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FORCE AND PRESSURE

KEY WORDS

Force : Push or a pull acting on an object.
Non-contact force : A non-contact force can be applied on an object without any physical contact with it.
Contact force : A contact force is applied on an object by direct or indirect physical contact (touching).
Friction : The resistance to motion experienced when two surfaces, in contact, move with respect to each other.
Lubrication : Introduction of a substance between two surfaces to reduce friction.
Pressure : Force per unit area.
Atmospheric pressure : Pressure exerted on an object by the weight of the air above it.
Fluids : Collective name for liquids and gases.
Pressure gauge : An instrument used to measure pressure.
Manometer : A type of pressure gauge used to measure pressure difference.

INTRODUCTION

A force is a push or a pull. Force gives an object the energy to move, stop moving, or change direction. When you write with a pen you exert a force. When you peddle your bike, blow your nose, turn on a faucet, chew your gum, or swimming in a pool, you are exerting forces on other objects. We would never be able to move without exerting forces on things. Other examples are:

* A flag being blown by the force of the wind.
* Iron being pulled towards a magnet.
* A jet engine propelling an airplane forward.
* A boy uses force to move the cart.

Now you must write five examples of a force moving an object.

FORCE- A PUSH OR A PULL

A force can be a push or a pull. For example, when you push to open a door you have to apply a force to the door. You also have to apply a force (pull) to open a drawer.
Imagine you are going for a school picnic. The bus has some trouble with its battery. The driver asks the boys to push the bus. What do the boys do? They apply force during pushing so that the bus starts moving (Fig.).

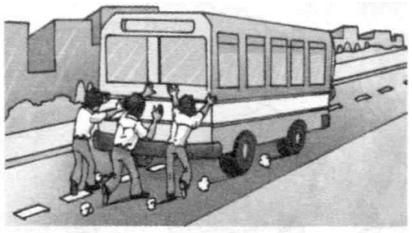


Figure : Boys pushing a bus

Imagine the door of your house is jammed, as it often happens in the rainy season. You have to apply force (pull or push) to open the door. If you carefully study the above examples, you will notice that the word force is associated with either pull or push, which causes some kind of motion. Similarly, actions like picking, lifting, opening, shutting, kicking, flicking are often used to describe some task, which usually results in some kind of change in the motion of an object.
Thus, in very simple terms, force is defined as push or pull.
You cannot see a force but often you can see what it does. Forces can change the speed of something, the direction it is moving in or its shape. For example, an elastic band gets longer if you pull it.

FORCES ARE DUE TO AN INTERACTION

The interaction of one object with another results in a force between the two objects.

The game of tug-of-war is a very good example of interaction of forces. A rope is being pulled in opposite directions by two teams facing each other. Initially, the rope is not pulled in any direction since the force applied on each side by the two teams get neutralised. At one point of time in due course, one of the two teams may be able to exert a greater force than the other. Then the rope gets pulled by the winning team. The resultant greater force in this case is towards the side to which the rope gets pulled.

EFFECTS OF FORCE

(i) Force can make a stationary object move and can change the speed of the object :

Force is that physical quantity that changes or tends to change the state of rest or uniform motion of an object in a straight line.

Examples: (a) A stationary football can be made to move by giving it a small push.

(b) The moving toy car can be made to stop by applying a force.

(c) A tractor can move a trolley by pulling it. (d) We push door to open or close it.

(e) A vehicle can be made to stop by applying brakes on it.

(ii) Force can change the direction of a moving object:

When a force is applied on a moving object perpendicular to its motion, it changes the direction of the motion of the object. It can also change the velocity of the object.

Examples : (a) A cricketer applies a tangential force to change the direction of the cricket ball.

(b) When a football in motion kicked perpendicular to its motion, direction of motion changes.

(c) When we hit a cricket ball with a bat, the direction in which the ball is moving changes.

(iii) Force can change the shape and size of the object :

A force applied on an object can also change its shape and size.

Examples: (a) When we compress a spring then its length decreases. (b) When we stress a spring then its length increases. (c) When we apply force on a balloon then its shape changes.

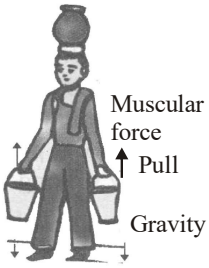
(iv) Force is applied to raise an object to a higher level :

Force is applied for lifting and putting the luggage on bus top or in a railway compartment while you go on travel. Similarly, force is applied to lift the pitcher and place it on the head.

(v) Force is applied to keep the raised object in raised position:

A man shown in the picture is shown holding the buckets full of water and the pitcher on his head. The buckets on the hands and the pitcher on the head are all the time being pulled down (towards the earth) due to the gravitational force of the earth (gravity).

Force is all the time applied by the man to keep the buckets and the pitcher in position.



To lift an object we use pull force in the direction opposite to the direction of the gravitational force.

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., $F = ma$

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 it is the rate of change of velocity i.e., change in velocity in unit time is said to be acceleration

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}} = \frac{v - u}{t} = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{time}}$$

Its S.I. unit is m/s^2 & C.G.S unit is cm/s^2

Units of Force :

(i) In C.G.S. system: $\because$ F = ma $\rightarrow$ gram × cm/s^2 = dyne

If m = 1 gram, a = 1 cm/s^2, then F = 1 dyne

When a force is applied on a 1 gram body and the acceleration produced in the body is 1 cm/s^2 then the force acting on the body will be one dyne.

(ii) In S.I. system: F = ma $\rightarrow$ kg × m/s^2 = Newton

If m = 1 kg and a = 1 m/s^2 then by F = ma,

F = 1 × 1 = 1 kg × m/s^2 = 1 Newton.

If a force is applied on a body of mass 1 kg and acceleration produced in the body is 1 m/s^2 then the force acting on the body will be one Newton.

RESULTANT FORCE

Many forces may be simultaneously applied on a body. For example, several persons may jointly make an effort to move a heavy body, each person pushes it i.e., applies a force on it. It is also possible that a stronger man pushes that body hard enough and produces same acceleration in it. If a single force acting on a body produces the same acceleration as produced by a number of forces, then that single force is called the resultant force of these individual forces.

Note :

* If the two forces act in the same directions on an object, then net force acting on it is the sum of two forces.
* If the two forces act in the opposite directions on an object, the net force acting on it is the difference between the two forces.

In the tug-of-war when two teams pull equally hard, the rope does not move in any direction.

So, we learn that a force could be larger or smaller than the other. The strength of a force is usually expressed by its magnitude. We must specify the direction in which a force acts. Also, if the direction or the magnitude of the applied force changes, its effect also changes.

BALANCED AND UNBALANCED FORCES

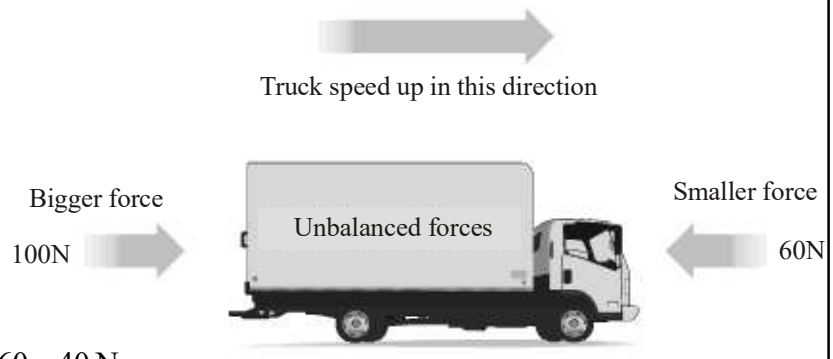
Suppose a toy car can move on its wheels along east- west direction. If we push the car with our left hand, it moves towards east. If we push the car with our right hand, it will move towards west. If we push the car with our left hand towards east and with right hand towards west simultaneously, it is possible that the car will remain at rest. In this case the forces balanced each other and there is no acceleration. If a set of forces acting on a body produces no acceleration in it, the forces are said to be balanced forces. If it produces a non-zero acceleration, the forces are said to be unbalanced forces. If two forces balance each other, they must be in opposite direction and have equal magnitudes.

If the forces on an object are unbalanced this is what happens:

* an object that is not moving starts to move
* an object that is moving changes speed or direction

Unbalanced forces make the truck speed up.

The resultant force is the difference between the two forces, which is 100 – 60 = 40 N.



More analysis on Balanced and Unbalanced force :

Have you ever had an arm wrestling competition with someone? If you compete against someone who is just about as strong as you are, there will probably be a time when both of you are pushing as hard as you can, but your arms stay in the same place. This is an example of balanced forces. The force exerted by each person is equal, but they are pushing in opposite directions, in this case together. It would look something like this.

Because the force that each of you is exerting is equal, the two forces cancel each other out and the resulting force is zero. Therefore, there is no change in motion.

Another great place to see balanced forces in action is in a tug of war. This is similar to an arm wrestling match, only in this case the forces are moving away from each other. Just like in arm wrestling, if the two teams have equal strength, or force, the rope will stay pretty much in the same place. It would look like this.

Again the resulting force is zero and there is no change in motion.

Unlike balanced forces, **unbalanced forces** always cause a change in motion. They are not equal and opposite. When two unbalanced forces are exerted in opposite directions, their combined force is equal to the difference between the two forces and is exerted in the direction of the larger force. Look at the following examples to help make this more clear.

Think again about the arm wrestling match. Only this time imagine that you are competing against a world famous body builder. Chances are that his force will be much greater than yours. Your arms will move in the direction he is pushing with a force that is equal to his force minus your force. It will look like this.

Or imagine that you and your friends are having a tug of war with the U.S. olympic weight lifting team. Again their force will probably be a little larger than yours. You will move in the direction they are pulling with a force that is equal to their force minus your force. It will look like this.

Unbalanced forces can also be exerted in the same direction. For example, imagine that your family's car breaks down on the road and you have to push it into a parking lot. If you and your brother or sister both push on the car, the resulting force on the car will be the sum of your forces and of course be in the direction that you are applying the force. The figure below shows how this would work.

Two important things to remember when working with balanced and unbalanced forces are

(1) forces in the same direction combine by addition, and

(2) forces in opposite directions combine by subtraction.

Example 1 :

Two tugboats are moving a barge. Tugboat A exerts a force of 3000 newtons on the barge. Tugboat B exerts a force of 5000 newtons in the same direction. What is the combined force on the barge?

Sol. Combined force = 5000 Newton + 3000 Newton = 8000 Newton

Example 2 :

Draw arrows showing the individual and combined forces of the tugboats in previous example.

Sol. ——→ + ——————→ = ————————→

Example 3 :

Now suppose that Tugboat A exerts a force of 2000 newtons on the barge and Tugboat B exerts a force of 4000 newtons in the opposite direction. What is the combined force on the barge?

Sol. Combined force = 4000 Newton – 2000 Newton = 2000 Newton (in the direction of Tugboat B)

Example 4 :

Draw arrows showing the individual and combined forces of the tugboats in previous example.

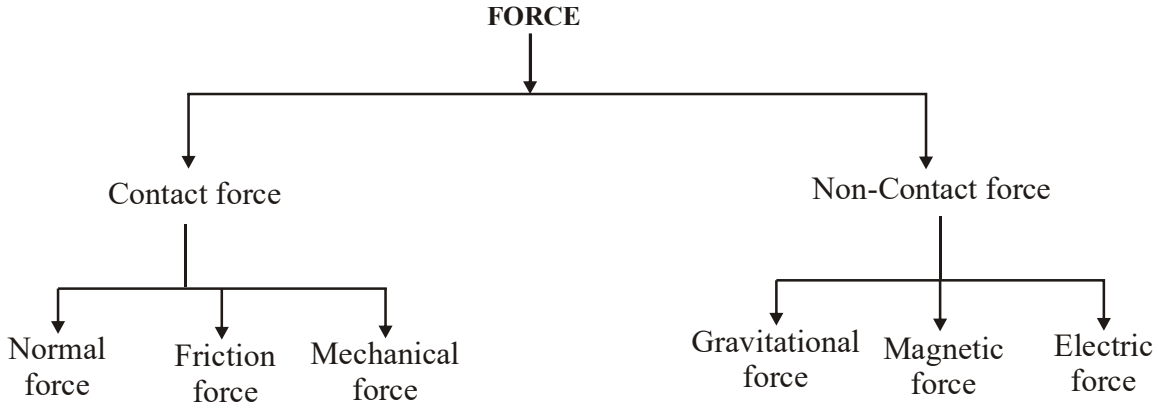
Sol. ——→ + ←—— = ←——

Example 5 :

Could there ever be a case when Tugboat A and Tugboat B are both exerting a force on the barge but the barge doesn't move? Draw arrows showing the individual and combined forces in such a situation.

Sol. Yes, if the forces are balanced. ——→ + ←—— (combined force equals zero).

TYPES OF FORCE



(a) Contact force :

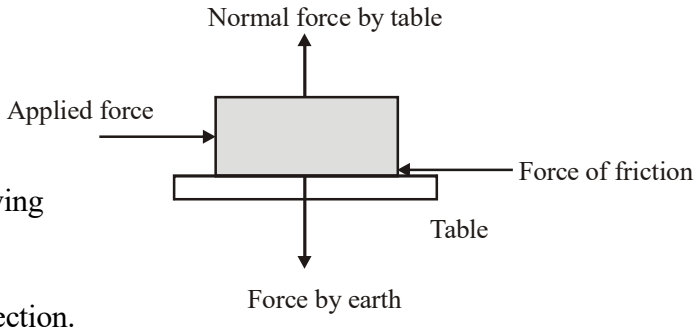
Force which acts on a body only when the body is in contact with the force is known as contact force.

Types of contact force :

(i) Normal force : If contact forces between the bodies are perpendicular to the surface in contact, the forces are known as normal forces.

Eg. : Consider a book on a table. The table pushes the book upwards and book pushes the table downwards, these forces are perpendicular to the surfaces of book and table. Thus the table applies a normal forces on book in the upward direction and book applies a normal force on table in downward direction.

(ii) Force of friction : Two bodies placed in contact can also exert forces parallel to the surfaces in contact, such a force is called force of friction or simply friction.



Suppose a body is placed on the table following three forces act on it :

(A) Force by earth in downward direction.

(B) Normal force due to table in upward direction.

(C) Applied force towards right.

Body is not moving, so all the forces must be balanced, normal force by table and force by earth balanced each other, to balance the applied force there must be an equal and opposite force, this force is known as

force of friction. If we increase the applied force and the body is still at rest it means force of friction also increases till it balanced by the applied force. The force of friction is self adjusting force. On increasing the applied force the force of friction will increase upto a limit. It is known as limiting friction, after it on increasing the applied force, the body starts to move.
We will learn more about friction in next Chapter.

(iii) Mechanical Forces : The forces generated by a machine are called mechanical forces.
No machine produces force on its own. In order to produce force we must supply it with some kind of energy. The force used to run a motor car engine is produced by using the energy of petrol. The force used to run steam engine is produced by using the energy of coal.
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. Animals like bullocks, horses, donkeys and camels are used to 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 called a contact force.

(b) Non-contact force : Force which acts on a body when the body is not in contact with the force is known as non-contact force. **Types of non-contact force:** (i) Gravitational force (ii) Electric force (iii) Magnetic force

(i) Gravitational force: It was Newton, who said that every object in this universe attracts every other object with a certain force. The force with which two objects attract each other is called the force of gravitation. The force of gravitation acts even if the two objects are not connected by any means. If, however, the masses of the objects are small, the force of gravitation between them is small and cannot be detected easily.
The force of attraction between any two particles in the universe is called gravitation or gravitational force.

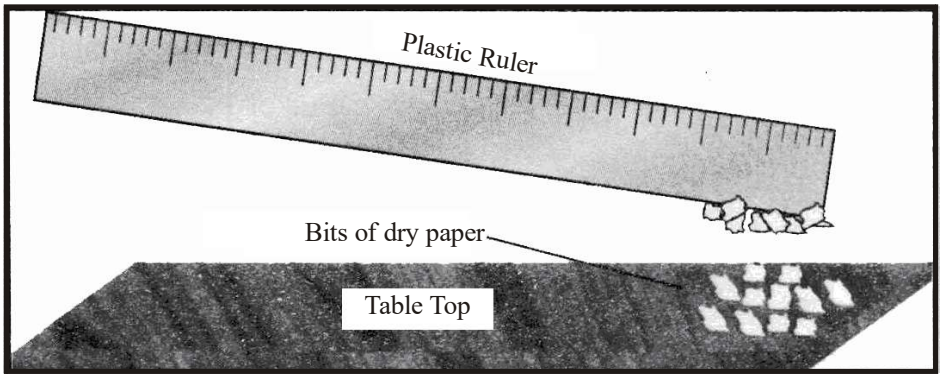
Force of gravity : The earth attracts all the bodies towards its centre. The force exerted by the earth on the body is known as weight of the body or force of gravity. It acts in vertically downward direction.
If mass of the body is m and acceleration due to gravity is g. Then force of gravity or weight = mg.
The value of g is 9.8 m/s^2 . For a body moving downward, g is taken as positive while for a body moving upward, g is taken as negative.

Mass and Weight : People often confuse mass and weight. Remember that weight is a force, and is measured in newtons. Mass is measured in kilograms (kg).
Mass : The mass of an object is the amount of matter or "stuff" it contains. The more matter an object contains, the greater its mass. An elephant contains more matter than a mouse, so it has a greater mass. Mass is measured in kilograms, kg, or grams, g. A 100 kg object has a greater mass than a 5 kg object. Remember an object's mass stays the same wherever it is.
Gravity : All objects have a force that attracts them towards each other. This is called gravity. Even you attract other objects to you because of gravity, but you have too little mass for the force to be very strong.

Gravitational force increases when:
* the masses are bigger * the objects are closer
Gravity only becomes noticeable when there is a really massive object like a moon, planet or star. We are pulled down towards the ground because of gravity. The gravitational force pulls in the direction towards the centre of the Earth.
"Down" is towards the centre of the Earth, wherever you are on the planet

Weight : Weight is a force caused by gravity. The weight of an object is the gravitational force between the object and the Earth. The more mass the object has the greater its weight will be.
Weight is a force, so it's measured in newtons. On the surface of the Earth an object with a mass of 1 kg has a weight of about 10 N.
Remember that mass is measured in kilograms, kg, and weight is measured in newtons, N.
The mass of an object stays the same wherever it is, but its weight can change. This happens if the object goes somewhere where gravity is stronger, or weaker, such as the Moon.
The Moon has less mass than the Earth, so its gravity is less than the Earth's gravity. This means that objects weigh less on the Moon than they do on the Earth.
The Moon's gravity is one sixth of the Earth's gravity. A 120 kg astronaut weighs 1200 N on Earth. On the Moon they would weigh only 200 N. The astronaut's mass is 120kg wherever they are.
The weight of an object changes if the strength of gravity changes.
Remember: a mass of 1kg has a weight of about 10N on Earth.

(ii) **Electrostatic Force :** Electrostatic force is another kind of force which can push or pull tiny objects. The following activity will prove it.
To show electrostatic force attracts tiny bits of paper.
Materials required : * Small bits of dry paper * a plastic ruler
Method: Rub one end of the plastic ruler against your hair. The hair must be dry. Otherwise you can rub the ruler on your woolen pullover. Bring the rubbed end of the ruler near tiny bits of paper. Notice how tiny paper bits cling to the plastic ruler.



Reason : It is because the plastic ruler gets electrically charged when rubbed with hair or wool. The electricity so produced pulls the bits of paper towards itself.
Thus, the activity clearly proves that electricity is a kind of force.
The electrostatic force is used in removing carbon and ash particles in smoke, coming out of the chimneys of big factories. This helps in reducing air pollution.

(iii) **Magnetic Force :** Substances like iron, steel, cobalt, nickel when placed in a coil carrying electric current, develop a strange property of attracting tiny bits of iron or steel towards themselves. The strange property of some substances to attract iron or steel objects towards itself is called magnetic property. The substance which has the above property is called a magnet.
Bar magnets are permanent magnets. This means that their magnetism is there all the time and cannot be turned on or off. They have two poles: 

Bar magnet : 1. north pole (or north-seeking pole) ; 2. south pole (or south-seeking pole).
The north pole is normally shown as **N** and the south pole as **S**.

Attract and repel :
If you bring two bar magnets together, there are two things that can happen:

* if you bring a north pole and a south pole together, they attract and the magnets may stick together
* if you bring two north poles together, or two south poles together, they repel and the magnets push each other away. We say that unlike poles attract, and like poles repel.

Testing for magnets : How can you test if a piece of metal is a magnet. Seeing if it sticks to a magnet is not a good test, because unmagnetised iron, steel, cobalt and nickel objects will be attracted to either pole of a magnet. So you can't test for what it is attracted to. But you can test what it repels:
Note : You can only show that an object is a magnet if it repels a known magnet.

FORCE DIAGRAMS

We can show the forces acting on an object using a force diagram. In a force diagram, each force is shown as a force arrow. An arrow shows:

* the size of the force (the longer the arrow, the bigger the force)
* the direction in which the force acts.

The arrow is usually labelled with the name of the force and its size in newtons. Text books often show a force with a thick coloured arrow, but it is best if you just use a pencil and ruler to draw an arrow with a single line.

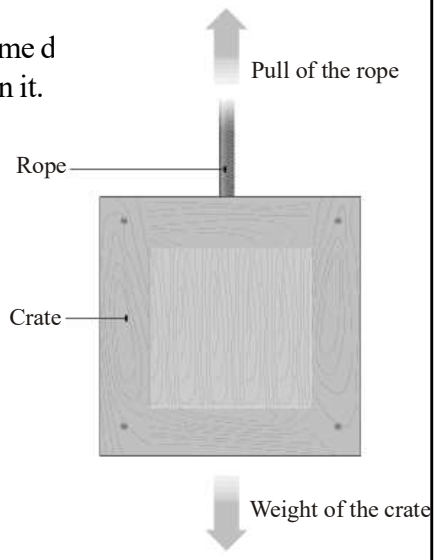
Balanced forces : When two forces acting on an object are equal in size but act in opposite directions, we say that they are balanced forces.
If the forces on an object are balanced (or if there are no forces acting on it) this is what happens:

* an object that is not moving stays still
* an object that is moving continues to move at the same speed and in the same d

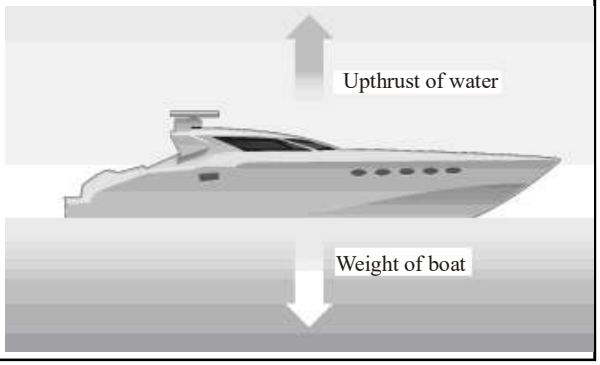
So notice that an object can be moving even if there are no forces acting on it.

Examples
Here are some examples of balanced forces.

Hanging objects :
The forces on this hanging crate are equal in size but act in opposite directions. The weight pulls down and the tension in the rope pulls up.
The forces on this hanging crate are balanced.

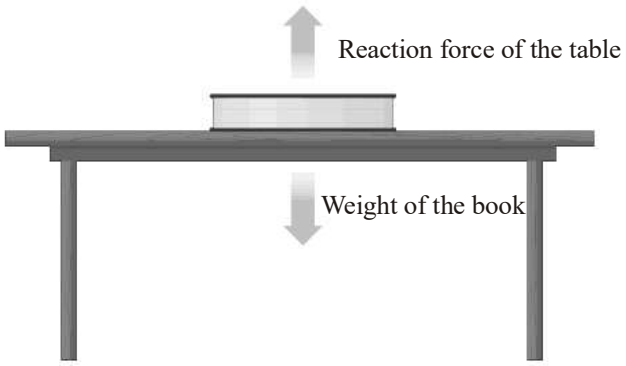


Floating in water :
Objects float in water when their weight is balanced by the upthrust from the water. The object will sink until the weight of the water it pushes out of the way is the same as the weight of the object.
A boat floats because its weight is balanced by the upthrust from the water



Standing on the ground :

When an object rests on a surface such as the ground, its weight is balanced by the reaction force from the ground. The ground pushes up against the object. The reaction force is what you feel in your feet as you stand still. Without this balancing force you would sink into the ground. The weight of a book lying on a table is balanced by the reaction force from the table top.



PRESSURE

It is defined as the force per unit area.

The S.I. unit of pressure is pascal (Pa), which is newton per square metre.

$$\text{Pressure (in Pa)} = \frac{\text{Force (in Newton)}}{\text{Area (in m}^2\text{)}}$$

The unit pascal is named after the french mathematician and physicist Blaise pascal. He was a child prodigy. He has made important contributions to the study of fluids and pressure, among many others. The effect of force on a body depends on the pressure produced. Some very important and useful devices such as syringes, dropper, straw, rebreathing apparatus, etc. work on the principle of pressure.

Conventional unit : Atmosphere (atm) defined as the average pressure exerted by the air at sea level.

$1 \text{ atm} \approx 10^5 \text{ N/m}^2 \approx 100 \text{ Kpa}$.

Meteorological unit of pressure is bar. $1 \text{ bar} = 10^5 \text{ Pa}$

Example 6 :

If a force of 5N is applied over an area of 2.5 m^2, calculate the pressure produced.

Sol. Given: Force = 5N, Area = 2.5 m^2

$$\text{We know, pressure} = \frac{\text{Force}}{\text{Area}} = \frac{5}{2.5} = 2 \text{ Pa}$$

Example 7 :

A block weighing 1200 N rests on an area of $4m^2$. Calculate the pressure exerted by the block on the surface which supports it.

Sol. $F = 1200 \text{ N}, \ A = 4m^2, \quad p = ? \ ; \ p = \frac{F}{A} \quad \Rightarrow \ p = \frac{1200}{4} \frac{\text{N}}{\text{m}^2} = 300 \text{ Pa}$

VARIATION OF PRESSURE WITH AREA

We know that pressure is inversely proportional to area. For same force on increasing the area on which it acts, the pressure applied decreases. Also on decreasing the area of application the pressure produced increases.

(a) Some Facts Involving Thrust and Pressure :

(i) Drawing pins make good use of pressure :

Drawing pins have a large round end for you to push. The round end has a large area, so it applies a low pressure to your thumb.

The sharp end has a very small area. The same pushing force produces a high pressure there, so it pushes into the notice board.

(ii) **Chair legs :** If you swing round on one leg of a chair, you put four times as much pressure on one point of the floor as you do if you sit properly. This is because four chair legs spread the pressure over four times more area than one chair leg can.

(iii) **Sewing needles have pointed tips:** A small force of fingers makes the needle pierce into the cloth easily and sewing becomes quicker.

(iv) Cutting items (knives and blades) have sharp edge. Cutting becomes easier.

(v) An angry child in arms prefers biting her mother with her tiny sharp teeth rather than punching her with fist.

(vi) The studs on football boot have only a small area of contact with the ground. The pressure under the studs is high enough for them to sink into the ground, which gives extra grip.

(b) Reducing pressure :

(i) **Vehicle brakes have flat surface :** This reduces pressure on the vehicle tyres and avoid their tearing.

(ii) **Broad sole shoes:** make walking easier on a soft land.

(iii) **Wide steel belt over the wheels of an army tank:** makes its movement easier over marshy land.

(iv) **Tractor tyres are broad:** Tractors do not sink in the soft land of the field while operating them.

(vi) **Hanging bags have wide straps:** They reduce pressure on the shoulders.

(vii) Skis have a large area to reduce the pressure on the snow so that they do not sink in too far.

Example: When we blow air inside a balloon, it expands. The air inside the balloon exerts a pressure on the inner wall of the balloon. If we blow in too much air and the material of the balloon is not capable of expanding further, increasing the pressure inside can cause the wall of the balloon to break at one or more points. This is why a balloon bursts when too much air is blown into it.

Note :

1. It is difficult for us to walk on sand because our feet will sink into sand. But a camel can walk on sand very easily. A camel has flat broad feet that increase the area of contact with the sand because of which the pressure exerted by the camel on the sand is reduced and its feet sink very little in sand. This makes a camel move fast on sand.
2. The skiers use flat and long skies to slide on the snow, because the larger the area of cross-section, the lesser is the pressure on the snow.
   Hence, a skier can easily slide on the snow without sinking his feet in it. It is for the same reason that snow sledges are not provided with wheels, because the wheels increase the pressure on the snow.
3. A porter places a round piece of cloth on his head in order to carry heavy loads. It is because the round piece of cloth increases the area of contact on his head, and hence, the load exerts less pressure.
4. All cutting instruments such as knives, blades, axes, picks, are sharpened at the cutting edge. As the cutting edge is sharpened, the area of cross-section decreases, and hence, the pressure exerted by them increases. Thus, they can easily cut a given surface.

ATMOSPHERIC PRESSURE

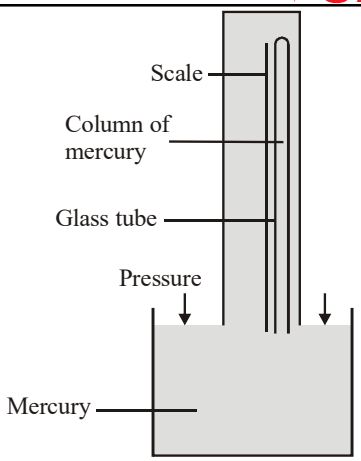
The discovery of atmospheric pressure gives a fact that air has weight. The weight of the atmosphere presses down on the earth's surface and creates a pressure on it. The pressure at any point exerted by the weight of the air above, it is called atmospheric pressure.

The atmospheric pressure on the earth's surface at sea level is one hundred thousand pascal i.e. 100 K Pa.

(a) Measurement of atmospheric pressure :

An instrument used to measure atmospheric pressure is a barometer. It consists of a long glass tube, which is sealed at one end. It is filled with mercury, a silvery liquid metal. The open end of the tube (filled with mercury) is placed in a small trough full of mercury.

The air exerts pressure on the mercury in the trough and is able to hold certain height of mercury column. When the air pressure reduces, the column of the mercury moves down and when the air pressure increase , the height of the mercury column increases. In this way, the pressure is measured by the height of the mercury column, in mm of Hg, i.e. the height of the mercury column in millimetres at sea level is 760.



(b) Variation of atmospheric pressure with altitude :

The atmospheric pressure at a place decreases with increase in altitude. The atmospheric pressure at a place is force exerted by the weight of the air column above that place. As we go up the length of the air column above us decreases. This means that its weight and the atmospheric pressure is smaller at higher places than at sea level.

(c) Need of atmospheric pressure :

If the pressure of atmosphere is removed suddenly, our blood vessels and tissues will rupture due to the pressure of the blood and other fluids inside. Thus the spacemen also wear special pressurized suits as in space there is no air and hence, no air pressure.

(d) Atmospheric pressure on other planets :

Atmospheric pressure will exist on a planet if it has an atmosphere.

Due to the existence of hydrogen as super hot liquid metal on Jupiter, the atmospheric pressure on Jupiter is very high. Atmospheric pressure on Venus is about 90 times as that on the surface of the earth due to the presence of CO_2 in its atmosphere.

Note :

1. At the top of a mountain, some people can feel their ears "popping" due to decrease in air pressure. The ears pop in order to balance the difference in pressure inside and outside the body.
2. Hovercraft: It is a vehicle which can travel on ground or water without actually touching the surface. Large fans are used to create an air cushion under the hovercraft. The pressure of the air cushion provides enough force to lift the hovercraft.

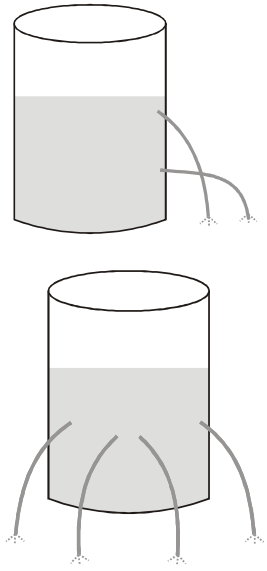
PRESSURE EXERTED BY FLUIDS (LIQUIDS AND GASES)

When an object is immersed in a liquid, the liquid exerts a net upward force on the object. This upward force determines whether an object will float or sink in a liquid.

If the upward force exceeds the weight of the object, the object will float, if the weight of the object exceeds the upward force, the object will sink.

(i) Pressure in a liquid increases with depth because the further down you go the greater the weight of liquid above. In figure water spurts out fastest and furthest from the lowest hole.

(ii) Pressure at one depth acts equally in all directions. The can of water in figure has similar holes all round it at the same level. Water comes out fast and spurts equally from each hole. Hence the pressure exerted by the water at this depth is the same in all directions.



(iii) Pressure depends on the density of the liquid. The denser the liquid, the greater the pressure at any given depth.

(iv) The pressure experienced by deep-sea divers is so great that they have to wear specially designed suits to protect themselves. They use special suits called diving suits and buoyancy compensators to combat the weight of their diving equipment and the water pressure at great depths.

(v) Dams are made stronger and thicker at the bottom than at the top to withstand the high pressures at greater depths.

APPLICATIONS OF PRESSURE

(i) 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 suction mechanism.

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

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

Note :

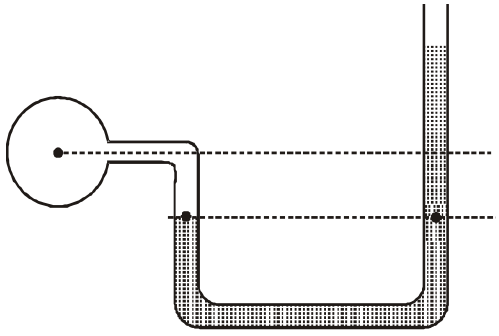
Decompression sickness :

Decompression sickness, one of the dangers of diving, is a common symptom noticed in most deep-sea divers. When a deep-sea diver stays underwater for a long time, he/she begins to inhale the nitrogen dissolved in water. Now if the diver were to swim to the surface quickly, it's like uncorking a soda bottle the gas is released. This leads to a painful condition called decompression symptoms, also called bends, which is characterised by severe pains in joints and chest, skin irritation, cramps and paralysis. In severe cases, the condition may prove to be fatal too. To avoid the effects of quick decompression, it is advisable that the diver rises slowly and/or makes intermittent stops on the way up (called "decompression stops") so that the gas can escape slowly.

Deep under water the solubility of gases increases due to their compression under high pressure. When the diver rises to the surface suddenly, there is a sudden drop in the surrounding pressure, which causes the nitrogen gas to escape or decompress. This results in the formation of nitrogen bubbles in the blood and tissues, consequently causing severe pains to the diver.

MANOMETER

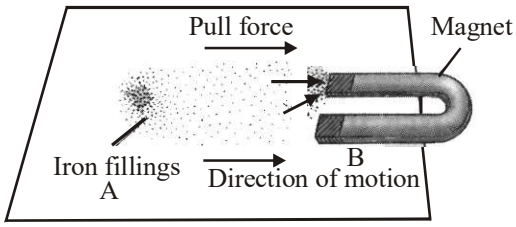
It is an instrument used to measure pressure. An open tube manometer is a simplest type of pressure gauge which measures pressure. It consists of a U-shaped tube containing a liquid. One arm of the tube is open to air and the other arm is connected to the vessel in which we want to measure the pressure.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



ACTIVITY ZONE

Activity 1 :

1. Bring a magnet near some iron filings or soft iron nails. Iron filings and the nails are pulled towards the magnet. Magnet exerts a pull force on iron pieces. This is magnetic force. It may act from a distance.

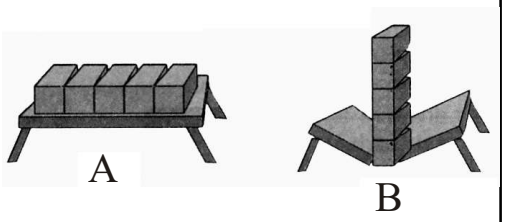


2. Hold the magnet over the iron filings or the soft iron nails. The iron filings or the nails may jump to rise and reach the magnet. They are being pulled by the magnetic force from the magnet.
You have also learnt earlier that only iron, cobalt and nickel are the three metals which are attracted (pulled) by the magnets. Also, these are the only three metals which can be magnetised (made into magnets) .

3. Each magnet has two poles. One is the North pole and the other is the South pole. When a bar magnet is suspended freely, tied with a piece of thread, it always comes to lie in North-South direction of the earth.

Activity 2 :

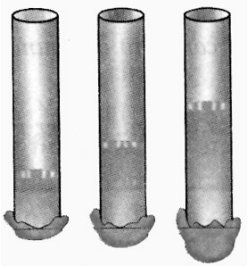
Take five wooden boxes of a most the same size, say each measuring 50 cm × 30 cm at the base. Fill them with scrap iron to make them heavy. Suppose the weight of each box comes to 60 kg.
Arrange these boxes on a wooden bench placing them side by side (as in 'A'). Note the impact of the push force from these boxes on the bench.



Again, rearrange these boxes on the same bench, placing them towards the centre and one over the other (as in 'B'). Note the impact of the push force froin these boxes on the bench.
Observation : In the arrangement 'A' the bench remains normal and it is not affected by the force of weight upon it. In the arrangement 'B', the bench either bends or breaks under the weight.

Activity 3 :

Take a glass tube open at both the ends. Tie a thin rubber sheath (may be a rubber balloon) on one of its ends. Hold the tube vertically and pour some water into it. The balloon bulges out showing that water has gone down and that it exerts a pressure on the rubber sheath. Add more water to the tube. The bulge increases.



From this we learn that: more is the height of the water column in the tube, more is the bulge. That is, water pressure increases with the increase in the height of the water column. OR
Water exerts a pressure on the bottom of the vessel in which it is kept.

Activity 4 :

1. Take a bucketful of water. Push an inverted empty glass bottle down into the water. The bottle is pushed upwards. The air from the bottle does not allow water to enter it. It remains empty. Tilt the bottle a little, air bubbles out of it and water gets into the bottle.

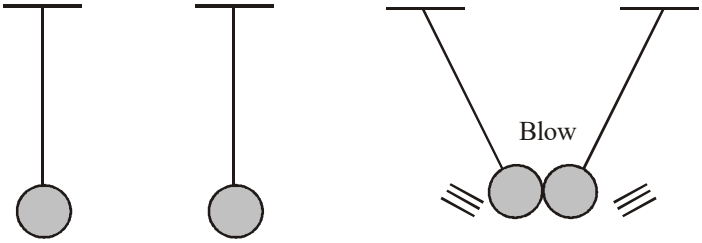
2. Repeat the same activity using a plastic mug. Try to push the mug into the water keeping it upside down. The mug is not easily pushed into the water.

Note :

1. Air exerts pressure on the surface of water. Air in the bottle and the mug does not permit water to enter till it escapes from the bottle or the mug.
2. Water exerts a thrust (upward pressure) upon the bottle and the mug and also upon the air inside the bottle and the mug.
   All fluids exert pressure.
3. Air occupies space.

Activity 5 :

Suspend two ping-pong balls parallel to each other using thread pieces of same length. Keep a distance of 3 to 4 cm in between the balls. Blow hard between the two balls and try to push them apart. Instead of balls moving away from one another they come closer to each other. Harder you blow closer the balls come.



This is because on blowing moving air in between the balls result in lowering, the pressure from moving air in between the balls is reduced in comparison to the air pressure around the balls. Higher air pressure around the balls pushes the balls towards one another. This activity can also be performed using inflated balloons instead of ping-pong balls.

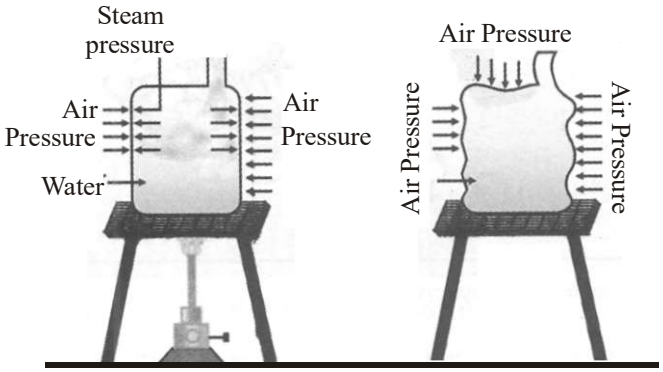
Activity 6 :

To show that atmosphere exerts huge pressure.

Materials required:

* An empty and clean 2 litre mobil oil can with screwable lid. * Water * Tripod stand * Burner.

Method: Pour 250 ml of water in the clean mobil oil can. Place the can on the tripod stand and heat with a burner. When the water starts boiling, the steam formed from it expels out air from the can. When the steam starts coming out freely from the mouth of can, stop heating and immediately screw the mouth of the can. Remove the can from the tripod stand and pour cold water over it. You will notice that the can gets crushed as shown in Fig.



Why does the can get crushed? It is because on pouring cold water, steam inside the can immediately changes into water. This in turn causes a near vacuum inside the can. Thus, the air from outside exerts pressure on the walls of the can and crushes it. The activity clearly shows that air exerts huge pressure.

Activity 7 :

Let's perform an activity to understand the charge concept.

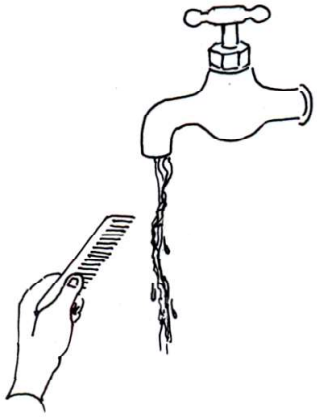
Things Required: Your plastic comb, a tap.

Method:

1. Turn on the tap to allow only a very narrow slow stream of water to come through.
2. Take your plastic comb and comb your hair with it. (Your hair should be dry and without oil).
3. Now when you place this comb close to the water stream, you will see that the water bends towards the comb.

Explain the observations.

When you comb your hair, static electrical charges accumulate on the teeth of the comb. These charges attract the stream of water. This then makes the stream bend towards the comb. During winters, when the weather is dry, take a newspaper sheet and hold it against a wall. Rub the entire surface with .the palm of your other hand rather briskly. You will find that the newspaper sticks to the wall. When we rub the newspaper surface with our dry palm, the paper gets charged and sticks onto the wall.



USEFUL TIPS

* A 'force' is a push or a pull acting on a body. The strength of force is called its magnitude. The international unit used to measure force is newton.
* Force can make a stationary object move or make a moving object move faster.
* Force can slow down or completely stop a moving object.
* Force can change the direction of a moving object.
* Force can change the shape or size of objects.
* The state of motion of an object is :
  (a) the speed at which the object is in motion, and (b) the direction of the motion.
  (c) the state of rest is also the state of motion in which the speed is zero.
* A non-contact force can be applied on an object without any physical contact with it.
* Gravitational, electric, and magnetic forces are examples of non-contact forces.
* Gravitational force is an attractive force between any two objects in the universe.
* A contact force is applied on an object by direct or indirect physical contact (touching).
* Friction is an example of a contact force.
* The point where force is applied on an object is called the point of contact.
* The force resulting from the action of muscles is called muscular force. We make use of muscular force of animals like bullocks, horses and camels get our activities done.
* When two forces acting on an object are equal in size but act in opposite directions, we say that they are balanced forces.
  If the forces on an object are balanced (or if there are no forces acting on it) this is what happens:
  – an object that is not moving stays still
  – an object that is moving continues to move at the same speed and in the same direction
  So notice that an object can be moving even if there are no forces acting on it.

* The name given to the physical quantity that combines force and the area over which it acts is called pressure.
* Pressure is defined as the force per unit area. The SI unit of pressure is pascal (Pa), which is newton per square metre.
* For the same force, increasing the area over which it acts decreases the pressure applied.
* In order to fix nails to walls, sharp nails are used, as the area of contact of the nail with the wall is small and more pressure acts on it for a given force.
* A suction pump sucks out all the air from a closed container, creating a vacuum in it.
* 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 pressure caused by the weight of air above any area on or near the earth's surface.
* The foundations of high rise buildings are kept very wide so that they do not sink under the extremely high pressure of the buildings.
* The shoulder bags are rovided with broad straps. The broad straps increase the area of contact between the strap and shoulder. This in turn reduces the pressure on the shoulder due to the weight of the bag.
* It is for the same reason that a drawing pin is kept broad at the thumb side, but very sharp at the pin side. The broader thumb tack reduces the pressure on the thumb, but the sharp pin tip increases the pressure on wooden board, and hence, can easily penetrate in it.
* The atmospheric pressure on the earth's surface at sea level is about one hundred thousand pascal, i.e., 100 kPa.
* The atmospheric pressure at sea level in terms of mm of Hg is 760 mm of Hg.
* The atmospheric pressure decreases as we go up in height.
* The pressure at any point under a liquid surface is due to the weight of the liquid column above the point.
* As we go deeper beneath the surface of a liquid, the pressure increases.
* The instrument used to measure pressure is called a pressure gauge.
* One simple type of pressure gauge is the open-tube manometer.