- **INTRODUCTION**

We use force all the time. We use force to open a door, to pick up the school bag, to brush our teeth, to squeeze out toothpaste from a tube, to turn on a tap and so on. Even the earth is exerting a force on us all time. It is pulling all of us and all things on earth towards it. We use force for every single action of ours! You have studied force in previous classes.

A person pushing a table

Do you remember what a force is?

NOTE :

- **Force has a sense of direction also. It means that we can apply the same amount of force in a different direction, producing different effects. Without a source, the force cannot be possible.**

Additional Stuff
When forces are applied on an object in the same direction, we get the net force by adding the magnitude of forces. When two forces are applied on an object in the opposite direction the net force is the difference in the magnitude of forces and acts in the direction of larger force.

- **UNIT OF FORCE**

(i) The SI unit (in standard international system) of force is called Newton and its symbol is **N**

(kg × m/sec^2)

(ii) C.G.S unit of force is dynes (gm cm/s^2)

1 Newton = 10^5 dynes,

1 N = kg – m/s^2

= 1(1000 gm) (100 cm/s^2)

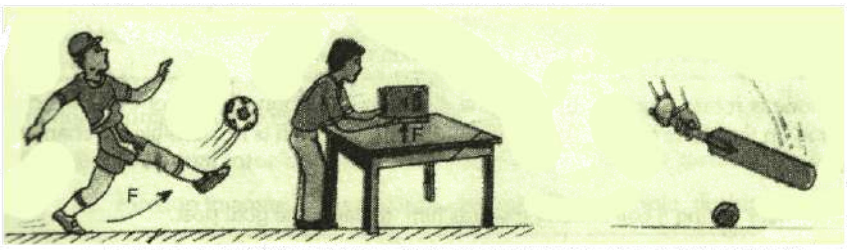
= 10^5 gm–cm/s^2

So that 1 N = 10^5 dyne

- **EFFECT OF FORCE**

- **FORCE CAN MOVE A BODY LYING AT REST**

Example :



Force exerting on bodies to move them from rest

(a) Kicking a stationary football.

(b) Lifting a book kept on a table top.

(c) Hitting a stationary ball with a bat.

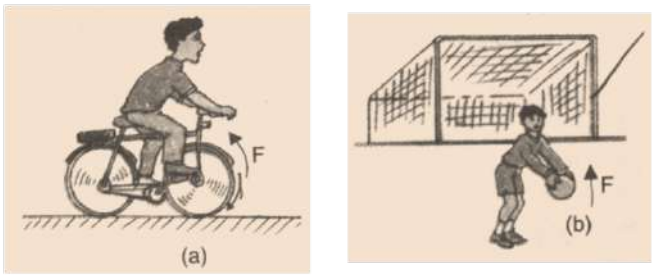
- **FORCE CAN STOP A MOVING BODY**

Example :

(a) A goalkeeper stopping a football moving towards the goal post.

(b) A moving bicycle coming to rest on applying brakes. Here the frictional force between the brake

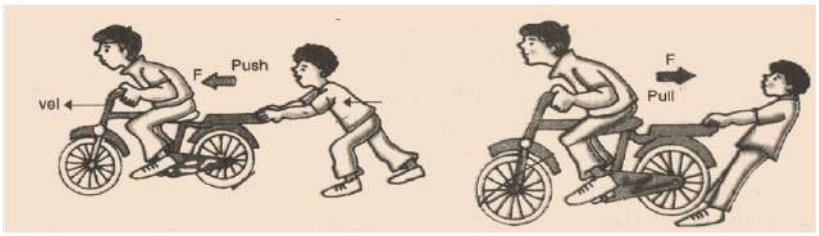
lining of the brake shoe and the bicycle wheel rim acts to stop the bicycle.



Force exerted to stop a moving body

FORCE CAN CHANGE THE SPEED OF A MOVING BODY

Ex. To decrease speed, force is applied in a direction opposite to the body's motion. If we apply force in the direction of motion of the body, it tends to increase the body's speed. For example, if your friend is riding a bicycle and you push the bicycle in the same direction. The speed of the bicycle will increase. On the other hand, if you pull the bicycle, i.e., you apply force against the direction of motion, the speed of the bicycle decreases.



(a) Force exerted in the direction of velocity (b) Force exerted in opposite direction of velocity

FORCE CAN CHANGE THE DIRECTION OF A MOVING BODY

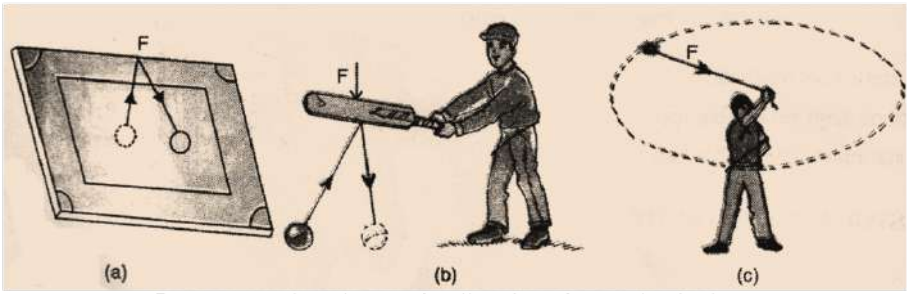
Example :

(a) A carom counter changes its direction after a collision.

(b) When a batsman hits a ball, he changes the direction of the ball.

(c) When a stone is rotated in a circular path, the direction of motion of the stone change continuously. The force acting on the stone towards the centre of the circular path is responsible for changing the direction of the stone.

(d)A football player hitting a ball coming towards him, towards the goal post.



Force exerted to change the direction of a moving body

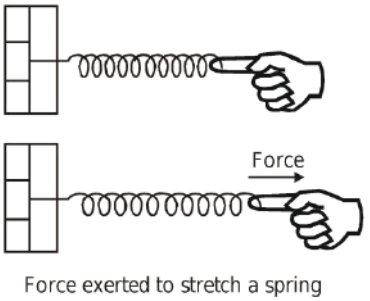
FORCE CAN CHANGE THE SHAPE AND SIZE OF AN OBJECT

Example :

(a) When we squeeze a toothpaste tube, it gets flattened.

(b) When we stretch a rubber band, its shape and size change.

(c) On stretching a spring, its length changes.



Force exerted to stretch a spring

- **FORCE CAN MAKE A BODY ROTATE.**

Example :

(a) When an electric current is passed through a ceiling fan's motor, forces are produced in the dynamo (or motor), making the fan rotate.

(b) For closing a door, you apply a push.

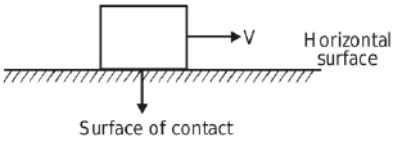
To conclude → , a force can accelerate a body, change its shape and size, or produce a rotational effect.

- **TYPES OF FORCE**

(I) CONTACT FORCE: When a force involves direct contact of two bodies, we call the force a contact force.

(II) FRICTIONAL FORCE:–

The force which acts to reduce relative motion between the surfaces of contact is called the frictional force.



Suppose a block is moving on a horizontal surface with a velocity (u). The darkened line at the bottom of the block is the surface of contact of the block with the floor. We notice that this surface of contact is moving towards the right with respect to the horizontal surface. To reduce this relative motion, a frictional force acts. The frictional force is exerted by the floor on the block in a direction opposite to velocity.

NOTE: Friction force :

(i) Frictional force acts in a direction opposite to that of the motion

(ii) The smoother the surface, the lesser is the frictional force.

Static friction: This acts when a body is stationary.

Kinetic friction: This acts when a body is moving.

- **Friction is helpful :**

(i) The friction between the floor and the soles of your feet or shoes allows you to walk comfortably.

(ii) Without friction between the tyres and the road, vehicles would skid.

(iii) It would be impossible to write without friction.

(iv) You require friction to light a match.

- **Friction causes problems :**

(i) Various machine parts which rub against each other.

(ii) Friction wastes energy too. When you ride a bicycle.

(iii) Friction generates heat.

(iv) Heat generated by friction can damage machines.

- **Reducing friction :**

(i) One way of reducing friction is to make the surfaces in contact smooth by polishing.

(ii) Another way of reducing friction is to use ball bearing or roller bearings.

(iii) The ones used between the wheel hub and the axle of a bicycle are small steel balls.

[Static friction is always greater than kinetic friction.]

(I) NORMAL FORCE :

The force acting on a body perpendicular to the surface of contact is called a normal force.

NOTE: Tension and spring force are also contact forces.

(II) MUSCULAR FORCE :

The force resulting due to the action of muscles is known as the muscular force. Animals also make use of muscular force to carry out their physical activities and other tasks. For example, animals like bullocks, horses, donkeys, and camels perform various tasks for us. In performing these tasks, they use muscular force. Since muscular force can be applied only when it is in contact with an object, it is also known as Biological Force.

(III) MECHANICAL FORCE :

The force exerted by a machine is called mechanical force. Machines do not produce force by themselves. To produce force, they need energy from other sources. Examples are the mechanical force produced by a car engine and the mechanical force produced by the turbines in a hydroelectric power station.

(A) NON-CONTACT FORCE

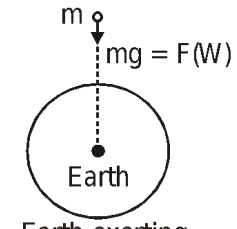
The force which a body applies to another body when the two bodies are not in contact with each other is called non-contact force.

- **GRAVITATIONAL FORCE :**

The force of attraction that one body exerts on the other because of its masses is called gravitational force.

Gravitational Force is the weakest force in nature. Still, this force is responsible for the revolution of the earth around the sun.

The S.I. unit of force is newton symbol (N) another unit of force, called the gravitational unit is kilogram force. Kg-f = kilogram force
1 kg-f = 9.80 N



Earth exerting gravitational force on mass m

The uniform acceleration produced in a freely falling body due to the gravitational force of the earth is known as acceleration due to gravity and it is denoted by the letter **g**. The value of g does not depend on the mass of the body. The value of g changes slightly from place to place but for most of the purposes it is taken as 9.8 m/s^2. Thus, **the acceleration due to gravity, g = 9.8 m/s^2.**

The force of gravity on a body is equal to the true weight of the body.

The force with which earth attracts a body is called the force of gravity. So a body of mass m is attracted by the earth towards its centre. This force is also called the weight (W) of the body.

$$W = mg$$

Fact File

We have read about different types of forces such as muscular, frictional gravitational, electrostatic force, magnetic force, tension, weight, viscous force, etc. But forces are fundamentally classified into four groups (a) Gravitational force (b) weak force (c) Electromagnetic force (d) Nuclear force. Scientists believe that these four groups also belong to a single type of force which is unknown to us as of date.

- **ELECTROSTATIC FORCE :**

  The force resulting from the repulsion of similar charges or attraction of opposite charges is called electrostatic force. For example, if we rub a plastic object like a pen or a comb with hair and bring it close to tiny bits of paper, the bits of paper get attracted to the plastic object. This is due to the electric force. Electrostatic Force can also attract tiny particles of dust and smoke. This method is used in air purifiers and factories to purify the air in chimneys before escaping into the atmosphere.

- **MAGNETIC FORCE :**

  This is the force exerted by magnets on each other and some metals like iron and nickel. Since magnets attract iron, magnets are used to separate waste iron objects from garbage dumps to

be recycled. Magnetic Force and electrostatic Force are inter-related and are together called electromagnetic force.

COMPETITION WINDOW

MASS

The amount of matter contained in a body is called it's mass

OR

The measure of the quantity of matter in a body is called it's mass.

The mass of a body is a **scalar quantity.** It is independent of **surroundings** and the **position** of the body. It is a **constant quantity for a given body.**

Mass is measured in kilogram (kg) in S.I. System.

WEIGHT

Everybody on the surface of the earth is attracted towards the centre of the earth. The Force of attraction depends upon the mass of the body and the acceleration due to gravity. The body's weight is the force with which it is attracted towards the centre of the earth. We know

$$F = ma$$

The acceleration produced by the force of attraction of the earth is known as acceleration due to gravity, i.e., g

$$F = ma = mg$$

But by definition, this force is equal to the body's weight, i.e., F = W.

$$W = mg$$

S.I. unit of weight is Newton (N), and in CGS, it is measured in dyne (dyn).

DIFFERENCES BETWEEN MASS AND WEIGHT

	MASS	WEIGHT
1	The mass of an object is the quantity of matter contained in it.	The weight of an object is the force with which it is attracted towards the centre of the earth
2	The SI unit of mass is kilogram (kg)	The SI unit of weight is newton (N).
3	The mass of an object is constant.	The weight of an object is not constant. It changes with the change in acceleration due to gravity (g).
4	The mass of an object can never be zero.	The weight of an object can be zero. For example, in the interplanetary space, where

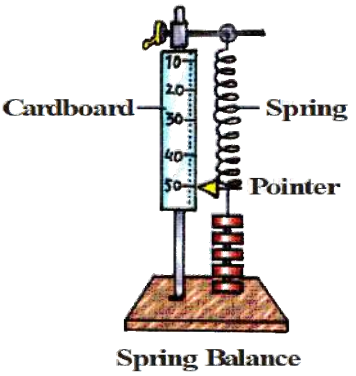
- **SPRING BALANCE**

  A spring balance is a device used to measure the weight of an object. It can also be used for the measurement of forces. Weighing machines that are used in schools or hospitals are also springing balances.

- **ACTIVITY**

  MAKING OF A SPRING BALANCE

  Take a spring and hang it from a stand. Attach a pointer near the free end of the spring. Fix a strip of cardboard by the side of the spring and mark '0'. Now suspend a 10 g load from the lower end. Mark 10 g force against the new position of the pointer. Add another 10 g load to the lower end of the spring. The length of the spring increases. Mark 20 g against the new position of the pointer on the strip. Go on adding loads in steps of 10 g and mark the new position of the pointer on the cardboard as 30, 40, 50. Your spring balance is now ready for use.



Spring Balance

- **WORKING:– Spring applies force on both ends. These forces are equal in magnitude but opposite in direction.**

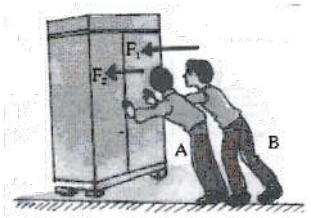
  A spring balance consists of a spring inserted in a metal tube. The metal tube has a vertical slop through which the pointer comes out. The object to be weighed is suspended on the hook at the bottom. When the object comes to equilibrium, it stretches the spring. As a result, the pointer comes down and shows the reading against a scale.

- **RESULTANT FORCE**

Suppose a single force acting on a body produces the same acceleration as produced by several forces. In that case, a single force is called the resultant of these individual forces.

The resultant force is also called the net force.

Ex. Suppose an almirah is being pushed by two persons, A and B. Let the force applied by A be $F_1 = 2N$ and that by B be $F_2 = 3N$. These two forces together will result in some displacement of the almirah in a given time. In another situation, a person C is pushing the same almirah kept initially in the position as the previous situation. Person C is applying a force F = 5N in the same direction as A and B.

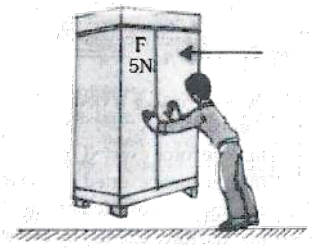


Two persons pushing an almirah

- **BALANCED FORCES**

When the force acting on a body cancel out the effects of each other so that the resulting force is zero, these forces are said to be balanced.

Ex. Let us consider a rigid almirah kept at rest on a horizontal surface. Let two forces, F1 and F2, act simultaneously on the almirah from opposite directions. If the two forces are equal, the effects produced by one force get cancelled by the effect produced by the other. The net Force or the resultant Force is then zero. The almirah continues to remain at rest. When the many forces acting on a body do not cause any change in its state of rest, or uniform motion is a straight line, the force is said to be balanced forces.

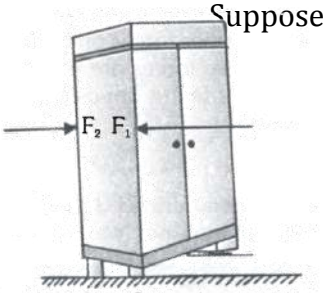


One person pushing an almirah

- **UNBALANCED FORCES**

If the number of forces acting on a body produces an acceleration in the body, then the forces acting are called unbalanced.

Suppose $F_1 = 5$ newton and $F_2 = 3$ Newton. In this case, a resultant force is acting on the almirah towards the direction of F_1. We say that an unbalanced force of 2 Newton will act on the almirah towards the direction of F_1.



Two opposing forces acting on the almirah

If forces acting on an object are balanced → An object at rest, remains at rest (a = 0)

If forces acting on an object are balanced → An object in motion remains in motion with the same velocity (a = 0)

If forces acting on an object are unbalanced → Object is accelerating (Acceleration depends on) unbalanced force and mass of the object

COMPETITION WINDOW

- **Mathematical Representation of Force:** Mathematically, force F is equal to the product of Mass M of a body and acceleration, a produced in the body due to that force. i.e. F = ma

  Acceleration: Mostly, the velocity of a moving object changes either in magnitude or in direction or in both when the object moves. The body is then said to have acceleration.

  So is the rate of velocity change, i.e. change in velocity in unit time, is said to be acceleration. (it is vector quantity)

$$Acceleration = \frac{Change\ in\ velocity}{time}$$

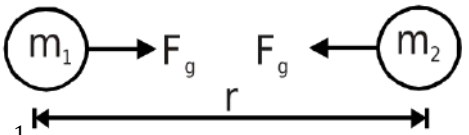
$$\Rightarrow \frac{v-u}{t} = \frac{Final\ velocity - initial\ velocity}{Time}$$

  It's SI. unit is m/s^2 & C.G.S. unit is cm/s^2

- **Gravitational Force: According to Newton**

  "Everybody in the universe attracts another body with force directly proportional to the product of their masses and inversely proportional to the square of the distance between them."

$f_g \propto m_1 m_2 \ldots\ldots (i)$



$f_g \propto \frac{1}{r^2} \ldots. (ii)$

  From equation (i) and (ii)

$f_g \propto \frac{m_1 m_2}{r^2}$ $\qquad$ $f_g = \frac{G m_1 m_2}{r^2}$

  Where G = universal gravitational constant G = 6.67×10^{-11} Nm^2/kg^2 or $Nm^2\ kg^{-2}$

- **ELECTROSTATIC FORCE: According to "Coulomb"**

  "The force acting between the charges is known as an electric force." If q_1 and q_2 are the charges, then the force acting between them would be,

$F = \frac{K q_1 q_2}{r^2}$

Where 'r' is the distance between q_1 and q_2, K is the **Coulomb's** constant

Force can be attractive or repulsive.

- **PRESSURE**

  It is defined as the force per unit area. The SI unit of pressure is the pascal (Pa), which is Newton per square metre.

  $Pressure\ (in\ Pa)\ = \frac{Force\ (in\ newton)}{Area\ (in\ m^2)}\ [P\ =\ F/a]$

- **VARIATION OF PRESSURE WITH AREA**

  The same force, increasing the area over which it acts, decreases the pressure applied.

  However, the inverse is also true: decreasing the area of application increases the pressure produced for the same force.

  Ex. The area under the edge of a knife's blade is extremely small. Beneath it, the pressure is high

  enough for the blade to push easily through the material that needs to be cut.

  Wall foundations have a large horizontal area. This reduces the pressure underneath so that the walls do not sink further into the ground under the weight of the building.

- **FLUID PRESSURE**

  Liquids and gases are together called fluids.

  Fluids exert pressure on all bodies immersed in them and on the walls of the container that holds them. The air inside the balloon exerts pressure on the inner walls of the balloon.

- **ATMOSPHERIC PRESSURE**

  A layer of air called the **atmosphere** surrounds the earth. As you know, the air also matters and has weight. The weight of the atmosphere exerts pressure on the surface of the earth. This pressure is called **atmospheric pressure**. Its magnitude is around 100-kilo pascals (100 kPa) at sea level. However, as we go upward, the magnitude of atmospheric pressure decreases gradually. The following activity will show the magnitude of atmospheric pressure on the earth's surface.

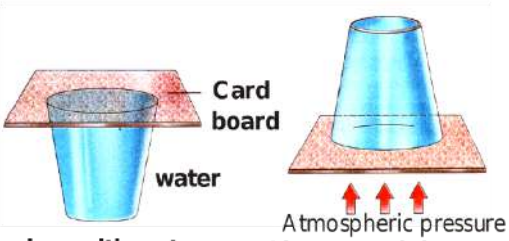
Activity

The magnitude of atmospheric pressure

Take a glass tumbler and fill it with water to the brim. Cover it with a thick sheet of paper (or cardboard). Press your palm over the sheet and quickly invert the tumbler. Slowly remove your palm supporting the piece of paper. What do you observe? Surprised?

Fact file

- It has been found that when deep-sea fish are brought to the surface of the sea, their bodies burst. It is because the blood in their bodies flows at very high pressure. At the surface of the sea, the pressure outside decreases. This difference in pressure causes their bodies to burst open.
- If the air exert such a huge pressure, why do our bodies not get crushed? It is because our blood contains dissolved oxygen at a pressure that is slightly more than the atmo spheric pressure. This counterbalances the atmospheric pressure.



A glass with water covered with a sheet

Glass containing water in inverted position

You have seen that the paper did not fall (as one expected it to.) This is because the atmospheric pressure provides enough force to push the piece of paper upward.

- **Barometer**

A barometer is a device used for measuring atmospheric pressure.

Atmospheric pressure measurements are important to meteorologists for weather forecasts. The unit of pressure used for the meteorological purpose is called the bar. A bar is a CGS unit of pressure and equals 10^5 pascals or 1 bar $= 10^5$ Nm^{-2}.

- **LIQUID PRESSURE:** A liquid exerts pressure on the wall of the container

Take some discarded plastic bottles and fix a glass tube near its bottom. It can be done by slightly heating one end of the glass tube and then inserting it near the bottom of the bottle. In case there is some leakage, your must seal it with molten wax. Now cover the free end of the glass tube with a thin rubber sheet. The rubber sheet fixed to the glass tube bulges on filling the plastic bottle up to half with water. When more water is added to the plastic bottle, there is a change in the bulge of the rubber sheet.

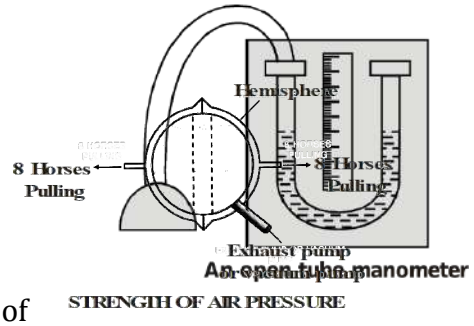
Since the rubber sheet is fixed on the side of the container, it shows that water exerts pressure on the side of the container. In other words, liquids exert pressure on the walls of the container.

- **MANOMETER**

It is an instrument used to measure liquid pressure. An open tube manometer is the simplest type of pressure gauge which measures pressure. It consists of a U-shaped tube containing a liquid. One arm of the tube is open to the air, and the other is connected to the vessel where we want to measure the pressure. The difference in liquid level represents the applied pressure.

ACTIVITY

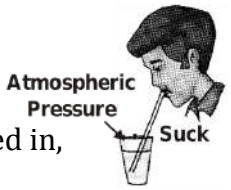
Air Pump



STRENGTH OF AIR PRESSURE

In 1654, German scientist Otto van Guericke invented a pump to evacuate air from a vessel. To demonstrate the force of air pressure, he joined two metallic hemispheres and pumped out the air inside them. He employed two terms of eight horses to pull each hemisphere apart. The hemispheres could not be separated by eight horses pulling the hemispheres from opposite directions. The hemispheres were held together by the air pressure from outside and was so large that even 16 horses could not overcome it.

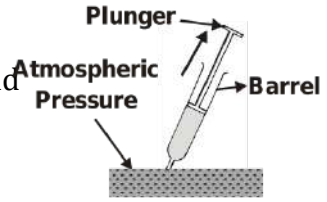
- **OTHER APPLICATIONS OF PRESSURE**



DRINKING WATER WITH A STRAW

(a) Drinking straw Straw is used to suck up aerated water; when air is sucked in, it causes a decrease in air pressure inside the straw. The outside atmospheric pressure forces the liquid inside the straw. The dropper also works on the same principle. This is known as the suction mechanism.

(b)Syringe In syringe, the pressure of the liquid (blood) forces the liquid to move into the syringe when its plunger is withdrawn.



INJECTION SYRINGE

(c) Vacuum cleaner A vacuum cleaner is an electrical appliance that cleans by suction. A fan inside the vacuum cleaner lower the air pressure and creates a low-pressure device. As a result, the air and dirt particles on and near the surface are sucked into the device.


VACUUM CLEANER

- **LOOKING BEYOND**

Blaise Pascal : (1623-1662) was a French physicist and mathematician. When he was only three

years old, his mother died, then his father devoted himself to the upbringing of the child.

- He was the first to construct a calculating machine; he demonstrated atmospheric pressure, established theoretical principles for the hydraulic transmission of power, and contributed extensively to mathematics.
- Following an intense religious experience in 1654, he gave up science, mathematics and technology and devoted himself to religious philosophy. He died before he was forty, having worked three careers into a short life.
- An instrument called a sphygmomanometer is used to measure the blood pressure of

humans. Blood pressure is the ratio of systolic (maximum) and diastolic (minimum) pressures. Normally it is 120/80 mm of Hg in a healthy adult. Pressures above 140/90 need medical attention.

SUMMARY

- A push or a pull acting on a body is called 'force'. Its unit is Newton.
- A force can :

(i) move a body

(ii) stop a moving body

(iii) change the speed of a moving body

(iv) change the direction of a moving body, and

(v) change the shape and size of objects.

- Contact forces act only when the interacting objects are in contact. Non-contact forces act from a distance.
- Weight is a force.
- Pressure is the physical quantity that combines force and the area over which it acts.
- A liquid exerts pressure in all directions.
- Liquid pressure increases with depth, whereas pressure is the same in all directions at the same depth.
- The pressure at any point under a liquid surface is due to the weight of the column of liquid above that point.
- Liquid pressure is measured with a manometer.
- The pressure exerted by air is called atmospheric pressure. It is exerted equally in all directions.
- Atmospheric pressure reduces as height above sea level increases.

KEYWORDS

- **Forces**: Push or pull acting on an object.
- **Contact force**: A force that acts upon another body through some material connector.
- **Non-connected Force**: A force that acts upon another body without the aid of a material connector.
- **Muscular Force**: The force produced by the muscles of living beings.
- **Weight**: The pull (Force) by which an object is attracted towards the earth.
- **Fluid**: A substance that can flow (both liquids & gases.)
- **Manometer**: A device used for measuring liquid pressure.