}$$

where

$V_1, V_2 \rightarrow$ Are the volume of the bodies.

Mathematically, in fig. (1)

$$R = ma$$

where,

ma = Inertia force

R = Resultant of system of forces.

For Example :

Apply D'Alembert Principle in case lift moving upward's and downward- Refer Fig. (2) and (3).

WORK ENERGY METHOD FOR TRANSLATION :

$$R \times S = \frac{W}{2g}(v^2 - u^2)$$

where,

RS = Work done by the forces act on body.

$\frac{W}{2g}v^2$ = Final kinetic energy.

$\frac{W}{2g}u^2$ = Initial kinetic energy.

FOR CURVILINEAR MOTION

$$W_{net} = \frac{1}{2} I\omega_f^2 - \frac{1}{2} I\omega_i^2.$$

slab called body centroid. These two curves are tangent at point I (instantaneous centre).

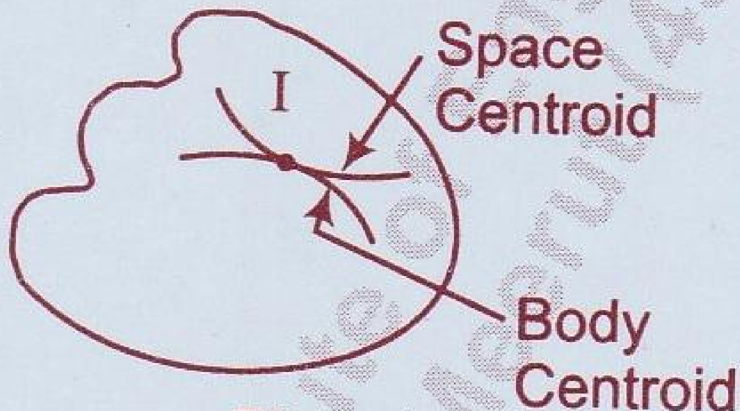


Fig.

PLANE MOTION :

A rigid body is said to perform plane motion when all parts of the body moves in parallel planes.

Unit-5

LOAD :

It is an agent which when applied on the body, then the body moves or tries to move.

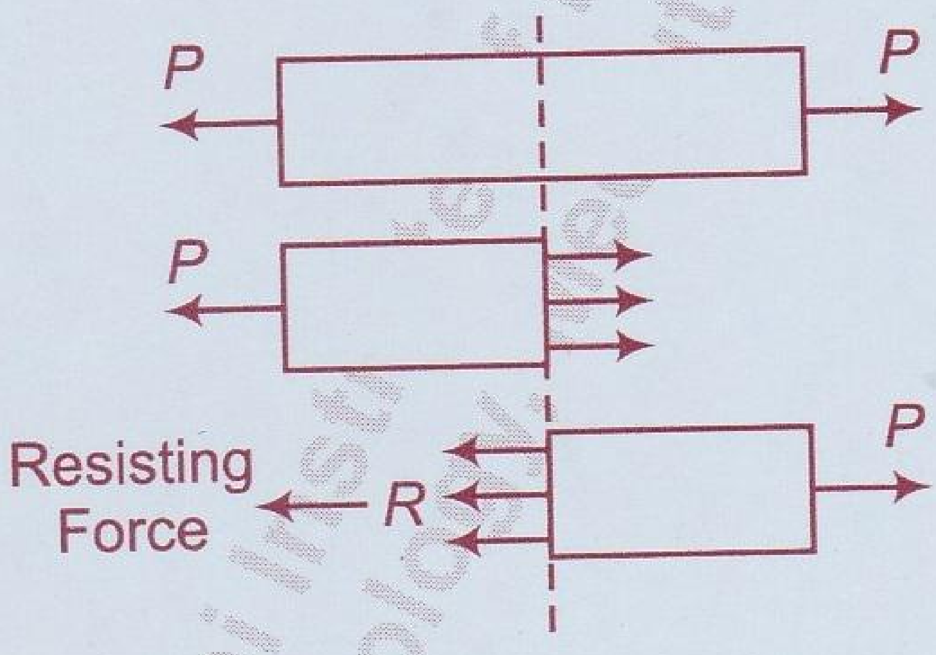
Classfication of Load :

According to manner of application :

1. Dead load or static load
2. Live or fluctuating load

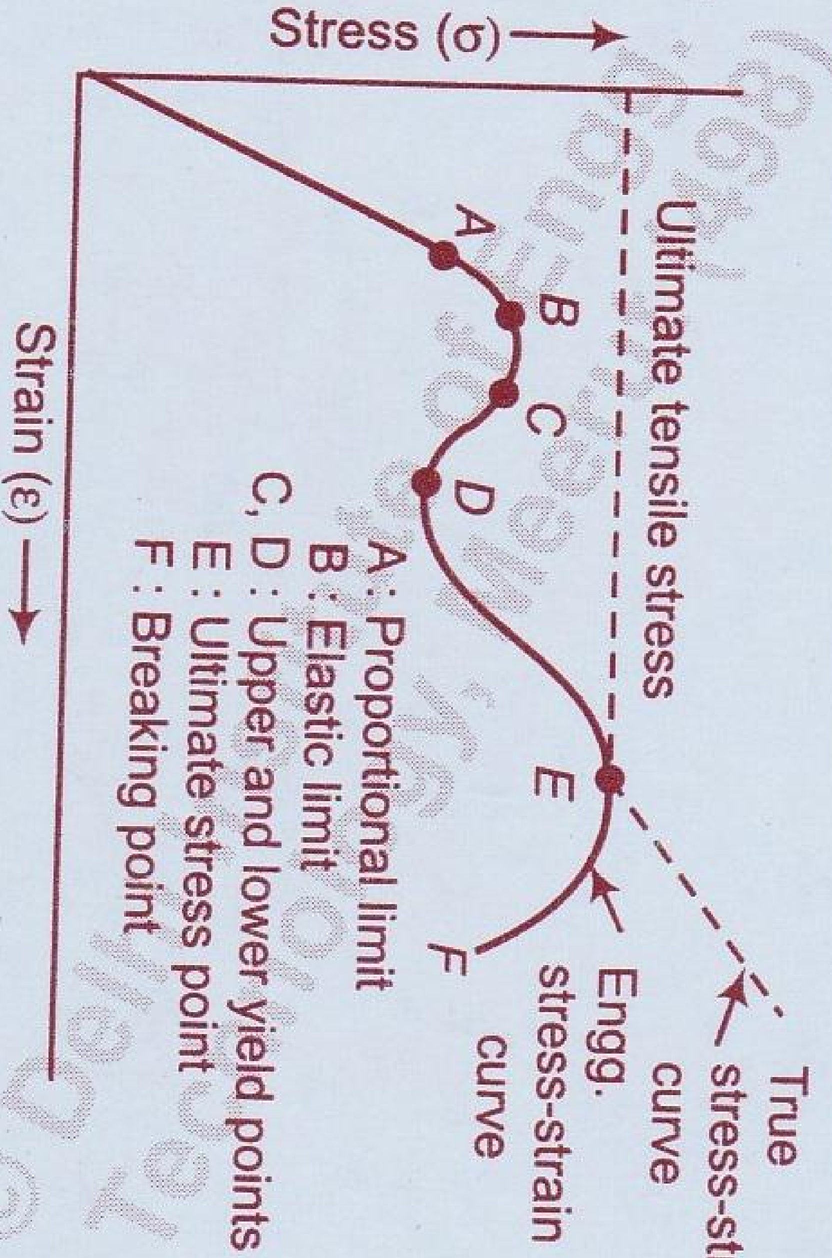
STRESS : (σ)

The internal resistance set up per unit cross-sectional area is called stress (σ).

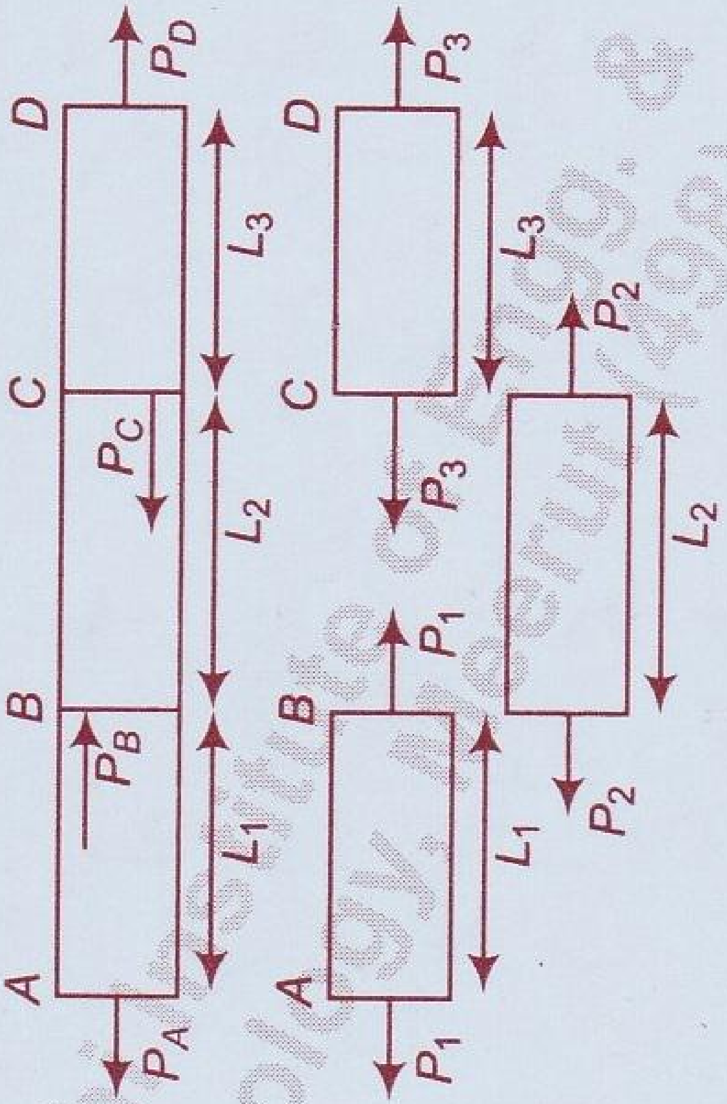


$$\therefore \quad \sigma = \frac{R}{A}$$

STRESS-STRAIN DIAGRAM FOR MILD STEEL



PRINCIPLE OF SUPER POSITION :



$$P_1 = P_D + P_B - P_C = P_A$$

$$P_2 = P_D - P_C = P_A - P_B$$

$$P_3 = P_D = P_A + P_C - P_B$$

COMPOSITE SECTION :

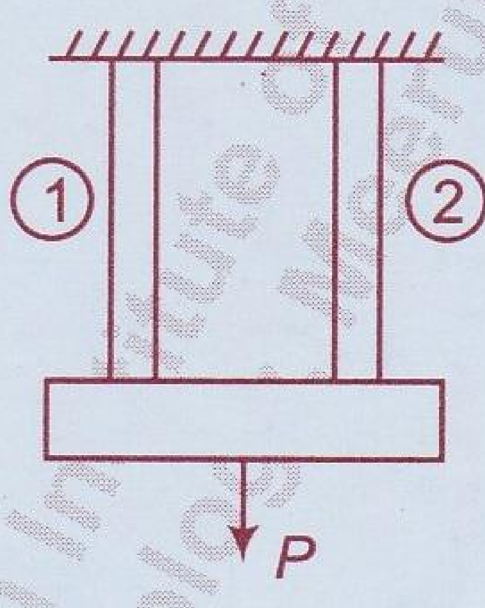
In this case we apply

$$\delta l_1 = \delta l_2$$

and

$$P = P_1 + P_2$$

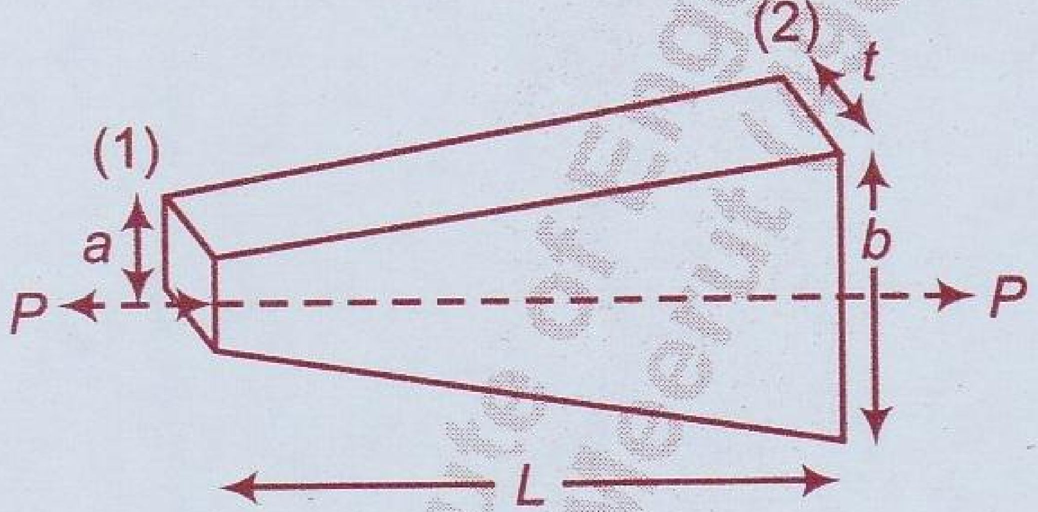
$$= \sigma_1 A_1 + \sigma_2 A_2$$



where $\sigma = \dfrac{P}{A}$

P = Total load.

DEFORMATION OF RECTANGULAR TAPER PLATE :



$$\delta L = \frac{PL}{(b-a)\,tE} \log_e \frac{b}{a}$$

where *a* and *b* are width at (1) and (2) point.

t = Thickness.

3. Strain Energy :

$$U = \frac{\sigma^2 AL}{2E}$$

4. Strain Energy Stored

= Work done by falling load

TORSION EQUATION :

$$\frac{T}{J} = \frac{G\theta}{L} = \frac{\tau}{R}$$

where T = Twisting mendent

G = Modulus of rigidity

J = Polar moment of Inertia

θ = Angle of twist

τ = Shear stress

R = Radius of shaft

L = Length of shaft.

ELASTIC CONSTANT :

Relation between E and G

$$E = 2G\,(1 + \mu)$$

Relation between E, G and K

$$E = \frac{9KG}{(3K + G)}$$

Relation between E and K

$$E = 3K\,(1 - 2\mu)$$

where E = Modulus of elasticity

G = Modulus of rigidity

K = Bulk modulus

μ = Poisson's ratio