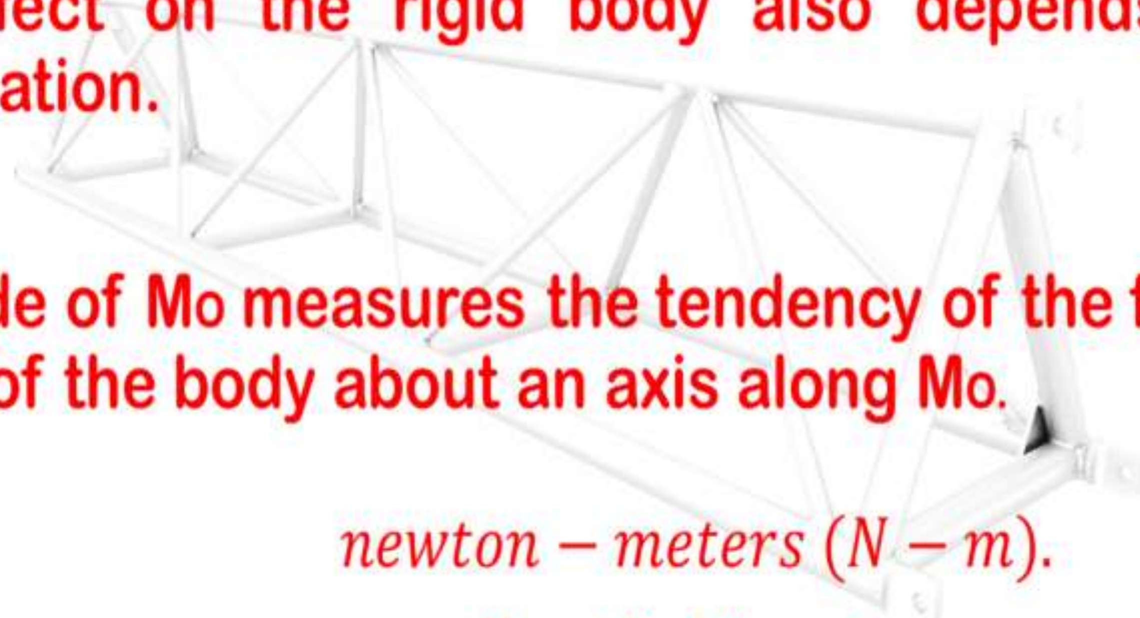
Moment of a Force About a Point

- A force vector is defined by its magnitude and direction.

- Its effect on the rigid body also depends on it point of application.



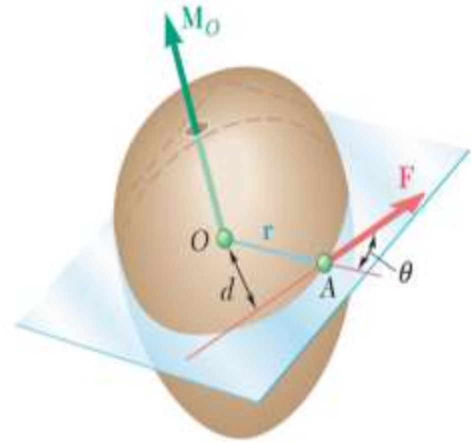
Magnitude of M_O measures the tendency of the force to cause rotation of the body about an axis along M_O.

$$newton - meters\ (N - m).$$

$$lb - ft\ /\ lb - in.$$

Moment

The moment of F about O is defined a



$$M_o = r \times F$$

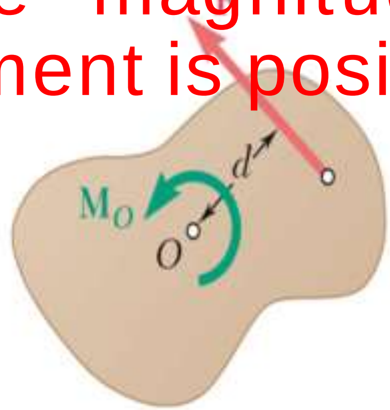
The moment vector Mo is perpendicular to the plane containing O and the force F.

The sense of the moment may be determined by the right-hand rule.

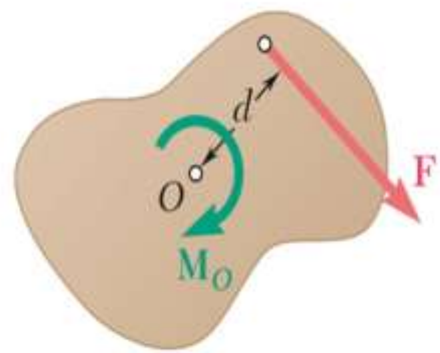
Moment in Two Dimensional System

If the force tends to rotate the structure counterclockwise, the sense of the moment vector is out of the plane of the structure and the magnitude of the moment is positive.

If the force tends to rotate the structure clockwise, the sense of the moment vector is into the plane of the structure and the magi the mom



(a) $M_O = + Fd$

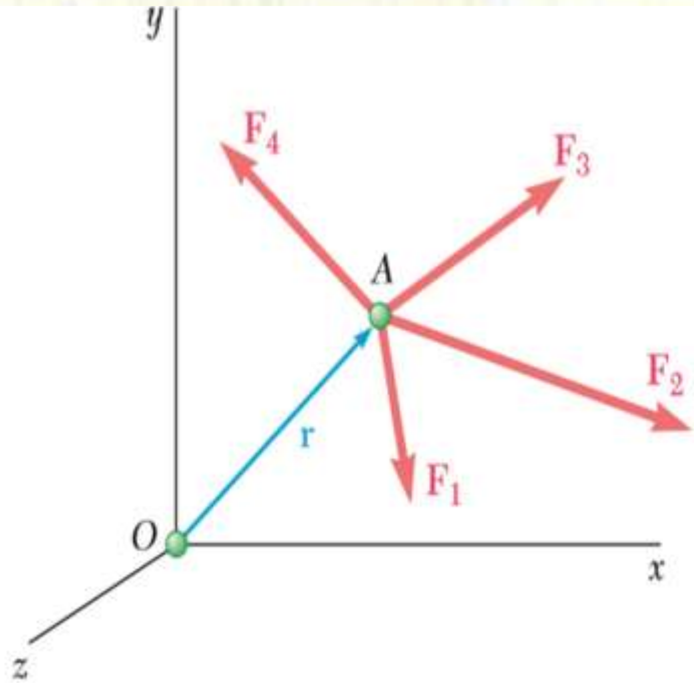


(b) $M_O = - Fd$

Varignon's Theorem

The moment about a given point O of the resultant of several concurrent forces is equal to the sum of the moments of the various forces about the same point O.

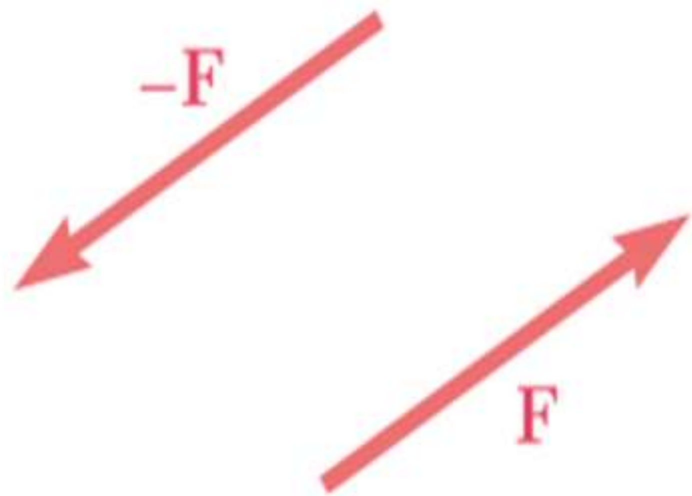
$$\mathbf{r} \times (\mathbf{F}_1 + \mathbf{F}_2 + \cdots) = \mathbf{r} \times \mathbf{F}_1 + \mathbf{r} \times \mathbf{F}_2 + \cdots$$



French mathematician Varignon (1654–1722) long before the introduction of vector algebra, is known as Varignon's theorem.

Couple

Two forces F and -F having the same magnitude, parallel lines of action, and opposite sense are said to



- The sum of the components of the two forces in any direction is zero.
- The sum of the moments of the two forces about a given point, however, is not zero.

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4.9. ARM OF A COUPLE

The perpendicular distance (a), between the lines of action of the two equal and opposite parallel forces, is known *as arm of the couple* as shown in Fig. 4.11.

Fig. 4.11.

4.10. MOMENT OF A COUPLE

The moment of a couple is the product of the force (*i.e.*, one of the forces of the two equal and opposite parallel forces) and the arm of the couple. Mathematically:

Moment of a couple $= P \times a$

where P = Magnitude of the force, and

a = Arm of the couple.

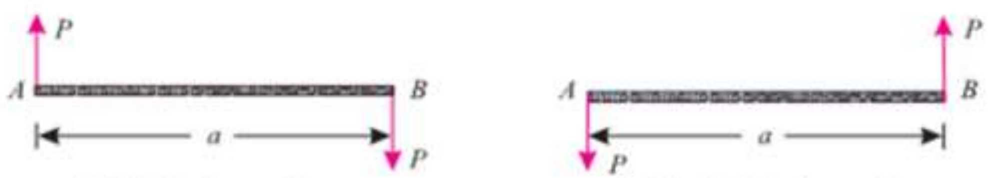
4.11. CLASSIFICATION OF COUPLES

The couples may be, broadly, classified into the following two categories, depending upon their direction, in which the couple tends to rotate the body, on which it acts :

1. Clockwise couple, and 2. Anticlockwise couple.

4.12. CLOCKWISE COUPLE

A couple, whose tendency is to rotate the body, on which it acts, in a clockwise direction, is known as a clockwise couple as shown in Fig. 4.12 (a). Such a couple is also called positive couple.



(a) Clockwise couple

(b) Anticlockwise couple

Fig. 4.12.

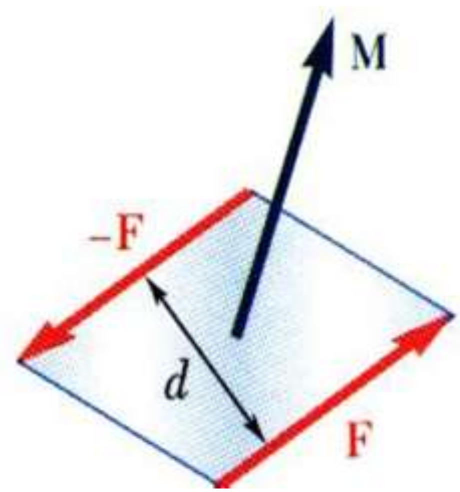
4.13. ANTICLOCKWISE COUPLE

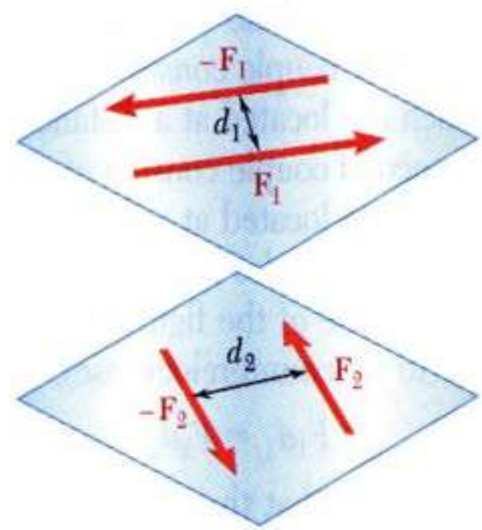
A couple, whose tendency is to rotate the body, on which it acts, in an anticlockwise direction, is known as an anticlockwise couple as shown in Fig. 4.12 (b). Such a couple is also called a negative couple.

Two couples will have equal moments if

- $F_1 d_1 = F_2 d_2$

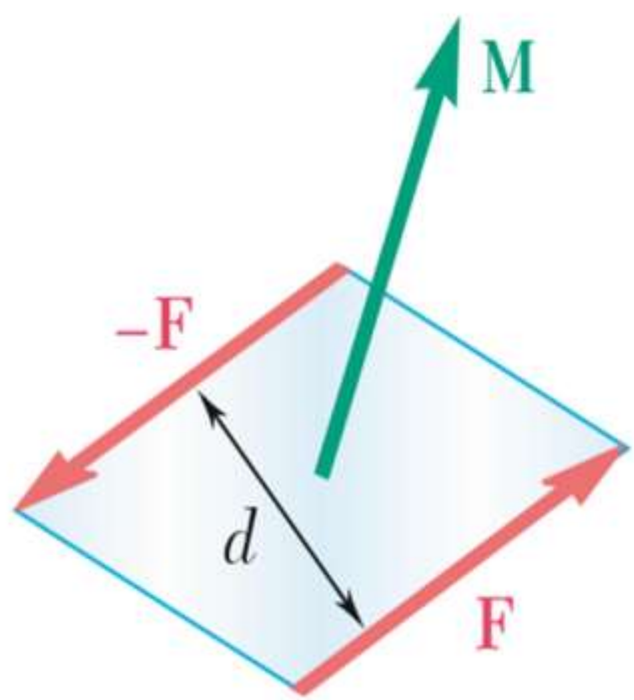
- the two couples lie in parallel planes, and
- the two couples have the same sense or the tendency to cause rotation in the same direction.





MOMENT Vector OF A COUPLE

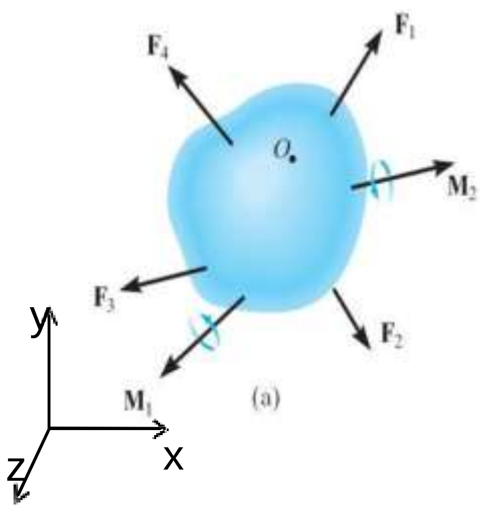
The moment vector of the couple is independent of the choice of the origin of the coordinate axes, i.e., it is a free vector that can be applied at any point with the same effect.



Rigid Body Equilibrium

A rigid body will remain in equilibrium provided

- Sum of all the external forces acting on the body is equal to zero, and
- Sum of the moments of the external forces about a point is equal to zero



$$\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma F_z = 0$$

$$\Sigma M_x = 0 \qquad \Sigma M_y = 0 \qquad \Sigma M_z = 0$$