
# UNIT 5

# FORCES AND MATTER

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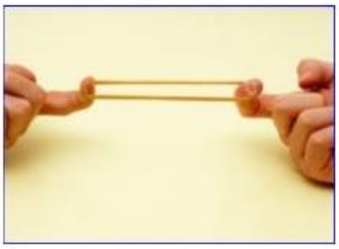
## FORCE

Force can be defined as
A push or a pull that changes or tends to change the state of rest or uniform motion of an object or changes the direction or shape of an object.

## FORCES ACTING ON SOLIDS

Solids have definite shapes and sizes; however, it is possible to change their shapes and sizes by applying external forces. When the external force is removed, the object tends to return to its original shape and size. This behavior is called elastic behavior. Solids can be stretched, squashed, bent, or twisted, as shown in Fig. These figures show the different ways in which the elastic behavior of solid objects can be demonstrated.

stretched



twisted

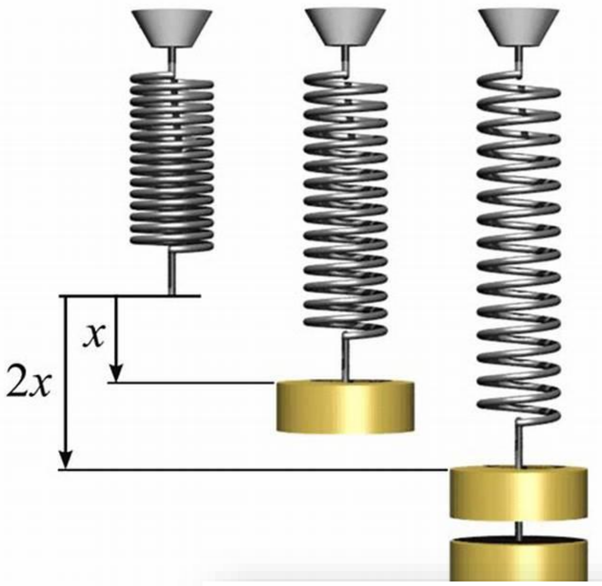
squashed

bent

## STRETCHING SPRINGS

Consider a spring hung from a rigid support, so that its top end is fixed; Fig Weights are hung on the other end of the spring. These are called loads. As the load is increased, the spring is stretched, and its length increases.

When the load is removed, the spring returns to its original length. This is called elastic change. When the load is increased in regular steps the length of the spring also increases simultaneously. If the load is increased greatly, the spring will change its shape permanently.

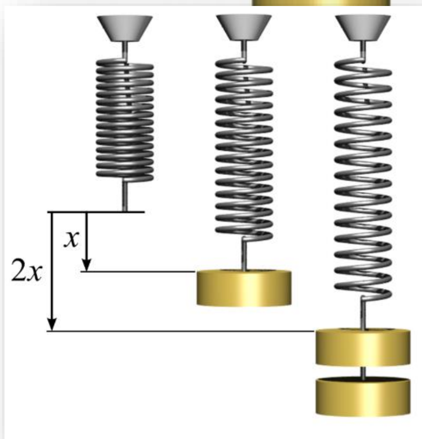



## EXTENSION OF SPRING

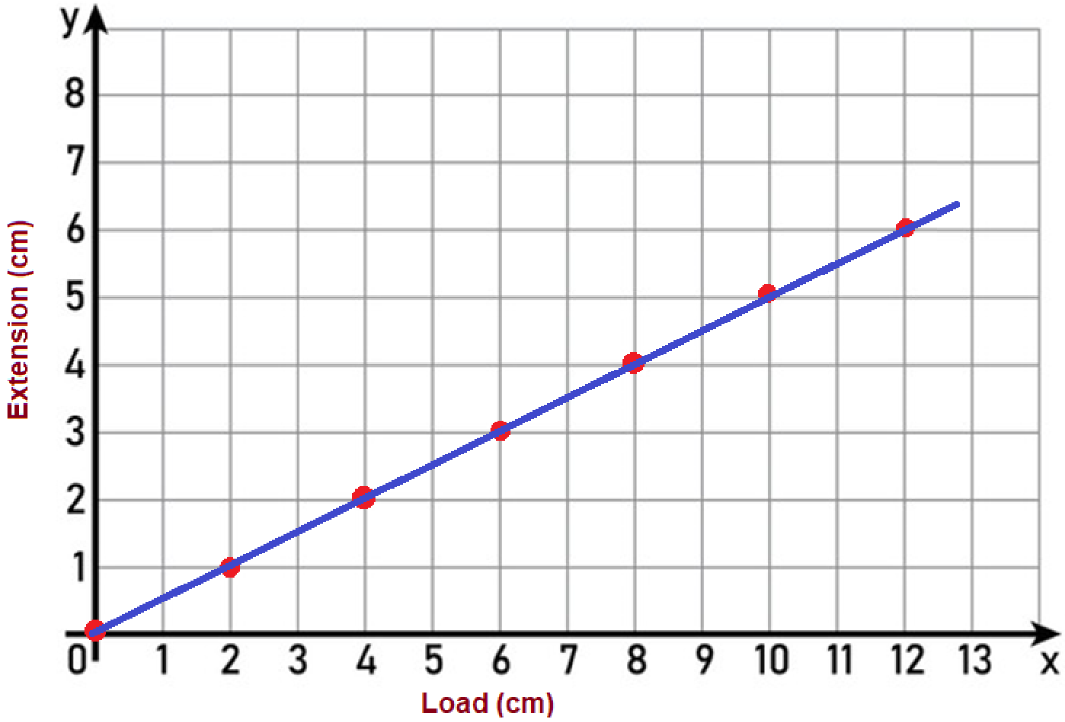
The length of the spring increases as the force (load) increases; Fig. This increase in spring length is known as extension. Hence

$$\textit{Length of stretched spring} = \textit{Original length} + \textit{Extension}$$

Let's experiment with stretching a spring of its original length 20cm. Table shows the recorded result of this experiment. The first column shows the increase in load in regular steps. The second column shows the increase in the length of the stretched spring. The third column shows the value of extension, due to the change in length in each step.




| LOAD (N) | LENGTH (cm) | EXTENSION (cm) |
|---|---|---|
| 0.0 | 20 | 0.0 |
| 2.0 | 21 | 1.0 |
| 4.0 | 22 | 2.0 |
| 6.0 | 23 | 3.0 |
| 8.0 | 24 | 4.0 |
| 10 | 25 | 5.0 |
| 12 | 26 | 6.0 |




The graph slopes up steadily. This shows that the extension increases in equal steps as the load increases. This behavior can also be observed in the table .

## HOOKE'S LAW

Within the elastic limit, the displacement produced in the spring is directly proportional to the force applied.

Mathematically if ‘F’ is the applied force and ‘x’ is the displacement (extension) in the spring then the equation for Hooke's law may be written as:

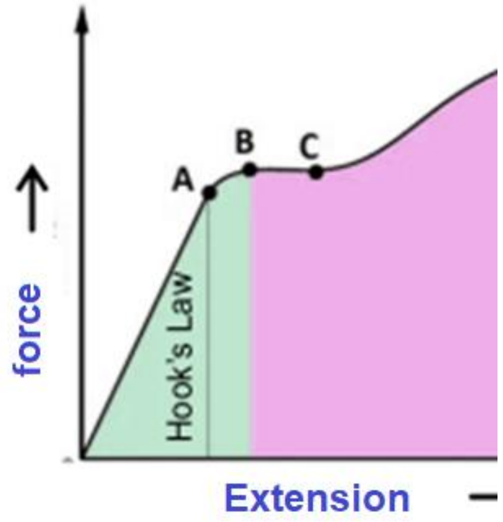
$$F \alpha \ x$$

$$F = k\, x$$

Where k is the spring constant.

## HOOKE'S LAW GRAPH

This illustrates that as applied force (stress) on material increases the extension in the spring also increases linearly and after a certain point that is elastic or yield limit the curve becomes non-linear. Thus up to point A, Hooke’s law is valid and the area under the curve up to this point is referred to as Hooke’s region. In the region between A to B, force or stress and extension are no longer held proportional. Thus, Hooke’s law is not valid in this zone. Beyond this body cannot retrace back to its original shape and size and the body will start deforming and it is said to be permanent deformation.



## PRESSURE

The force acting normally per unit area on the surface of a body is called pressure.

## FORMULA

$$pressure = \frac{Force}{Area}$$

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

**UNIT OF PRESSURE:**

The unit of pressure is Newton per metre square ($N/m^2$ or $Nm^{-2}$ )

**1 $Nm^{-2}$ = 1 Pascal**

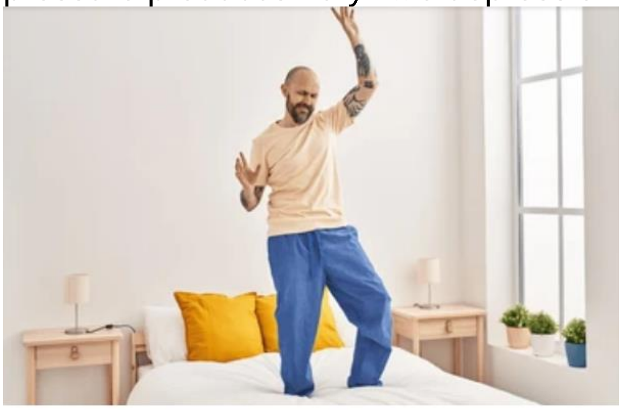
Pascal is also the unit of pressure. It is represented by “**Pa**”

**PASCAL:**

**If one Newton force is applied on a unit area then the pressure exerted is one Pascal.**

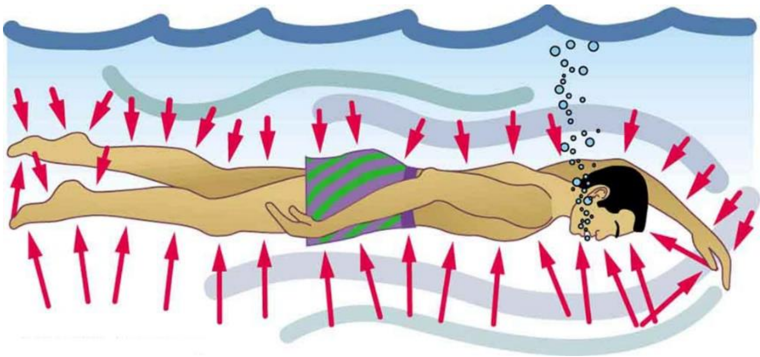
**HIGH PRESSURE, LOW PRESSURE**

When a man stands on a cushion then only his two feet (having a smaller area) are in contact with the cushion. Due to this, the weight of the man falls on a small area of the cushion producing a large pressure. This large pressure causes a big depression in the cushion. On the other hand, when the same man is lying on the cushion, then his whole body (having a large area) is in contact with the cushion. In this case, the weight of the man falls on a much larger area of the cushion producing much smaller pressure. And this smaller pressure produces very little depression in the cushion.



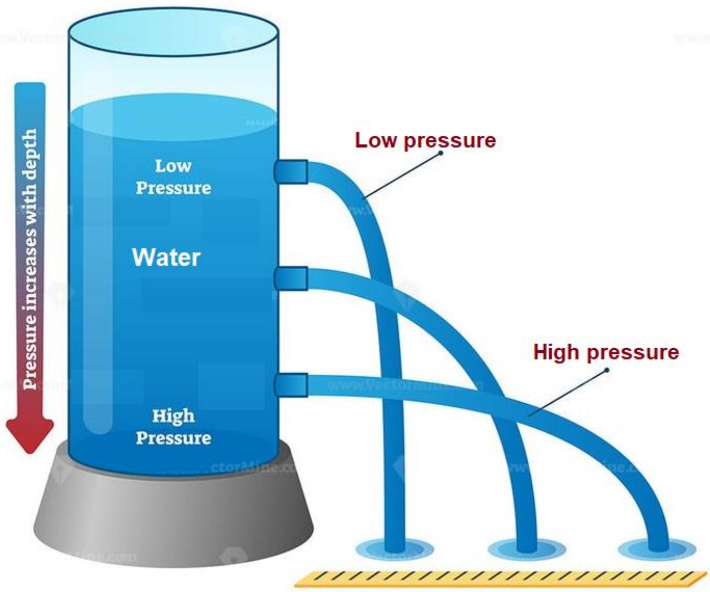
# PRESSURE IN FLUIDS

A fluid is a collection of molecules that are randomly arranged and held together by weak cohesive forces and by forces exerted by the walls of a container. Both liquids and gases are fluids. The pressure exerted by fluids is known as fluid pressure. It acts in all directions. This is because the molecules of fluids move around in all directions, causing pressure on every surface they collide with. A swimmer in a swimming pool experiences the pressure by water which pushes the swimmer from all sides



**PRESSURE INCREASES WITH DEPTH**

The right figure shows a sample way of demonstrating that the pressure in a liquid increases with depth. The water comes out of the lower tube in the tank fastest due to the greatest pressure. The pressure is caused by the weight of the liquid above the level of the tube, and the weight of the liquid is proportional to the height of the liquid above the level. The distances reached from the base of the tank by the jet of water are roughly proportional to the height of the water




**CALCULATING PRESSURE IN A LIQUID**

The pressure exerted by a liquid is experienced by any surface in contact with it. An expression for the pressure **P** at a depth h in a liquid of density ρ can be found by considering a small horizontal area **A.**

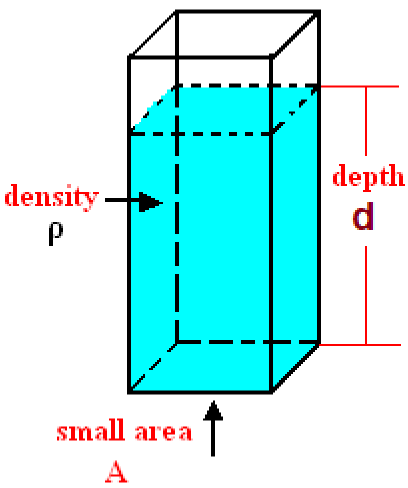
$$pressure = \frac{Force}{Area}$$

$$pressure = \frac{weight}{Area}$$

$$P = \frac{mg}{A} \quad \ldots\ldots\ldots\ldots(i)$$

$$mass = (density)(volume)$$

$$m = (\rho)(A \times d)$$




By putting the expression of mass in equation (i)

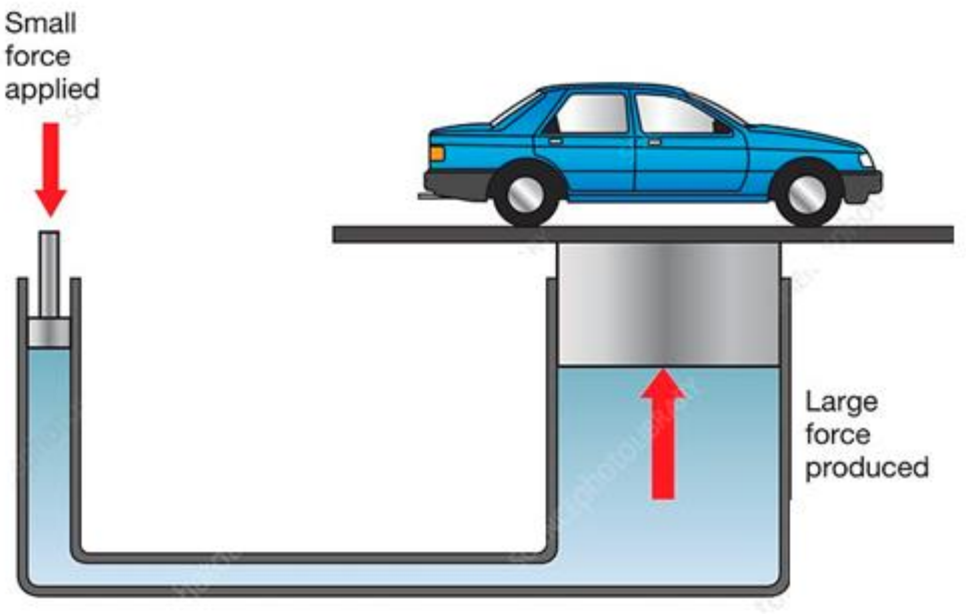
$$P = \frac{(\rho)(A \times d)g}{A}$$

$$P = \rho g d$$

## PASCAL'S LAW

The pressure applied externally at any point of a liquid enclosed in a container is transmitted equally to all parts of the liquid in container.

### 1. HYDRAULIC LIFT OR HYDRAULIC JACK.




**Hydraulic lift is able to raise up large weight up to relatively short distance. The hydraulic lift or jack is applications of hydraulics being used as a simple machine to multiply force. It contains an incompressible fluid in a U-shaped tube which is narrower at start and becomes wider area at end which is fixed with a movable piston on each side. If a small force $F_1$ is applied to the small piston of the hydraulic lift as shown in figure, the pressure is transmitted with in all directions. The pressure on the large piston is the same as the pressure on the small piston; however, the force $F_2$ on the large piston is greater because of its large surface area which used to uplift the car**.

**the pressure on the small piston = the pressure on the small piston**

$$P_1 = P_2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Or

$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$

**Where ( $F_2$ / $F_1$ ) is known as mechanical advantage which is equal to the ratios of areas..**