

## Module I: FORCES AND MOMENT

### Session 4

#### Moment of a Force

It is the turning effect produced by a force, on the body, on which it acts. The moment of a force is equal to the product of the force and the perpendicular distance of the point, about which the moment is required and the line of action of the force. The units of moment may be N-m, N-mm etc. The moment of a force about a point is a vector which is directed perpendicular to the plane containing the moment centre and the force.

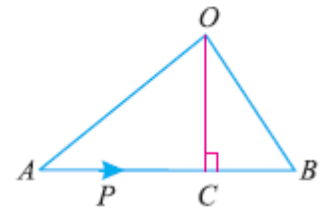
Mathematically, moment  $M = P \times l$

where  $P$  = Force acting on the body, and

$l$  = Perpendicular distance between the point, about which the moment is required and the line of action of the force.

#### Geometrical Interpretation of Moment

The moment of a force about any point is equal to twice the area of the triangle, whose base is the line that represents the force and whose vertex is the point about which the moment is taken.



#### Varignon's Principle of Moments (Law of Moments)

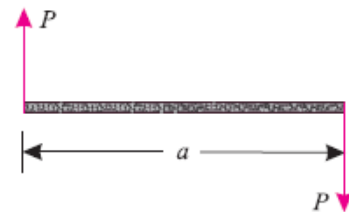
It states, "If a number of coplanar forces are acting simultaneously on a particle, the algebraic sum of the moments of all the forces about any point is equal to the moment of their resultant force about the same point."

#### Couple

A pair of two equal, opposite and parallel forces is known as a couple.

A couple is unable to produce any translatory motion (*i.e.*, motion in a straight line). But it produces a motion of rotation in the body, on which it acts. The simplest example of a couple is the forces applied to the key of a lock, while locking or unlocking it.

The rotational effect of a couple is measured by its moment which is defined as the product of either of the forces and the perpendicular distance between the forces. The perpendicular distance ( $a$ ), between the lines of action of the two equal and opposite parallel forces, is known as arm of the couple.



Moment of a couple =  $P \times a$

where  $P$  = Magnitude of the force, and

$a$  = Arm of the couple.

*Examples of a couple:*

- Winding of a watch or a clock
- Opening or closing of a water tap
- Unscrewing the cap of an ink bottle

- Locking/unlocking of a lock with a key
- Turn of the cap of a pen

### **Characteristics of a Couple**

A couple has the following characteristics:

- The algebraic sum of the forces constituting the couple is zero.
- The translator effect of a couple on a body is always zero.
- The algebraic sum of the moments of the forces, constituting the couple, about any point is the same and equal to the moment of the couple itself.
- A couple cannot be balanced by a single force. But it can be balanced only by a couple of opposite sense.
- Any no. of coplanar couples can be reduced to a single couple, whose magnitude will be equal to the algebraic sum of the moments of all the couples.
- Any two couples are equivalent if their moments are equal both in magnitude and direction.
- The effect of a couple on a body remains unchanged if the couple is rotated through an angle, shifted to any other position and replaced by another pair of forces whose rotational effect is same.