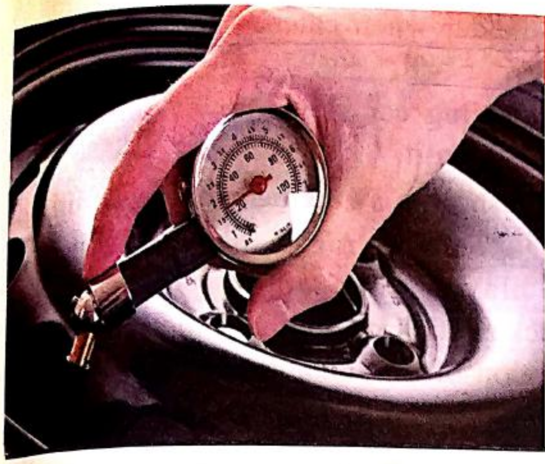


3

Force and Pressure

Theme : A force is a push or pull upon an object resulting from the object's interaction with another object. Turning effect of a force is more if the distance between the point of application of force and the hinge on a door is more. It is given a special name — Moment of force. Pressure is defined as force per unit area. Solids, liquids and gases all exert pressure. Atmosphere also exerts pressure, activities are carried out to demonstrate that solid, liquid and gases exert pressure.

In this chapter you will learn to

- explain the turning effect of a force, with examples from daily life
- define moment of force
- express moment of force in proper units
- solve simple numerical problems based on moment of force
- define pressure
- express pressure in proper units
- solve simple numerical problems based on formula for pressure
- describe pressure exerted by a liquid
- demonstrate that liquids exert pressure
- describe pressure exerted by a gas
- describe atmospheric pressure
- express thoughts that reveal originality, speculation, imagination, a personal perspective, flexibility in thinking, invention or creativity
- present ideas clearly and in logical order.

LEARNING OBJECTIVES

- Revising previous concepts learnt by children
- Building on children's previous learning
- Demonstration of turning effect of force
- Explanation of turning effect and factors on which it depends
- Engaging children in task for calculation of turning effect
- Demonstration of pressure exerted by a force on an object
- Explanation: pressure depend on the area of surface on which the force acts
- Demonstration of pressure exerted by a liquid
- Demonstration of pressure exerted by a gas
- Explanation of pressure exerted by atmosphere
- Engaging children in tasks to show that:
  - (a) Pressure depends on area
  - (b) Liquids exert pressure
  - (c) Gases exert pressure

- Observation/experimentation/analysis
- Student led experiments (reasoning to be given by children individually)
- Investigate the effect on pressure when walking on flat shoes and pointed heels on our body support system

  For example: Children reasoning as to why is it easier to hammer a sharp pin respective to a blunt pin?

KNOWING CONCEPTS

- Turning effect of force (moment of force): concept, definition and calculation
- Pressure
  - Definition • Unit
  - Calculation of pressure in simple cases
  - Pressure exerted by liquids (Qualitative only)
  - Pressure exerted by gases — Atmospheric pressure (qualitative only)

FORCE

We have read that a body which does not change its position with respect to its surroundings is said to be at rest or stationary, whereas a body which changes its position with respect to its surroundings is said to be in motion or a moving body.

A force is a cause (push or pull) which tends to result in movement or change in size or shape of the body. A force when applied as push or pull on a stationary body which is free to move, can produce motion in it and if applied on a moving body, it can change the speed of motion of body (*i.e.* can speed up or slow down the moving body) or it can change both the speed and direction of motion.

Examples :

1. A grass roller initially at rest when pulled, begins to move.
2. A fielder when catches a ball, stops the moving ball.
3. A moving car slows down on applying brakes on it.
4. A push on a swinging girl speeds up her swing.
5. A player when applies force by his hockey stick on the ball, the direction of motion of ball changes.

When force is applied as stretch or squeeze on a body which is not free to move, it changes the size or shape of the body.

Examples :

1. On stretching a rubber string, its length increases.
2. On squeezing a tube of gum, its shape changes.

Thus, we define force as below :

Force is that cause which changes the state of a body (either the state of rest or the state of motion) or it changes the size or shape of the body.

Do You Know ?

1. The speed of a body is defined as the distance travelled by it in one second.
2. Speed up means more distance travelled in one second and slow down means less distance travelled in one second.

Note : 1. A force does not change the mass of the body on which it is applied.

2. We cannot see a force. However, we can see or feel the effect of a force.

3. A force is expressed by stating both its magnitude and direction.

4. A force is represented by an arrow (→). The length of arrow is a measure of its magnitude and the arrow head shows the direction.

UNIT OF FORCE

The S.I. unit of force is newton. The symbol for newton is N. This unit is named after the English scientist Sir Issac Newton who did a lot of research work on force.

One newton is defined as the force which when applied on a moving body of mass 1 kg in the direction of its motion, increases its speed by 1 m s^{-1} in one second.

We have read that our earth attracts each body towards it. The force of attraction exerted on a body by earth is called the weight of the body or the force of gravity that acts on the body.

The force of gravity (or weight) of a body is different at different places on earth. At a place, the force of gravity on a body of mass 1 kg is called 1 kgf or 10 N. In other words, 1 N is the force of gravity at a place on 0·1 kg (100 g) mass. Thus, the unit of force kgf and N are related as :

$$1 \text{ kgf} = 10 \text{ N (nearly)*}$$

In other words, one newton is the force that we have to exert to hold a mass of 100 g on our palm (Fig. 3.1).

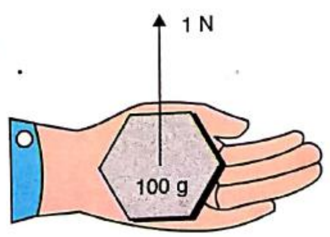


Fig. 3.1 Force of **1 N** *on a mass of* **100 g** *to hold it*

* Precisely 1 kgf = 9·8 N

Do You Know ?

1. A body in which the inter-spacing between its constituent particles do not change when a force is applied on it, is called a rigid body and if it changes, the body is called a non-rigid body.

2. A force when applied on a rigid body can cause only the change in motion of the body. But a force when applied on a non-rigid body can cause both the change in its size or shape and the motion in it.

TURNING EFFECT OF A FORCE

We have read above that if a force is applied on a stationary rigid body, it starts moving in a straight line in the direction of force as shown in Fig. 3.2. In Fig. 3.2, a ball moves on pushing.

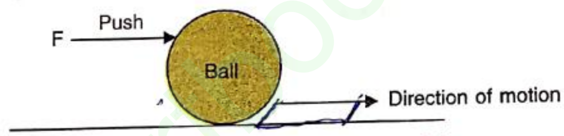


Fig. 3.2 A ball moves on pushing

Now if the body is not free to move, but it is pivoted at a point O and a force F is applied at a suitable point A, it begins to turn about the point O. (Fig. 3.3). The vertical axis passing through the point O about which the body turns, is called the axis of rotation. In Fig. 3.3, on pushing, the wheel begins to turn about its pivoted point O.

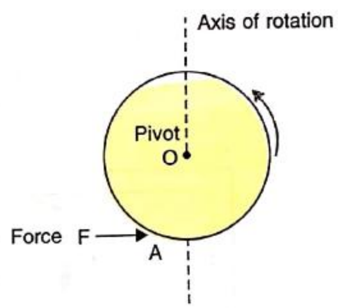


Fig. 3.3 Turning of a wheel about the pivot, on pushing

Similarly, when the handle of a door is either pushed or pulled, the door begins to turn about the hinges which hold the door at rest.

Thus, *a force (push or pull) has a turning effect on a body which is not free to move in a straight line, but is pivoted at a point about which it can turn.*

FACTORS AFFECTING THE TURNING OF A BODY

The turning effect of a force on a body depends on the following two factors :

1. **The magnitude of the force applied.** Larger the magnitude of force applied, more is the turning effect on the body.
2. **The perpendicular distance of the force from the pivoted point.** Larger the perpendicular distance of point at which the force is applied, from the pivoted point, more is the turning effect on the body.

SOME EXAMPLES IN DAILY LIFE

1. To open or shut a door, we apply a force (push or pull) F normal to the door at its handle P which is provided at the maximum distance from the hinges as shown in Fig. 3.4. We can notice that if we apply the force at a point Q (near the hinge R), much greater force is required to open the door and if the force is applied at the hinge R, we will not be able to open the door howsoever large the force may be. Thus, the handle P is provided near the free end of the door so that a smaller force at a larger perpendicular distance, produces the required turning effect of force to open or shut the door.

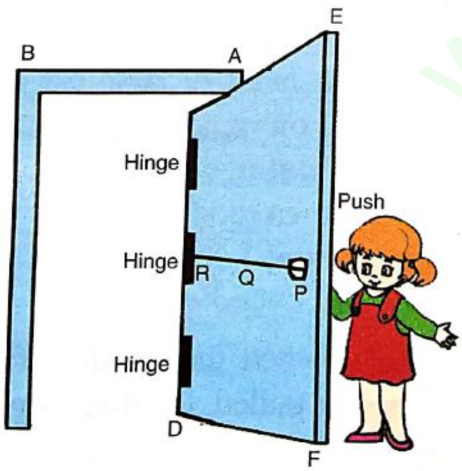


Fig. 3.4 Opening of a door by push

2. The upper circular stone A of a hand flour grinder is provided with a handle H near its rim (*i.e.* at the maximum distance from centre) so that it can easily be rotated about the iron pivot P at its centre by applying a small force at the handle H (Fig. 3.5).

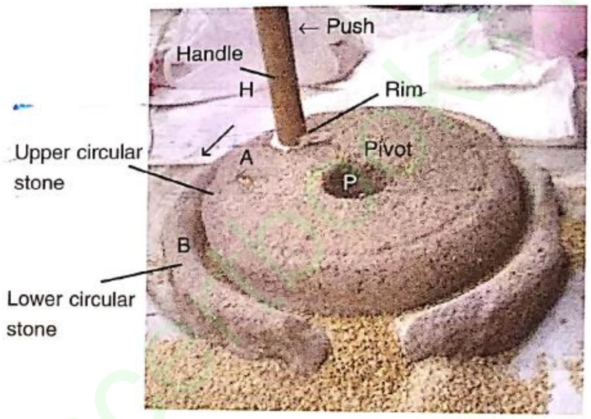


Fig. 3.5 Turning of a hand flour grinder

3. A potter's wheel has a wheel pivoted at the centre. The potter turns the wheel by means of a stick at the rim of the wheel as shown in Fig 3.6.

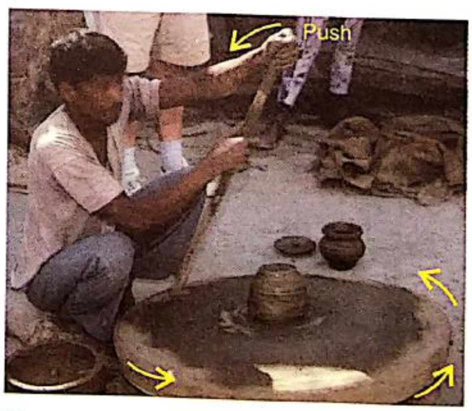


Fig. 3.6 Turning of a potter's wheel

4. A carpenter uses a drill machine which is provided with a handle so that by applying a less force at the end of handle, the drill can be turned easily (Fig. 3.7).

Fig. 3.7 Turning of a drill machine

5. To turn a steering wheel in a car or truck, the driver applies force at a point on the rim of the wheel as shown in Fig. 3.8.

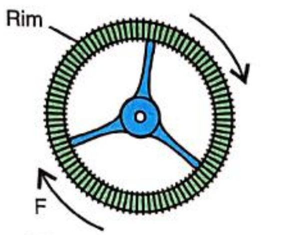


Fig. 3.8 Turning of a steering wheel

6. In a bicycle to turn the wheel, the force is applied on the pedal so that distance of force from the axle of wheel is increased (Fig. 3.9).

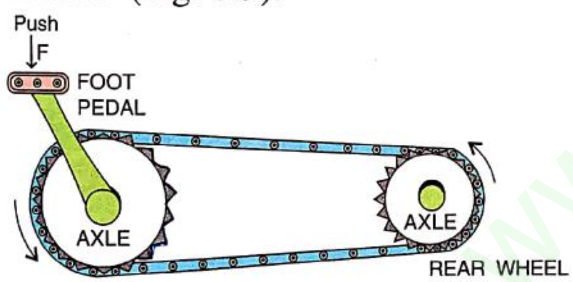


Fig. 3.9 Turning of wheel of a bicycle

7. A spanner used to tighten or loosen a nut, has a long handle to produce a large turning effect by a small force applied at the end of its handle as shown in Fig. 3.10.

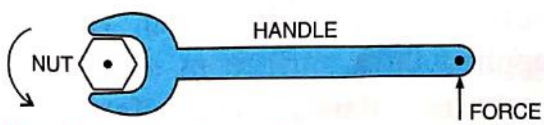


Fig. 3.10 Turning of a spanner

Conclusion : From the above examples, we conclude that the turning of a body about the pivot depends not only on the magnitude of the force, but it also depends on the perpendicular distance of the force from the point of rotation. Larger the perpendicular distance, less is the force needed to turn the body. Actually the turning effect on a body depends on the product of both the magnitude of force and the perpendicular distance of force from the pivoted point. This product is called the moment of force (or torque). In other words, a body turns (or rotates) about the pivoted point due to the moment of force.

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.

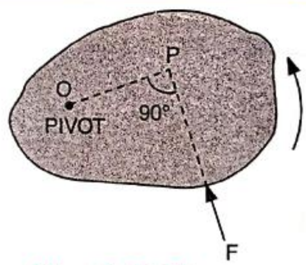


Fig. 3.11 Moment of a force

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.

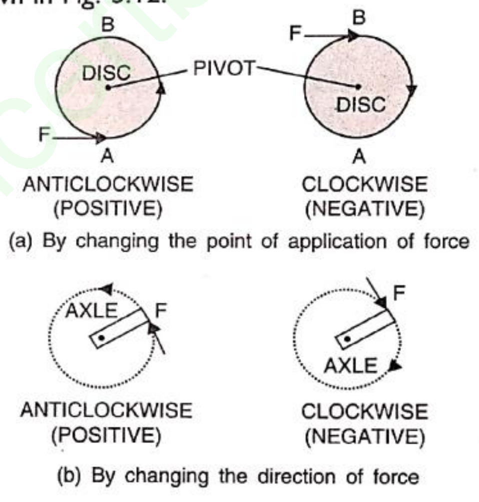


Fig. 3.12 Anticlockwise and clockwise moments

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)

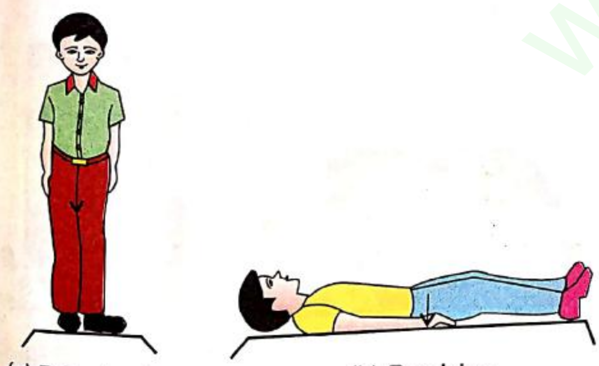
1 N = 100 gf (nearly).

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).

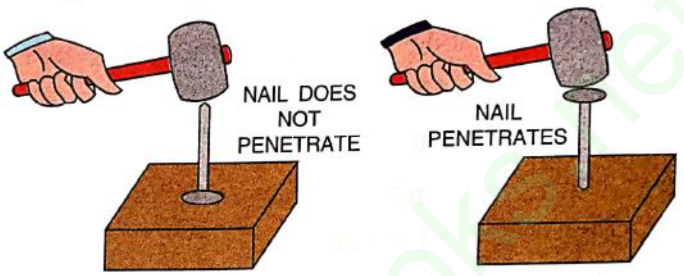


(a) Boy standing (more pressure)

(b) Boy lying (less pressure)

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.



(a) Nail with its flattened blunt end on the block

(b) Nail with its sharp end on the block

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 :

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

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.*

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

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

(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

$$1 \text{ atm} = 76 \text{ cm of mercury column}$$
$$= 1{\cdot}013 \times 10^5 \text{ Pa}$$

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.

1. Dependence of pressure on the area of surface :

When you stand on sand, a thrust equal to your weight acts on a smaller area and so exerts more pressure on sand, hence you sink more. But when you lie down on sand, the same thrust acts on a larger area and so exerts less pressure, hence you sink less. Similarly, when you hammer a nail with its flattened end resting on a wooden block, thrust exerted by you acts on a larger area, so less pressure acts on the nail. Hence, it does not go into the block. But when you hammer the nail with its sharp end resting on the block, the same thrust acts on a smaller area, so more pressure acts on the nail. Hence, it easily prenetrates into the block.

Fig 3.15 (a) shows a block of mass 10 kg and dimensions 40 cm × 20 cm × 10 cm lying on a table top on its side 40 cm × 20 cm. The thrust exerted by the block on the table top is equal to the weight of the block *i.e.* 10 kgf. This thrust acts on an area A_1 = 40 cm × 20 cm = 800 cm^2. The pressure on the table top is

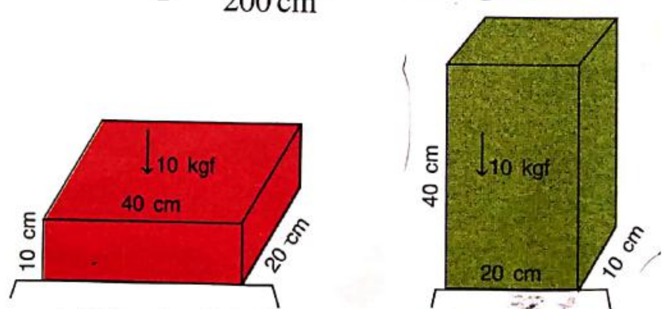
$$P_1 = \frac{10 \text{ kgf}}{800 \text{ cm}^2} = 0{\cdot}0125 \text{ kgf cm}^{-2}$$

Now if the block is turned so that it lies on its side 20 cm × 10 cm as shown in Fig 3.15 (b), the thrust exerted by the block on the table top is the same, equal to 10 kgf. But now, this thrust acts on an area

$$A_2 = 20 \text{ cm} \times 10 \text{ cm} = 200 \text{ cm}^2.$$

The pressure P_2 on the table top now is :

$$P_2 = \frac{10 \text{ kgf}}{200 \text{ cm}^2} = 0{\cdot}05 \text{ kgf cm}^{-2}$$



(a) Thrust = 10 kgf
Area = 800 cm^2
Pressure = 0·0125 kgf cm^{-2}

(b) Thrust = 10 kgf
Area = 200 cm^2
Pressure = 0·05 kgf cm^{-2}

Fig. 3.15 Lesser the area of surface, more is the pressure

Thus, pressure exerted by a body depends on the surface area on which the thrust of the body acts. *Smaller the surface area, more is the pressure exerted by the thrust and larger the surface area, lesser is the pressure exerted by the same thrust.*

This can also be demostrated by the following activity.

ACTIVITY 1

Push a sharp pin into a piece of wood as shown in Fig 3.16 (a). Now try to push a nail with your thumb into the wood [Fig. 3.16 (b)]. You will not be able to push the nail into the wood but you will be able to push the pin into the wood. The reason is that the tip of the nail is of large area than the tip of the pin, so pressure exerted on nail is less than on the pin, hence pin gets inserted but the nail does not. Now, to insert the nail into the wood, hammer it as shown in [Fig. 3.16(c)]. You will find that the nail now gets inserted into the wood because thrust on it has increased the pressure.

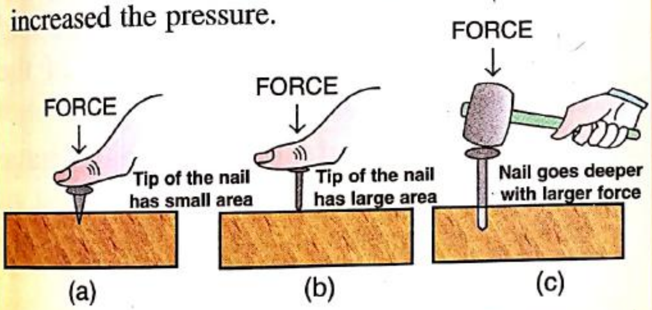
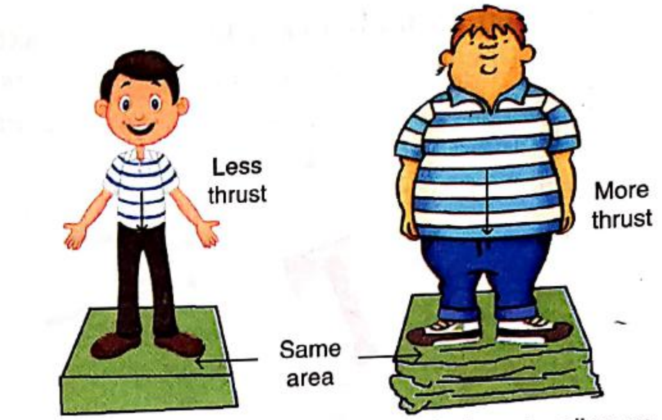


Fig. 3.16 Pressure increases when area decreases and force increases

2. Dependence of pressure on the thrust (or force):

In Fig. 3.17 (a), a thin boy is standing on a brick kept on a bed. He exerts some pressure due to his weight. But in Fig. 3.17 (b), a fat boy is standing on the same brick kept on the bed. In this case, the pressure exerted by the fat boy is more due to his excess weight. Thus, greater the thrust on a surface



(a) A thin boy standing on a bed (less pressure)

(b) A fat boy standing on a bed (more pressure)

Fig. 3.17 More the thrust, more is the pressure

more is the pressure on it while smaller the thrust on the same surface, less is the pressure on it.

This can be demonstrated by the following activity.

ACTIVITY 2

Take three identical blocks of solid wood X, Y and Z. Place these blocks on mud as shown in Fig 3.18. You will notice that the block X alone sinks less into the mud, but the blocks Y and Z placed one above the other, sink into the mud deeper.

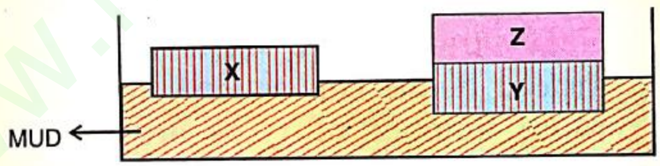


Fig. 3.18 X sinks less while Y and Z together sink more

EXAMPLES OF PRESSURE IN OUR DAILY LIFE

(A) Decrease in area increases the pressure

1. A nail or a board pin has one end pointed and sharp while the other end is blunt and flat. On applying force, the pointed end will exert greater pressure as the area of contact is small and hence it will go deep into the given surface.

2. The cutting tools like a blade, knife, axe etc, (Fig. 3.19), have very sharp edges. The sharp edges have very small area of contact, so the pressure applied by a force is more.

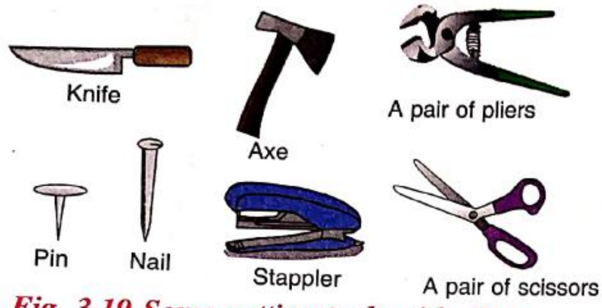


Fig. 3.19 Some cutting tools with sharp or pointed edges

3. Pointed heels of footwear exert more pressure on the ground than the regular flat heels. Therefore, a lady with pointed heel sandals finds it difficult to walk on a muddy road than on a tarred road.
4. The narrow heeled sandal of a girl hurts more than the broad heeled shoe of a boy. This is because more pressure is exerted by the girl than that by the boy as her heel is narrow than the heel of the shoe.

(B) Increase in area decreases the pressure

1. Heavy trucks have six to eight tyres instead of the conventional four tyres. More number of tyres are used to increase the area of contact and thereby reduce the pressure on the ground.
2. A camel can move more conveniently on sand as compared to a horse. The reason is that the camel has broader feet than horse. The broader feet of the camel provide lesser pressure on the sand and it becomes easier for the camel to walk. In the case of a horse, the area of the feet is less, due to which the pressure is more and hence the feet show a tendency to sink inside the sand, making it difficult to walk.
3. Skiers use long flat skis to slide over the snow. The larger the area of contact, the lesser is the pressure on the snow. This helps the skier to slide comfortably without sinking in the snow.
4. Army tanks are usually very heavy and they exert large pressure on the ground, if they move on wheels. Hence they are made to move over the broad steel tracks called caterpillar wheels of tanks. These tracks are used to increase the surface area so as to reduce the pressure on the ground and hence avoid sinking of their wheels in the ground.
5. Foundation of buildings are kept wide so that the weight of the building may act on larger area. As a result, it will exert less pressure on the ground. This avoids sinking of buildings into the earth.
6. A porter wears turban on his head when he has to carry heavy loads. This helps in increasing the area of contact of load and head so as to reduce the pressure of the load on his head.
7. School bags and shopping bags have broad straps or belts so that the area of contact increases and thus the pressure on the hand or shoulder is reduced.
8. Wide wooden sleepers are placed below the railway tracks (Fig 3.20) so that the pressure exerted by the rails on the ground becomes less.

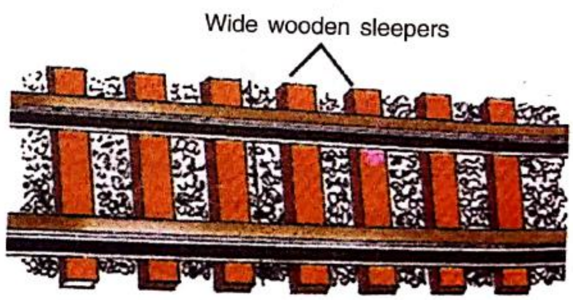


Fig. 3.20 Railway track having wide wooden sleepers

Difference between thrust and pressure

Thrust	Pressure
1. Thrust is the sum total of force acting perpendicular to a surface.	1. Pressure is the thrust acting per unit area.
2. It is independent of the area over which the force is applied.	2. It depends on the area on which the force acts.
3. It's S.I. unit is newton (N).	3. The S.I. unit is N m^{-2} or Pa.

LIQUID PRESSURE

A solid exerts pressure on a surface due to its own weight. Similarly, liquids have weight. They also exert pressure on the container in which they are kept. A solid exerts pressure only on the surface at its bottom. But a liquid exerts pressure not only on the surface of its container at the bottom, but also sideways, that is, in all directions. This can be demonstrated by the following activities.

ACTIVITY 3

A liquid exerts pressure at the bottom of its container.

Take a glass tube. Tie a balloon at its lower end. Hold it vertically straight as shown in Fig. 3.21 (a). Pour some water in the tube [Fig. 3.21 (b)]. You will notice that the balloon bulges out.

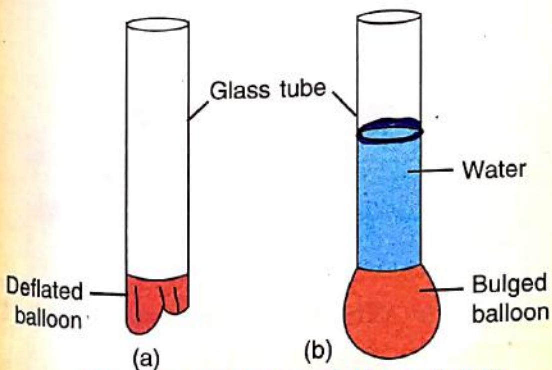


Fig. 3.21 Balloon bulges due to pressure of water column

Conclusion : The water column exerts a pressure on the balloon. The force on the balloon is equal to the weight of the water column which is called thrust. If W is the weight of water column and A the area of mouth of balloon, then

$$\text{Thrust} = W$$

and $$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} = \frac{W}{A}$$

ACTIVITY 4

A liquid exerts pressure sideways also on the walls of container.

Take a glass tube closed at one end and having an opening in its side near the bottom. Tie a balloon at the side opening of the tube. Hold the tube vertically as shown in Fig 3.22 (a). Pour some water in the tube [Fig. 3.22 (b)]. You will notice that the balloon bulges out.

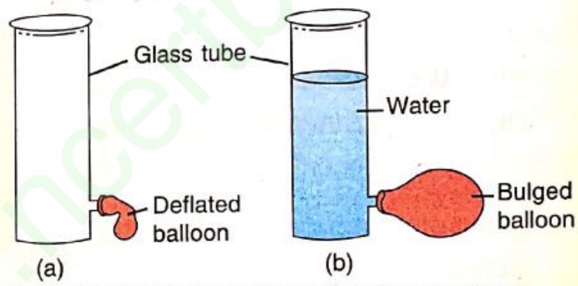


Fig. 3.22 Balloon bulges due to pressure of water on the sides of tube

This shows that liquids exert pressure sideways also on the walls of the container.

ACTIVITY 5

A liquid exerts pressure in all directions

1. Take a plastic mug and water in a bucket. Invert the mug and try to press it so as to immerse the mug into water. You will experience an upward push on your hand. This is because of the pressure exerted by water in the upward direction. Thus, liquids exert pressure in the upward direction also.

2. Take a balloon. Fill it with water. Tie its mouth. Make holes in it by inserting a pin at several places in all the directions. You will notice that water flows out through each hole (Fig. 3.23). This shows that water in the balloon exerts pressure in all directions.

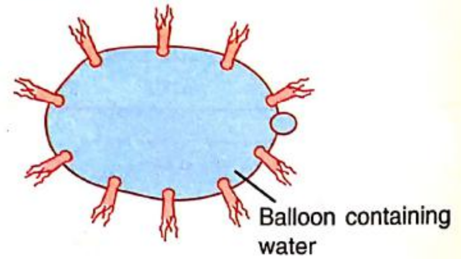


Fig. 3.23 Water inside a balloon exerts pressure in all directions

FACTORS AFFECTING LIQUID PRESSURE

The pressure at a point in a liquid depends on the following two factors :

1. **The height of the liquid column.** Liquid pressure increases with the height of the liquid column above the point.
2. **The density of the liquid.** Liquid pressure increases with the increase in density of the liquid.

1. Liquid pressure increase with the height of the liquid column :

This can be demonstrated by the following activities.

ACTIVITY 6

Take a glass tube open at both ends. Hold it vertically. Tie a balloon at its lower end. Pour some water in the tube. You will notice that the balloon bulges out as shown in Fig. 3.24 (a). Add some more water. You will find that the balloon bulges more [Fig. 3.24 (b)]. This shows that greater the height of the water column in the tube above the balloon,

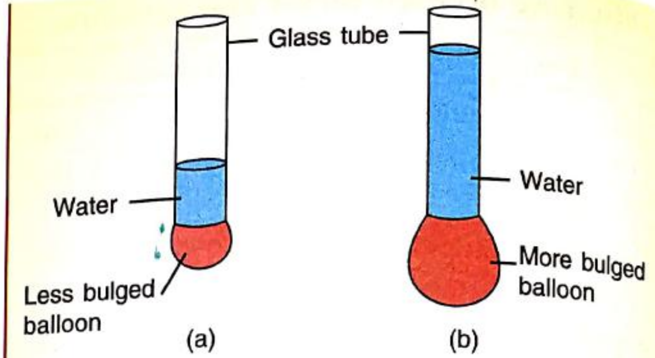


Fig. 3.24 Liquid pressure increases with the height of the liquid column

greater is the pressure exerted by it on the balloon. Thus, the liquid pressure at a point increases with the height of the liquid column above that point.

ACTIVITY 7

Take an empty tin cylinder. Make two holes in it, A near the top and B near the bottom. Close the holes A and B with an adhesive tape. Place the cylinder on a block kept on a table. Fill the cylinder with water. Remove the adhesive tape from the holes. You will notice that the water coming out from the upper hole A falls close to the cylinder and the water coming out from the lower hole B falls farther from the cylinder (Fig. 3.25). This shows that the liquid pressure at a point increases with the height of the liquid column above it.

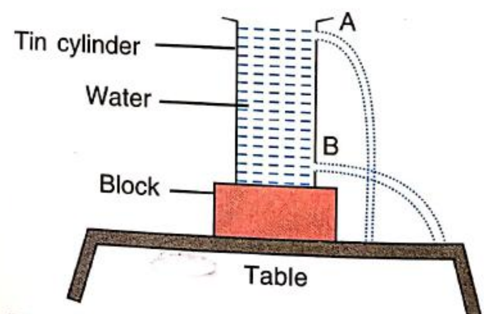


Fig. 3.25 Liquid pressure increases with the height of the liquid column

2. Liquid pressure increases with the increase in density of liquid :

This can be demonstrated by the following activity.

ACTIVITY 8

Take two identical glass tubes A and B open at both ends. Hold them vertical and tie a balloon at the lower end of each tube. Pour some water in the tube A. Now pour mustard oil in the tube B such that its height in the tube B is same as the height of water in the tube A as shown in Fig. 3.26. You will notice that the balloon attached with the tube B bulges more than that attached with the tube A. This shows that the same height of mustard oil exerts more pressure than water. Since the density of mustard oil is more than that of water, therefore we conclude that liquid pressure increases with the increase in density of the liquid.

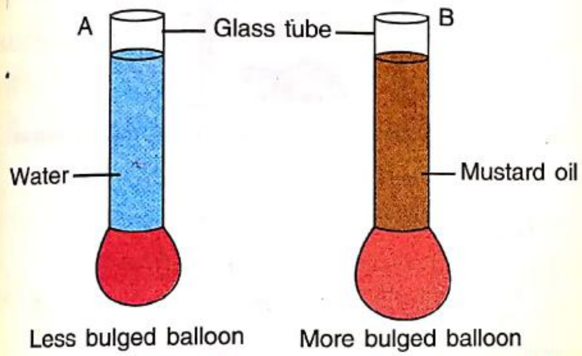


Fig. 3.26 Liquid pressure increases with increase in density of liquid

CONSEQUENCES OF LIQUID PRESSURE

Thickness of walls of a dam is increased towards the bottom : The reason is that the pressure at a point due to a liquid increases with the increase in height of the liquid column

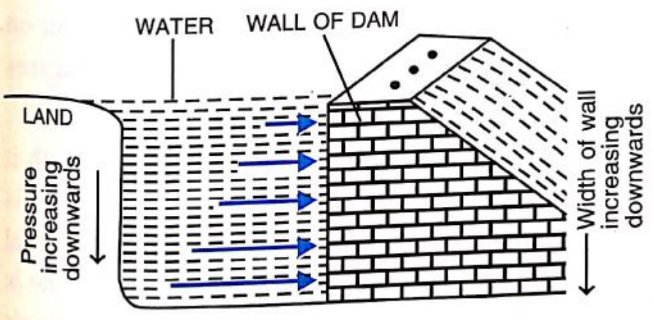


Fig. 3.27 Wall of a dam with its thickness increased towards the bottom

above it, so thickness of the walls of a dam is increased towards the bottom so as to withstand the increasing pressure of water (Fig. 3.27). The arrows in the figure show the increasing pressure towards the bottom of the dam.

Do You Know ?

1. A liquid seeks its own level. The height of level of liquid in tubes of different area of cross sections always remains same, although volume of liquid is different in different tubes as shown in Fig 3.28. This is called hydrostatic paradox.

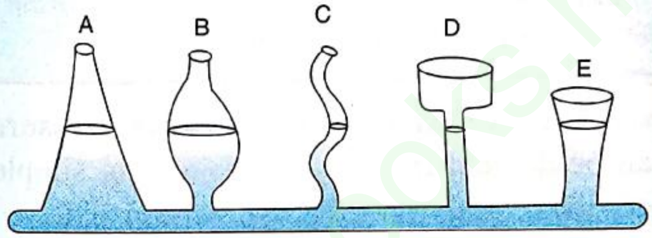


Fig. 3.28 A liquid seeks its own level

2. If a body is immersed in a liquid, the pressure of liquid on the bottom surface of body is more than at its top surface. Due to this difference in pressure, a force acts on the body (force = difference in pressure x area of surface of bottom) in the upward direction which is called the buoyant force or upthrust.

3. Pressure at any point inside the sea/ocean is much greater than that at its surface. The pressure increases with the increase in depth. That is why deep sea-divers wear specially designed swim suits to counter such high pressure.

ATMOSPHERIC PRESSURE

Like liquids, gases also exert pressure. Our earth is surrounded by air to a height of about 200 kilometre. This envelop of air around the earth is called the **atmosphere**.

Air has weight. The weight of air exerts a thrust on earth. The thrust on unit area of the earth surface due to the column of air is called the **atmospheric pressure**. This is about 10^5 N m^{-2}. Thus, a thrust of 100,000 N acts on every 1 m^2 of the surface of objects on earth.

Do You Know ?

We all are under the atmospheric pressure (=100,000 N m^{-2}). The surface area of an average human body is 2 m^2. Therefore, a total thrust of about 200,000 N acts on our body by the atmosphere. However, we are not aware of this enormous thrust since the blood in the veins of our body also exerts a pressure (called the blood pressure) which is slightly more than the atmospheric pressure. This blood pressure makes the effect of atmospheric pressure ineffective.

The existence of atmospheric pressure can be demonstrated by the following simple activities.

ACTIVITY 9

Take a glass filled with water up to its brim and place a post card on top of it as shown in Fig. 3.29. Now press the palm of your one hand on top of the post card, then invert the water filled glass (keeping it tightly closed with the post card placed) upside down. Now gently remove your hand from the post card to release it. You will observe that the post card does not fall down from the glass although the pressure due to water column in the glass acts on it. The reason is that the atmospheric pressure acting upwards on the post card from outside the glass, overcomes the pressure on post card due to water in the glass.

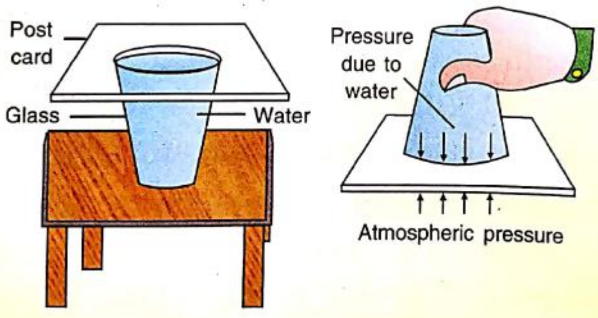
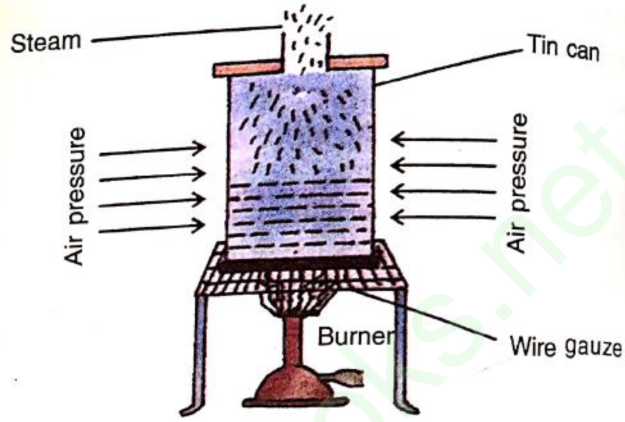


Fig. 3.29 Air exerts pressure

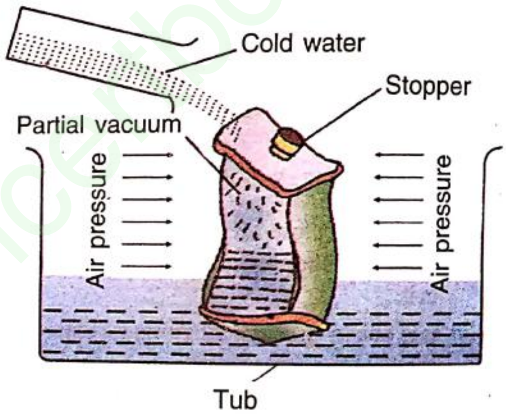
ACTIVITY 10

Crushing can experiment

Take a thin walled tin can provided with an airtight stopper. Remove the stopper. Fill the can partially with water. Heat the can over the flame of a burner till water begins to boil [Fig 3.30(a)]. Now the air pressure inside and outside the can is the same.



(a) Air pressure inside and outside the can is same



(b) Air pressure outside the can is more than that inside

Fig. 3.30 Crushing can experiment

When the steam starts coming out of the opening, put the stopper and remove the can from the burner. Then place the can in a tub and pour cold water on the can. You will notice that the can collapses [Fig. 3.30 (b)].

The reason is that the steam has driven out with it most of the air from the can. When cold water is poured, steam condenses into water, leaving a partial vacuum in the can. The air pressure from outside is now more than that from the inside. This excess air pressure from the outside exerts force due to which the can collapses.

STANDARD VALUE OF ATMOSPHERIC PRESSURE

At sea level on earth surface, the atmospheric pressure is 76 cm or 760 mm of mercury column which is equal to 1 atm or $1{\cdot}013 \times 10^5$ Pa.

Note **:** The atmospheric pressure decreases with increasing altitude *i.e.* as we go higher above the earth surface, the air pressure decreases.

SOME EXAMPLES IN DAILY LIFE TO SHOW THE EXISTENCE OF ATMOSPHERIC PRESSURE

Some of the examples in our daily life showing the effect of air pressure are given below:

1. When a drink is sucked with a straw (Fig. 3.21), the air of the straw goes into the lungs and thus air pressure in the straw decreases. The atmospheric pressure acting on the drink exerts force on the drink to move up into the straw and then into the mouth.

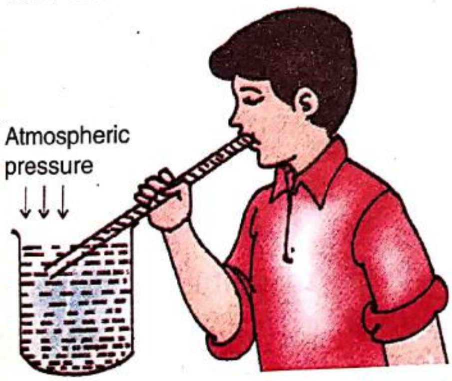


Fig. 3.31 Sucking a drink with a straw

2. When we blow air in a balloon, it bulges because of the pressure exerted by the air filled in it.
3. It is due to atmospheric pressure that ink gets filled into a fountain pen.
4. Water is drawn up from a well by a water pump because of the atmospheric pressure acting on water in the well.
5. The syringe gets filled with the liquid when its plunger is pulled up due to the atmospheric pressure acting on the liquid.
6. Rubber suckers are used as hooks in the kitchen and bathroom. They remain pressed against the wall due to the atmospheric pressure from outside.
7. It is difficult to take out oil from a sealed tin if only one hole is made in it. But if another hole is also made, the atmospheric pressure acts on the oil due to air entering in the tin through this hole and the oil then comes out of the tin through the other hole easily.
8. Lizards are able to move on the wall and stay whenever they desire. This is because their feet behave like suction pads, so they remain pressed against the wall due to the atmospheric pressure.
9. The astronauts and mountaineers have to wear special type of suits to protect themselves from adverse effects of low pressure prevailing at the great heights.
10. Nose bleeding often occurs at high altitudes. The reason is that the atmospheric pressure is low at high altitudes, but the pressure inside the human body does not change. Thus, the excess pressure inside the body compared to the atmospheric pressure, causes nose bleeding.

SOLVED EXAMPLES

1. Calculate the moment of force of 5 N applied on a body at a distance of 20 cm from a pivoted point.

Solution : *Given*, force F = 5 N,
distance d = 20 cm = 0·2 m

Moment of force = force F × distance d
= 5 N × 0·2 m = 1 N m

2. The moment of force of 10 N about a pivot is 5 N m. Calculate the distance of force from the pivot.

Solution : *Given,* moment of force = 5 N m,
force F = 10 N

Let d metre be the distance of force from the pivot, then

Moment of force = force F × distance d

$$5 \text{ N m} = 10 \text{ N} \times d$$

$$d = \frac{5 \text{ N m}}{10 \text{ N}} = 0{\cdot}5 \text{ m}$$

3. Julie can open a 2 m wide door by a minimum force of 2·5 N. Find the moment of force needed to open the door.

Solution : *Given,* force F = 2·5 N, distance d = 2 m

Moment of force = F × d
= 2·5 N × 2 m = 5·0 N m

4. A boy opens a nut by applying a force of 150 N using a wrench of length 30 cm. If he wants to open it by a force of 50 N, what should be the length of wrench ?

Solution : *Given*, force F = 150 N,
distance d = 30 cm = 0·3 m

Moment of force required = F × d
= 150 N × 0·3 m = 45 N m

Now if force F = 50 N, moment of force needed = 45 N m, length d = ?

Moment of force = force × distance

$$45 \text{ N m} = 50 \text{ N} \times d$$

$$d = \frac{45}{50} \text{ m} = 0{\cdot}9 \text{ m (or 90 cm)}$$

5. A solid block of weight 80 N and base area 1·6 m^2 is placed on a surface. Calculate the pressure exerted on the surface.

Solution : *Given*, Thrust (F) = weight = 80 N
area A = 1·6 m^2

$$\text{Pressure} = \frac{\text{thrust}}{\text{area}} = \frac{80 \text{ N}}{1{\cdot}6 \text{ m}^2} = 50 \text{ Pa}$$

6. If a pressure of 50 Pa acts on an area of 4 m^2, calculate the thrust applied.

Solution : *Given*, Pressure P = 50 Pa, area A = 4 m^2

$$\text{Since, pressure P} = \frac{\text{thrust F}}{\text{area A}}$$

Thrust F = pressure P × area A
= 50 × 4 = 200 N

7. A force of 20 N acts normally on a body having area of cross section 10 cm^2. Calculate the pressure exerted by the body.

Solution : *Given*, thrust F = 20 N

$$\text{Area A} = 10 \text{ cm}^2 = \frac{10}{1000} \text{ m}^2$$

$$= 10^{-3} \text{ m}^2$$

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}} = \frac{20 \text{ N}}{10^{-3} \text{ m}^2}$$

$$= 2 \times 10^4 \text{ N m}^{-2}$$

8. What is the magnitude of thrust required in newton to produce a pressure of 26500 Pa on an area of 100 cm^2 ?

Solution : *Given*,

$$\text{Area A} = 100 \text{ cm}^2 = \frac{100}{10000} \text{ m}^2 = 10^{-2} \text{ m}^2$$

pressure P = 26500 Pa

$$\text{Since, } P = \frac{F}{A}$$

Thrust F = P × A = 26500 × 10^{-2} N
= 265 N

9. A normal force of 100 N can produce a pressure of 100000 Pa. Calculate the area in cm^2 on which the force shall act to exert the pressure.

Solution : *Given*, Thrust F = 100 N

pressure P = 100000 Pa

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

$$\therefore\ A = \frac{F}{P} = \frac{100}{100000}\ m^2 = \frac{1}{1000}\ m^2$$

$$= \frac{1}{1000} \times 10000\ cm^2 = 10\ cm^2$$

10. A force of 10 N acts normally on a surface of area $0{\cdot}2\ m^2$. Find the pressure exerted on the surface.

Solution : *Given*, F = 10 N, $A = 0{\cdot}2\ m^2$

$$\text{Pressure } P = \frac{F}{A} = \frac{10\ N}{0{\cdot}2\ m^2} = 50\ N\ m^{-2}$$

11. The dimensions of heel of shoes of a girl weighing 45 kgf are $1{\cdot}5$ cm × 1 cm. Find the pressure exerted on the ground when she is standing on one heel.

Solution : *Given*, F = 45 kgf,

$A = 1{\cdot}5\ cm \times 1\ cm = 1{\cdot}5\ cm^2$

$$\text{Pressure } P = \frac{F}{A} = \frac{45\ kgf}{1{\cdot}5\ cm^2} = 30\ kgf\ cm^{-2}$$

12. A block of weight 5 kgf and dimensions 5 cm × 2 cm × 1 cm rests on a table in three different positions with its base as (i) 5 cm × 2 cm, (ii) 2 cm × 1 cm, (iii) 1 cm × 5 cm. Calculate the pressure exerted on the table in each case.

Solution : *Given*, In each case, F = 5 kgf

(i) In the first case,

$$A = 5\ cm \times 2\ cm = 10\ cm^2$$

$$\text{Pressure } P = \frac{F}{A} = \frac{5\ kgf}{10\ cm^2} = 0{\cdot}5\ kgf\ cm^{-2}$$

(ii) In the second case,

$$A = 2\ cm \times 1\ cm = 2\ cm^2$$

$$\text{Pressure } P = \frac{F}{A} = \frac{5\ kgf}{2\ cm^2} = 2{\cdot}5\ kgf\ cm^{-2}$$

(iii) In the third case,

$$A = 1\ cm \times 5\ cm = 5\ cm^2$$

$$\text{Pressure } P = \frac{F}{A} = \frac{5\ kgf}{5\ cm^2} = 1\ kgf\ cm^{-2}$$

13. A girl weighing 50 kgf wears sandals of pencil heel of area of cross section 1 cm^2, stands on a floor. An elephant weighing 2000 kgf stands on foot each of area of cross section 25 cm^2, on the floor. Compare the pressure exerted by them.

Solution : *Given*, for girl: Weight or force F_1 = 50 kgf

Area of both heels

$$A_1 = 2 \times 1\ cm^2 = 2\ cm^2$$

$$\text{Pressure } P_1 = \frac{F_1}{A_1} = \frac{50\ kgf}{2\ cm^2} = 25\ kgf\ cm^{-2}$$

For elephant, Weight = force F_2 = 2000 kgf

Area of four feet

$$A_2 = 4 \times 250\ cm^2 = 1000\ cm^2$$

$$\text{Pressure } P_2 = \frac{F_2}{A_2} = \frac{2000\ kgf}{1000\ cm^2} = 2\ kgf\ cm^{-2}$$

$$\text{now } \frac{\text{Pressure exerted by girl}}{\text{Pressure exerted by elephant}} = \frac{P_1}{P_2}$$

$$= \frac{25\ kgf\ cm^{-2}}{2\ kgf\ cm^{-2}} = 12{\cdot}5 : 1$$

Thus, the girl's pointed heel sandals exert $12{\cdot}5$ times more pressure than the pressure exerted by the elephant.

RECAPITULATION

- A force when acts on a rigid body which is free to move, can produce only the change in state of rest or motion.
- A force when acts on a non-rigid body which is free to move, can produce change in state of rest or motion as well as change in size or shape of the body.
- A force requires both its magnitude and direction to represent it.
- Force is represented by an arrow. The length of arrow is a measure of its magnitude and the arrow gives its direction.
- The S.I. unit of force is newton (symbol N) and its gravitational unit is kilogram force (kgf) where

  $$1 \text{ kgf} = 10 \text{ N (nearly)}.$$
- If a force is applied on a body which is pivoted at a point, the force can turn the body about that point. This is called the turning effect of force.
- The turning effect of a force depends on two factors : (i) the magnitude of force, and (ii) the perpendicular distance of force from the pivoted point. Greater the magnitude of force, more is the turning effect. Similarly greater the perpendicular distance of force from the pivoted point, more is the turning effect.
- The product of magnitude of force and the perpendicular distance of force from the pivoted point is called moment of force about the pivoted point, *i.e.*

  Moment of force = force (F) × perpendicular distance (d).
- The S.I. unit of moment of force is newton × metre (symbol N m).
- If a body turns towards the right, the moment of force is clockwise and negative but if the body turns towards the left, the moment of force is anticlockwise and positive.
- Thrust is a force that acts normally on a surface.
- Thrust exerted by a body on a surface is same howsoever it is placed.
- The effect of thrust depends on the area of the surface on which it acts.
- The units of thrust are kgf, gf and newton (N). They are related as :

  $$1 \text{ kgf} = 1000 \text{ gf}, 1 \text{ kgf} = 10 \text{ N (nearly) and } 1 \text{ N} = 100 \text{ gf (nearly)}$$
- Pressure is defined as the thrust per unit area *i.e.* Pressure $P = \dfrac{\text{Thrust F}}{\text{Area A}}$.
- Pressure on a surface depends on :

  (a) the area of the surface on which the thrust acts, (b) the magnitude of thrust acting on the surface.
- Smaller the surface area, more is the pressure exerted by the thrust.
- More the thrust on an area, more is the pressure.
- The pressure on a surface is increased by reducing the area of the surface and is reduced by increasing the area of the surface.
- The S.I. unit of pressure is newton per metre^2 (symbol N/m^2 or N m^{-2}) which is also called pascal (symbol Pa).
- Liquids and gases exert pressure in all directions. They exert pressure not only at the bottom, but also on the sides of the container in which they are kept.
- Pascal's law states that the pressure exerted by a liquid at a depth is same in all directions.

- The liquid pressure depends on the following two factors :
  - (a) the height of the liquid column. Liquid pressure at a point increases with the increase in height of the liquid column above that point.
  - (b) the density of the liquid. Liquid pressure increases with the increase in the density of liquid.
- The envelop of air up to a height of about 200 km around the earth is called the atmosphere.
- The weight of air exerts thrust on earth.
- The atmospheric pressure is the thrust on a unit area of the earth surface due to the column of air above it.
- At sea level the atmospheric pressure is equal to the pressure of 0·76 m of mercury column of air = 1 atm $= 1{\cdot}013 \times 10^5$ Pa.
- Atmospheric pressure decreases with increasing height from the sea level.

TEST YOURSELF

A. Objective Questions :

1. Write **true** or **false** for each statement :
   (a) The S.I. unit of force is kgf.
   (b) A force always produces both the linear and turning motions.
   (c) Moment of force = force × perpendicular distance of force from the pivoted point.
   (d) Less force is needed when applied at a farther distance from the pivoted point.
   (e) For a given thrust, pressure is more on a surface of large area.
   (f) The pressure on a surface increases with an increase in the thrust on the surface.
   (g) A man exerts same pressure on the ground whether he is standing or he is lying.
   (h) It is easier to hammer a blunt nail into a piece of wood than a sharply pointed nail.
   (i) The S.I. unit of pressure is pascal.
   (j) Water in a lake exerts pressure only at its bottom.
   (k) A liquid exerts pressure in all directions.
   (l) Gases exert pressure in all directions.
   (m) The atmospheric pressure is nearly 10^5 Pa.
   (n) Higher we go, greater is the air pressure.

   Ans.: True—(c), (d), (f), (i), (k), (l), (m)
   False—(a), (b), (e), (g), (h), (j), (n)

2. Fill in the blanks :
   (a) 1kgf = ... N (nearly)
   (b) Moment of force = ... × distance of force from the point of turning
   (c) In a door, handle is provided .... from the hinges.
   (d) The unit of thrust is ....
   (e) Thrust is the .... force acting on a surface.
   (f) Pressure is the thrust acting on a surface of .... area.
   (g) The unit of pressure is ....
   (h) Pressure is reduced if .... increases.
   (i) Pressure in a liquid .... with the depth.
   (j) The atmospheric pressure on earth surface is nearly ....

   Ans.: (a) 10 (b) force (c) farthest (d) newton (e) normal (f) unit (g) pascal (h) area of surface (i) increases (j) 10^5 Pa

3. Match the following :

	Column A		Column B
(a)	Camel	(i)	broad and deep foundation
(b)	Truck	(ii)	broad feet
(c)	Knife	(iii)	six or eight tyres
(d)	High building	(iv)	sharp cutting edge
(e)	Thrust	(v)	atm
(f)	Moment of force	(vi)	N
(g)	Atmospheric pressure	(vii)	N m

   Ans.: (a)–(ii), (b)–(iii), (c)–(iv), (d)–(i), (e)–(vi), (f)–(vii), (g)–(v)

4. Select the correct alternative :

(a) S.I. unit of moment of force is :

(i) N (ii) N cm
(iii) kgf m (iv) N m

(b) To obtain a given moment of force for turning a body, the force needed can be decreased by :

(i) applying the force at the pivoted point
(ii) applying the force very close to the pivoted point
(iii) applying the force farthest from the pivoted point
(iv) none of the above.

(c) The unit of thrust is :

(i) kgf (ii) kg
(iii) g (iv) m s^{-1}

(d) The unit of pressure is :

(i) N × m (ii) kgf
(iii) N m^{-2} (iv) kgf m^2

(e) The pressure and thrust are related as :

(i) Pressure = Thrust
(ii) Pressure = Thrust × Area
(iii) Pressure = Thrust / Area,
(iv) Pressure = Area / Thrust

(f) A body weighing 5 kgf, placed on a surface of area 0·1 m^2, exerts a thrust on the surface equal to :

(i) 50 kgf (ii) 5 kgf
(iii) 50 kgf m^{-2} (d) 5 kgf m^{-2}

(g) The feet of lizards act like :

(i) moving pads (ii) drilling pads
(iii) suction pads (iv) none of the above

(h) Pressure exerted by a liquid is due to its :

(i) weight (ii) mass
(iii) volume (iv) area

(i) Pressure inside a liquid increases with:

(i) increase in depth
(ii) decrease in depth
(iii) decrease in density
(iv) none of the above

(j) The atmospheric pressure at sea level is nearly :

(i) 10 Pa (ii) 100,000 Pa
(iii) 100 Pa (iv) 10,000 Pa

(k) Nose bleeding may occur at a high altitude because :

(i) the atmospheric pressure decreases
(ii) the oxygen content of atmosphere decreases
(iii) the atmospheric pressure increases
(iv) there are strong air currents at the high altitude

Ans.: (a)–(iv), (b)–(iii), (c)–(i), (d)–(iii), (e)–(iii), (f)–(ii), (g)–(iii), (h)–(iii), (i)–(i), (j)–(i), (k)–(ii), (l)–(i)

B. Short/Long Answer Questions :

1. Define force. State its S.I. unit.
2. State two effects of a force when applied on a body.
3. How does the effect of a force differ when it is applied on (a) a rigid body, (b) a non-rigid body ?
4. State the effect of force F in each of the following diagrams (a) and (b).

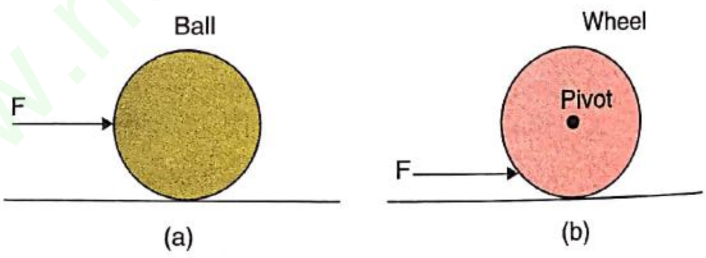


Fig. 3.32

5. Define the term moment of force.
6. State the S.I. unit of moment of force.
7. State two factors on which affect moment of force.
8. In Fig. 3.33 a force F is applied in a direction passing through the pivoted point O of the body. Will the body rotate ? Give reason to support your answer.

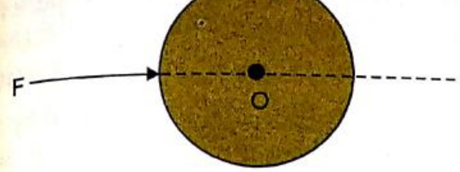


Fig. 3.33

9. Write the expression for the moment of force about a given axis of rotation.
10. State one way to decrease the moment of a given force about a given axis of rotation.
11. State one way to obtain greater moment of a given force about a given axis of rotation.
12. What do you mean by the clockwise and anti-clockwise moment of force ?
13. Explain the following :
    (a) The spanner (or wrench) has a long handle.
    (b) The steering wheel of a vehicle is of large diameter.
    (c) The hand flour grinder is provided with a handle near the rim.
    (d) It is easier to open the door by pushing it at its free end.
    (e) A potter turns his wheel by applying a force through the stick near the rim of wheel.
14. What is thrust ?
15. State the unit of thrust.
16. On what factors does the effect of thrust on a surface depend ?
17. Define the term 'pressure' and state its unit.
18. How is the thrust related to pressure ?
19. Name two factors on which the pressure on a surface depends.
20. When does a man exert more pressure on the floor : while standing or while walking ?
21. Why do camels or elephants have broad feet ?
22. A sharp pin works better than a blunt pin. Explain the reason.
23. Why is the bottom part of the foundation of a building made wider ?
24. It is easier to cut with a sharp knife than with a blunt one. Explain.
25. A gum bottle rests on its base. If it is placed upside down, how does the (i) thrust, (ii) pressure change ?
26. Explain the following:
    (a) Sleepers are used below the rails.
    (b) A tall building has wide foundations.
27. Describe an experiment to show that a liquid exerts pressure at the bottom of the container in which it is kept.
28. Describe a suitable experiment to demonstrate that a liquid exerts pressure sideways also.
29. Describe a simple experiment to show that at a given depth, a liquid exerts same pressure in all directions.
30. State two factors on which the pressure at a point in a liquid depends.
31. Describe an experiment to show that the liquid pressure at a point increases with the increase in height of the liquid column above that point.
32. Which fact about liquid pressure does the diagram in Fig. 3.34 illustrate ?

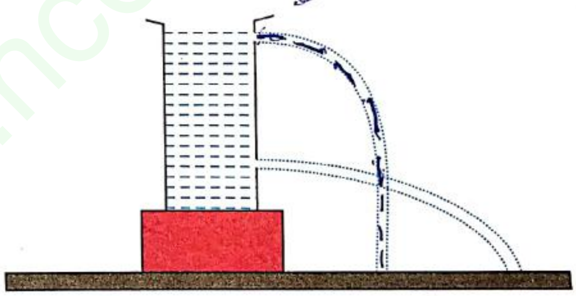


Fig. 3.34

33. Describe an experiment to show that liquid pressure depends on the density of liquid.
34. A dam has broader walls at the bottom than at the top. Give a reason.
35. What do you mean by atmospheric pressure ?
36. Write the numerical value of the atmospheric pressure on the earth surface in pascal.
37. We do not feel uneasy even under the enormous atmospheric pressure. Give a reason.

38. Describe a simple experiment to illustrate that air exerts pressure.

39. Describe the crushing tin can experiment. What do you conclude from this experiment ?

40. Give reasons for the following :
   (a) A balloon collapses when air is removed from it.
   (b) Water does not run out of a dropper unless its rubber bulb is pressed.
   (c) Two holes are made in a sealed oil tin to take out oil from it.

41. How does the atmospheric pressure change with altitude ?

C. Numericals :

1. Find the moment of force of 20 N about an axis of rotation at distance 0·5 m from the force. **Ans.** 10 N m

2. The moment of a force of 25 N about a point is 2·5 N m. Find the perpendicular distance of force from that point. **Ans.** 10 cm

3. A spanner of length 10 cm is used to open a nut by applying a minimum force of 5·0 N. Calculate the moment of force required. **Ans. 0·5 N m**

4. A wheel of diameter 2 m can be rotated about an axis passing through its centre by a moment of force equal to 2·0 N m. What minimum force must be applied on its rim ? **Ans.** 1 N

5. A normal force of 200 N acts on an area of 0·02 m^2. Find the pressure in pascal. **Ans.** 10,000 Pa

6. Find the thrust required to exert a pressure of 50,000 pascal on an area of 0·05 m^2. **Ans.** 2500 N

7. Find the area of a body which experiences a pressure of 50,000 Pa by a thrust of 100 N. **Ans.** 2×10^{-3} m^2

8. Calculate the pressure in pascal exerted by a force of 300 N acting normally on an area of 30 cm^2. **Ans.** 10^5 Pa

9. How much thrust will be required to exert a pressure of 20,000 Pa on an area of 1 cm^2 ? **Ans.** 2 N

10. The base of a container measures 15 cm × 20 cm. It is placed on a table top. If the weight of the container is 60 N, what is the pressure exerted by the container on the table top ? **Ans.** 2000 Pa

11. Calculate the pressure exerted on a surface of 0·5 m^2 by a thrust of 100 kgf. **Ans.** 200 kgf m^{-2}

12. A boy weighing 60 kgf stands on platform of dimensions 2·5 cm × 0·5 cm. What pressure in pascal does he exert ? **Ans.** 4.8×10^6 Pa

13. Fig 3.35 shows a brick of weight 2 kgf and dimensions 20 cm × 10 cm × 5 cm placed in three different positions on the ground. Find the pressure exerted by the brick in each case.

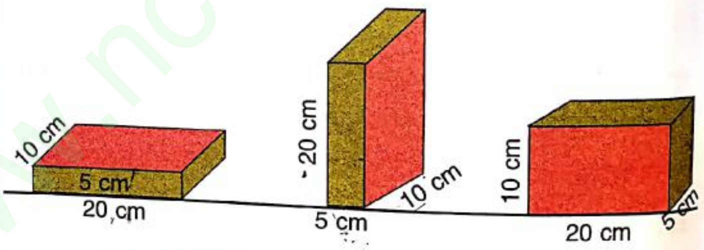


Fig. 3.35 Pressure exerted by a brick placed in three different positions

Ans. (a) 0·01 kgf cm^{-2} (b) 0·04 kgf cm^{-2} (c) 0·02 kgf cm^{-2}

Project Work

Take a tray with dimensions about 40 cm × 30 cm × 10 cm. Fill it completely with wheat flour and level its surface plane.

(1) Lay down a brick A gently on the surface of flour. Write your observtion. Then place another identical brick B on brick A. What change do you observe ? Write and explain it.

(2) Remove both the bricks and level the surface plane again. Now lay down the brick A and place the brick B to stand vertical. Write your observations for the brick A and brick B. Explain the difference in observation of both bricks when placed on flour.