Example 10.4 Mass of an object is 10 kg. What is its weight on the earth?

Solution:

Mass, m = 10 kg
Acceleration due to gravity, $g = 9.8 \text{ m s}^{-2}$

$W = m \times g$

$W = 10 \text{ kg} \times 9.8 \text{ m s}^{-2} = 98 \text{ N}$

Thus, the weight of the object is 98 N.

Example 10.5 An object weighs 10 N when measured on the surface of the earth. What would be its weight when measured on the surface of the moon?

Solution:

We know,
Weight of object on the moon
= (1/6) × its weight on the earth.
That is,

$$W_m = \frac{W_e}{6} = \frac{10}{6} \text{ N.}$$

$= 1.67$ N.

Thus, the weight of object on the surface of the moon would be 1.67 N.

Questions

1. *What are the differences between the mass of an object and its weight?*
2. *Why is the weight of an object on the moon $\frac{1}{6}^{th}$ its weight on the earth?*

10.5 Thrust and Pressure

Have you ever wondered why a camel can run in a desert easily? Why an army tank weighing more than a thousand tonne rests upon a continuous chain? Why a truck or a motorbus has much wider tyres? Why cutting tools have sharp edges? In order to address these questions and understand the phenomena involved, it helps to introduce the concepts of the net force in a particular direction (thrust) and the force per unit area (pressure) acting on the object concerned.

Let us try to understand the meanings of thrust and pressure by considering the following situations:

Situation 1: You wish to fix a poster on a bulletin board, as shown in Fig 10.3. To do this task you will have to press drawing pins with your thumb. You apply a force on the surface area of the head of the pin. This force is directed perpendicular to the surface area of the board. This force acts on a smaller area at the tip of the pin.

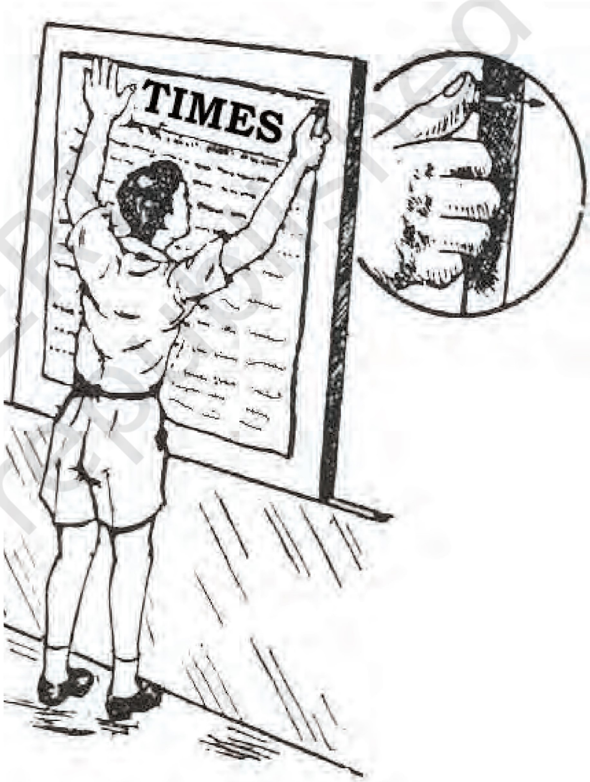

***Fig. 10.3:** To fix a poster, drawing pins are pressed with the thumb perpendicular to the board.*

Situation 2: You stand on loose sand. Your feet go deep into the sand. Now, lie down on the sand. You will find that your body will not go that deep in the sand. In both cases the force exerted on the sand is the weight of your body.

You have learnt that weight is the force acting vertically downwards. Here the force is acting perpendicular to the surface of the sand. The force acting on an object perpendicular to the surface is called thrust.

When you stand on loose sand, the force, that is, the weight of your body is acting on an area equal to area of your feet. When you lie down, the same force acts on an area equal to the contact area of your whole body, which is larger than the area of your feet. Thus, the effects of forces of the same magnitude on different areas are different. In the above cases, thrust is the same. But effects are different. Therefore the effect of thrust depends on the area on which it acts.

The effect of thrust on sand is larger while standing than while lying. The thrust on unit area is called pressure. Thus,

$$\text{Pressure} = \frac{\text{thrust}}{\text{area}} \qquad (10.20)$$

Substituting the SI unit of thrust and area in Eq. (10.20), we get the SI unit of pressure as N/m^2 or $N\ m^{-2}$.

In honour of scientist Blaise Pascal, the SI unit of pressure is called pascal, denoted as Pa.

Let us consider a numerical example to understand the effects of thrust acting on different areas.

Example 10.6 A block of wood is kept on a tabletop. The mass of wooden block is 5 kg and its dimensions are 40 cm × 20 cm × 10 cm. Find the pressure exerted by the wooden block on the table top if it is made to lie on the table top with its sides of dimensions (a) 20 cm × 10 cm and (b) 40 cm × 20 cm.

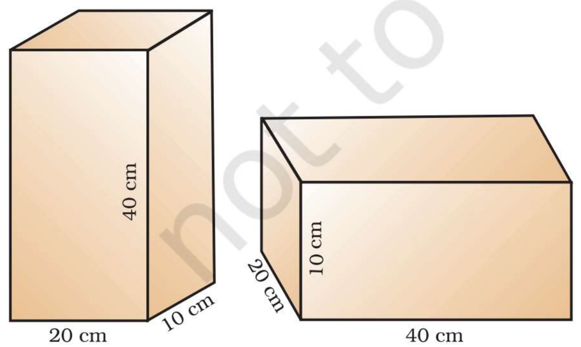

Fig. 10.4

Solution:

The mass of the wooden block = 5 kg

The dimensions

= 40 cm × 20 cm × 10 cm

Here, the weight of the wooden block applies a thrust on the table top.

That is,

$$\text{Thrust} = F = m \times g$$
$$= 5\ \text{kg} \times 9.8\ \text{m s}^{-2}$$
$$= 49\ \text{N}$$

Area of a side = length × breadth
= 20 cm × 10 cm
= $200\ cm^2 = 0.02\ m^2$

From Eq. (10.20),

$$\text{Pressure} = \frac{49\,\text{N}}{0.02\,\text{m}^2}$$
$$= 2450\ \text{N m}^{-2}.$$

When the block lies on its side of dimensions 40 cm × 20 cm, it exerts the same thrust.

Area = length × breadth
= 40 cm × 20 cm
= $800\ cm^2 = 0.08\ m^2$

From Eq. (10.20),

$$\text{Pressure} = \frac{49\,\text{N}}{0.08\,\text{m}^2}$$
$$= 612.5\ \text{N m}^{-2}$$

The pressure exerted by the side 20 cm × 10 cm is 2450 $N\ m^{-2}$ and by the side 40 cm × 20 cm is 612.5 $N\ m^{-2}$.

Thus, the same force acting on a smaller area exerts a larger pressure, and a smaller pressure on a larger area. This is the reason why a nail has a pointed tip, knives have sharp edges and buildings have wide foundations.

10.5.1 Pressure in Fluids

All liquids and gases are fluids. A solid exerts pressure on a surface due to its weight. Similarly, fluids have weight, and they also