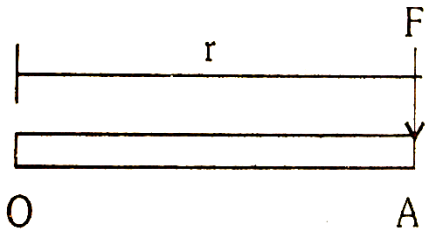
Moments

Moment of a Force:

Moment of a force about a point is defined as the product of the force and the perpendicular distance of the line of action of the force from that point.



In the above figure, F is a downward force applied at 'A' and r is the perpendicular distance of the line of action of the force from the point O.

The moment (μ) of the force F about 'O' is given by

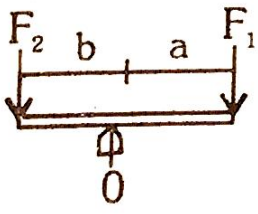
μ_o = F x r (i.e. Force x Perpendicular distance)

Downward force applied at A_1 will have a tendency to rotate OA about the point 'O'. Hence moment may also be defined as the turning effect produced by a force.

Moment is classified into two types.

) Clockwise moment

ii) Anticlockwise moment



In the above figure, downward force F_1 acting on the right hand side of the fulcrum 'O' at a distance of 'a' produces clockwise moment about 'O'.

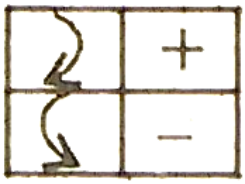
∴ Moment of F_1 about 'O' = F_1 x a (clockwise)

But downward force F_2 applied on the left hand side of the fulcrum 'O', at distance of b, produces anticlockwise moment about 'O'.

∴ Moment of F_2 about 'O' = F_2 x a (clockwise)

Sign convention:

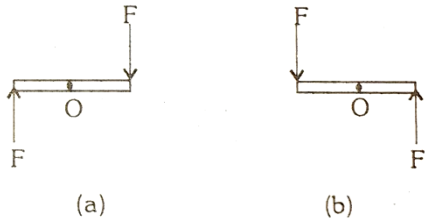
Positive sign for clockwise moment, negative sign for anticlockwise moment.



Unit of moment:

In S.I. system, unit of moment is Newton – metre (Nm) Force is measured in Newton and the distance is measured in metre.

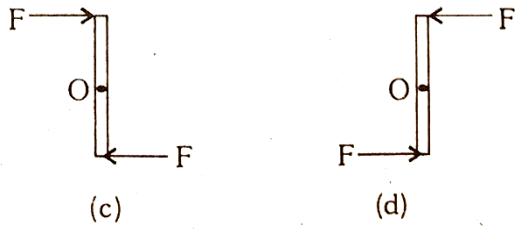
Moment of vertical forces:



About a point (at 'O') right hand side downward force and left hand side upward force produces clockwise moment, shown in fig. (a). Similarly

about a point (at 'O'), right hand side upward force and left hand side downward force produces anticlockwise moment, shown in fig. (b).

Moment of Horizontal Forces :

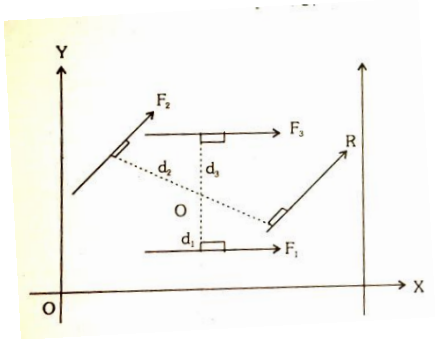


About a point (at 'O' in fig). upward right hand side force and downward left hand side produces clockwise moment (fig. c.). Similarly about a point, upward left hand side force and downward right hand side force produces anticlockwise moment.

Varignon's theorem :

The algebraic sum of the moments of any number of forces about any point in their plane is equal to the moment of their resultant about the same point. Varginon's theorem is also known as theorem of moments.

Consider a rigid body subjected to three coplanar forces F_1, F_2 and F_3 as shown in figure, at perpendicular distances d_1, d_2 and d_3 from a point O.



Let the resultant force R is at a distance 'd' from O.

From Varignon's theorem,

Sum of the moments of the forces F_1, F_2, and F_3 about 'O' is equal to the moment of resultant force R_1 about the same point O'.

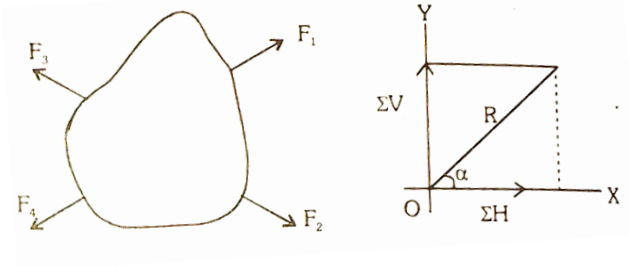
i.e. $F_1d_1 + F_2d_2 + F_3d_3 = R.d.$

Sum of the moment of all the forces about a point = moment of their resultant force about the same point.

Varignon's theorem is used in locating the resultant force.

Resultant force of Non – Concurrent & Non – Parallel forces:

The magnitude and direction of resultant force can be determined by analytical method as same for concurrent force system, But, location of the resultant force of non-concurrent and nonparallel force system is determined by the concept of moment and Varignon's principle.



$$R = \sqrt{(\sum H)^2 + (\sum V)^2} \quad and$$

Direction of resultant force, $a = \tan^{-1}\left[\frac{\sum V}{\sum H}\right]$

$\therefore \sum M = R \times X$

Where

$\sum m$ = algebraic sum of moments of given forces about a particular point.

R = Resultant force

x = the perpendicular distance of the line of action of Resultant force from the reference point, about which algebraic sum of moment of given forces is determined.