MOMENT OF FORCE

The moment of a force is equal to the product of the magnitude of the force and the perpendicular distance of the force from the pivoted point.

Consider a body which is pivoted at a point O. If a force F is applied on the body in the direction FP as shown in Fig 3.11, the force is unable to produce linear motion of the body in its direction because the body is not free to move, but this force turns (or rotates) the body about the point O, in the direction shown by the arrow in Fig. 3.11.

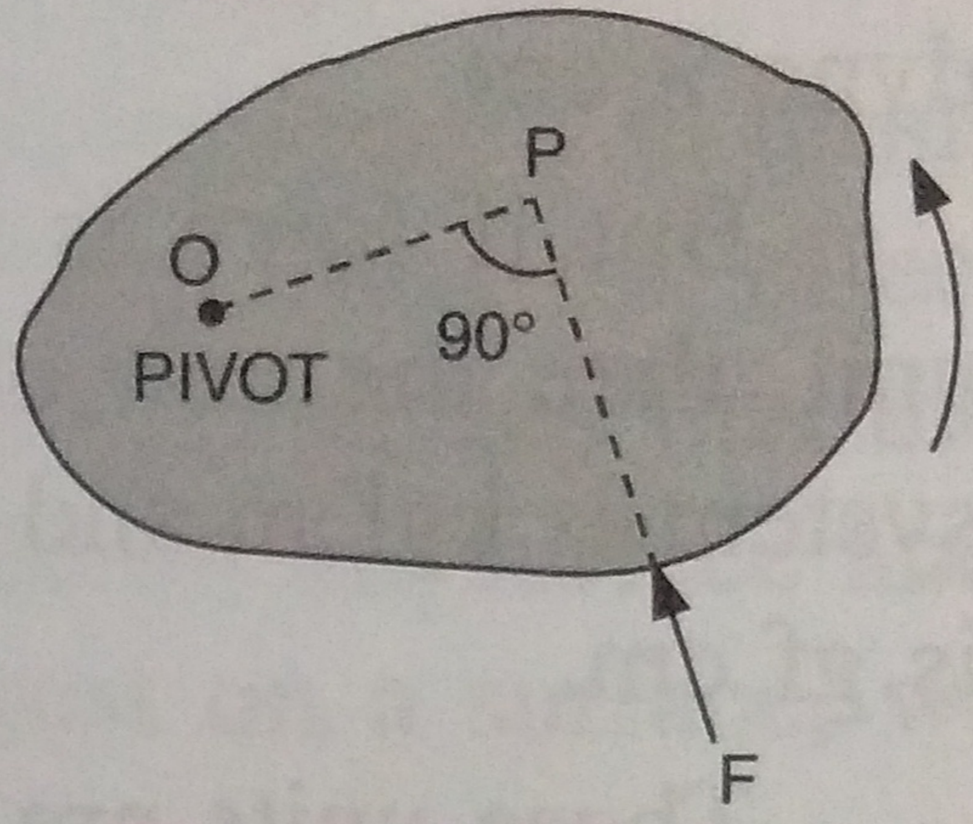


Fig. 3.11 Moment of a force

In Fig. 3.11, the perpendicular distance of the force F from the pivoted point O is OP.

Therefore,

Moment of force about the point O

= Force × perpendicular distance of force from the point O

= F × OP

Note : For producing maximum turning effect on a body by a given force, the force is applied on the body at a point for which the perpendicular distance of the force from the pivoted point is maximum so that the given force may provide the maximum torque to turn the body.

UNIT OF MOMENT OF FORCE

Unit of moment of force

= unit of force × unit of distance

The S.I. unit of force is newton and that of distance is metre, so the S.I. unit of moment of force is **newton × metre**. This is written in short form as N m.

Note : The unit newton × metre (N m) of moment of force or torque is not written as joule (J).

The C.G.S unit of moment of force is dyne × cm.

But if force is measured in gravitational unit, then the unit of moment of force in S.I. system is kgf m and in C.G.S. system, the unit is gf cm.

These units are related as follows :

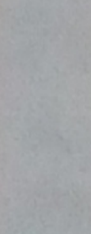
$$1 \text{ N m} = 10^5 \text{ dyne} \times 10^2 \text{ cm}$$
$$= 10^7 \text{ dyne cm}$$
$$1 \text{ kgf m} = 10 \text{ N m (nearly)}^*$$
and $$1 \text{ gf cm} = 1000 \text{ dyne cm (nearly)}^*$$

For example, Reena has to apply a minimum force of 1·5 N on the handle of the door of width 1·2 m to open it. This means that the minimum moment of force required to open the door is 1·5 N × 1·2 m = 1·8 N m. Now if she wants to open it by applying the force at the mid point between the handle and hinges, (*i.e.* at distance 0·6 m from the hinges), she will have to apply a force F such that

$$F \times 0{\cdot}6 \text{ m} = 1{\cdot}8 \text{ N m}$$

or $$F = \frac{1{\cdot}8 \text{ N m}}{0{\cdot}6 \text{ m}} = 3{\cdot}0 \text{ N}$$

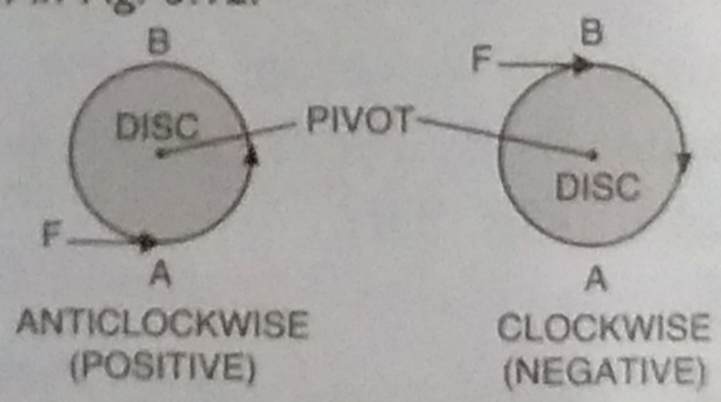
Thus, on decreasing the distance of the applied force from the point of rotation, the magnitude of force increases.



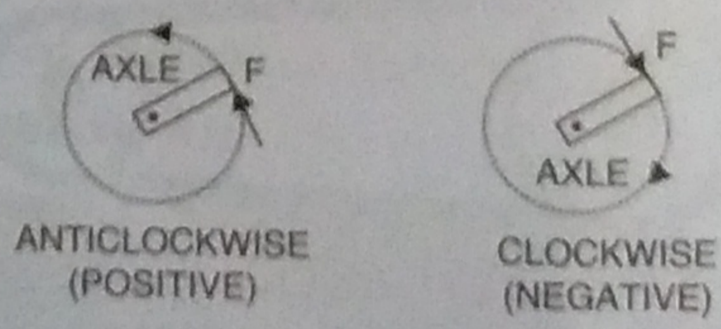
Do You Know ?

1. Conventionally, if the effect on the body is to turn it anticlockwise, moment of force is called anticlockwise moment and it is taken positive. If the effect on the body is to turn it clockwise, the moment of force is called clockwise moment and taken in negative.

2. The direction of rotation of a body can be changed either by changing the point at which the force is applied or by changing the direction of force applied as shown in Fig. 3.12.



(a) By changing the point of application of force



(b) By changing the direction of force

Fig. 3.12 Anticlockwise and clockwise moments

PRESSURE

Thrust : A force can be applied on a surface in any direction. If the force is applied on a surface in a direction normal (perpendicular) to the surface, the force is called thrust. Thus, *the force acting normally*

* Precisely 1 kgf m = 9·8 N m, 1 gf cm = 980 dyne cm

on a surface is called ***thrust***. A body, when placed on a surface, exerts a thrust on the surface equal to its own weight.

The unit of thrust is same as that of the weight or force. Thus, the units of thrust are kilogram force (kgf), gram force (gf) and newton (N). These units are related as :

1 kgf = 1000 gf

1 kgf = 10 N (nearly)

1 N = 100 gf (nearly).

THE EFFECT OF THRUST

The effect of thrust depends on the area of the surface on which it acts. Smaller the area of the surface on which a thrust acts, larger is its effect. But the effect of a thrust is less on a larger area.

Examples :

(1) If you stand on loose sand, your feet sink deeply into the sand. But when you lie on sand, your body does not sink much into the sand. In both the cases, the thrust exerted on the sand is same. The reason is that, when you stand, the thrust acts on a smaller area, so you sink more in the sand, and when you lie down, the same thrust acts on a larger area so you sink less in the sand. (Fig. 3.13).

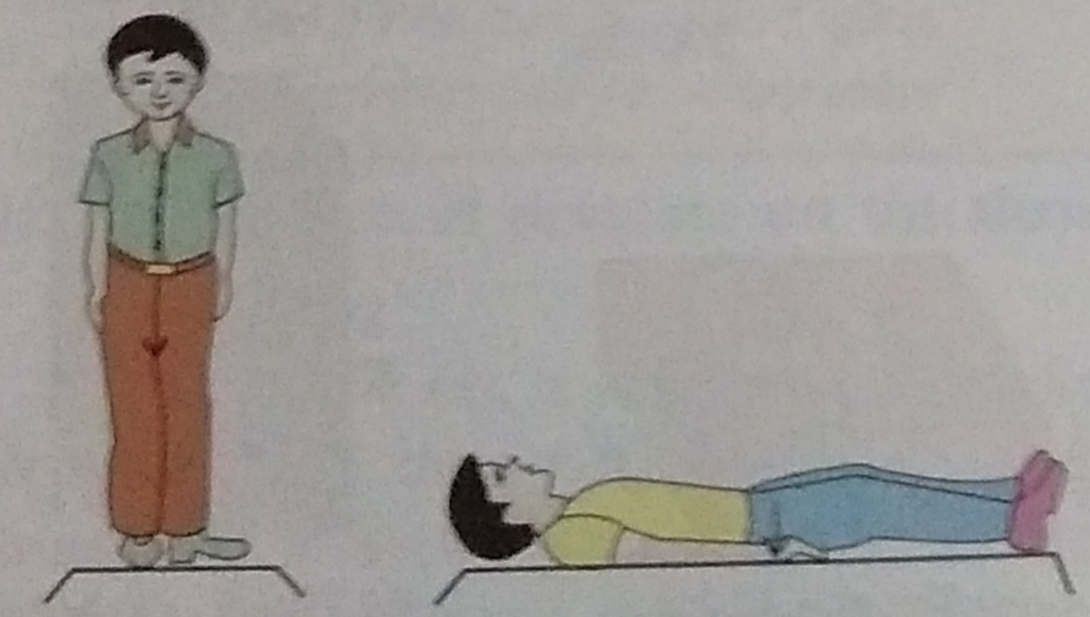


Fig. 3.13 Same thrust but different effects

(2) If you hammer a nail holding it with its flattened end resting on a wooden block [Fig. 3.14 (a)], you find it difficult to get the nail into the block. But if you hammer the nail holding its sharp end resting on the block [Fig. 3.14 (b)], the nail penetrates into the block easily. The reason is that when thrust acts on the flattened end, the effect of thrust is small but when the same thrust acts on the sharp end, the effect of thrust is more.

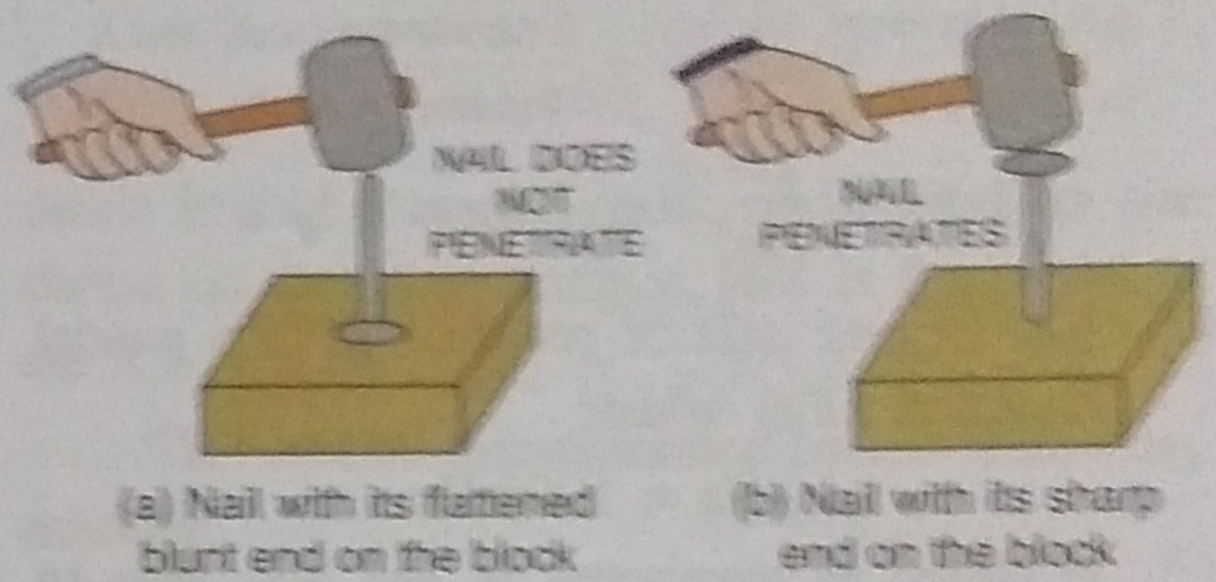


Fig. 3.14 Effect of thrust is more on a smaller area than on a bigger area

The effect of thrust is expressed in terms of a quantity called pressure. More the effect of a given thrust on a surface, we say that the thrust exerts more pressure on the surface and if less is the effect of thrust on a surface, we say that the thrust exerts a less pressure on the surface.

DEFINITON OF PRESSURE

Pressure is defined as the thrust per unit area. Thus,

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$$

It is denoted by the letter P.

If a thrust F acts on an area A, the pressure P is :

$$P = \frac{F}{A}$$

UNITS OF PRESSURE

(1) The S.I. unit of thrust (or force) is newton (N) and that of area is metre^2 (m^2), so the S.I. unit of pressure is newton/metre^2 (symbol N/m^2 or N m^{-2}). This unit is also called pascal (symbol Pa) after the name of the scientist Blaise Pascal. Thus,

1 pascal is the pressure exerted by a thrust of 1 newton on a surface of area 1 metre^2.

i.e.

$$1 \text{ pascal} = \frac{1 \text{ newton}}{1 \text{ metre}^2}$$

$$\text{or } 1 \text{ Pa} = \frac{1 \text{ N}}{1 \text{ m}^2} \text{ } i.e. \text{ } 1 \text{ Pa} = 1 \text{ N m}^{-2}$$

(2) The bigger unit of pressure is kilo pascal (symbol kPa) where

$$1 \text{ kPa} = 1000 \text{ Pa.}$$

(3) If thrust is measured in kgf and area in cm^2, then pressure is expressed in unit kgf cm^{-2}.

(4) The atmospheric pressure is generally expressed in a unit **atm** where

1 atm = 76 cm of mercury column

$$= 1{\cdot}013 \times 10^5 \text{ Pa}$$

FACTORS AFFECTING PRESSURE

The pressure on a surface depends on the following two factors :

1. On the area of the surface on which thrust acts,
2. On the magnitude of thrust acting on the surface.

Work-Sheet

Q.1 What is moment of force?
Q.2 What is the unit of moment of force?
Q.3. What is the relation between gf cm and dyne cm?
Q.4. What is pressure?
Q.5. What is thrust?
Q.6. What is the relation between N and gf?
Q.7. What is the S.I unit of pressure?
Q.8. What are the factors that affect pressure?
Q.9. The moment of force of 10 N about a pivot is 5 Nm. Calculate the distance of force from the pivot.
Q.10. A solid block of weight 80N and base area $1.6 m^2$ is placed on a surface. Calculate the pressure exerted on the surface.