

8th Science Lesson 2 Notes in English

2] Force And Pressure

Introduction:

We see many objects in our daily life. Some of them are moving and some of them are at rest. A ball at rest moves when it is kicked. Similarly when we push or pull objects which are at rest, they begin to move. This push or pull is called force. Force acting in a particular area, produces pressure. For example when we fasten a nail on the wall, pressure is exerted. Not only solids, gases and liquids also exert pressure. Pressure exerted by liquids and gases finds application in different fields. Hydraulic lift and hydraulic break are working due to liquid pressure. In this lesson you will study about force and pressure. You will also study about surface tension viscosity and friction.

Force:

We do so many activities in our daily life like, opening a door, kicking a football, striking a carrom coin etc., To do these activities an external agency is needed. This external agency is called force. Force can either set an object at rest into motion or bring a moving object to rest. It can even change the shape and size of certain objects.

Force is defined as an external agency which changes or tends to change the state of rest or the state of uniform motion of a body or the direction of a moving body or the shape of a body. Force is a vector quantity, which has magnitude and direction. It is measured by a unit called 'newton' (N).

Effects of Force:

Observe the strokes a batsman in cricket game. If he wants to hit the cricket ball to the boundary, the striking force on the ball must be greater. So, the greater the force you apply on a body, greater will be its effect on it.

If you prick a blown up balloon with a single pin it will burst. But, this did not happen even though many more pins were pricking the balloon. A single pin produces a large pressure over a small area. But, when large number of pins prick a body, each pin exerts very little pressure on the balloon, as the applied force gets distributed over a large surface of the body. So, the balloon will not burst.

Thus, we can conclude that the effect of a force depends on the magnitude of the force and the area over which it acts. The force acting perpendicularly on any given surface area of a body is known as thrust. It is measured by the unit newton.

Pressure:

The effect of force can be measured using a physical quantity called pressure. It can be defined as the amount of force or thrust acting perpendicularly on a surface of area of one square meter of a body.

$$\text{Pressure} = \text{Thrust (or) Force} / \text{Area}$$

ie., $P = F / A$

The SI unit of pressure is pascal (named after the French scientist Blaise Pascal).

1 pascal = 1 Nm^{-2}

Pressure exerted by a force depends on the magnitude of the force and the area of contact.

The effect of pressure can be increased by increasing the thrust or by decreasing the surface area of the body. The axe, nail, knife, injection needle, bullet etc., are having sharp fine edges so as to exert a larger pressure on a smaller area of the body in order to produce maximum effect.

Examples:

1. More number of wheels are provided for a heavy goods-carrier for decreasing the pressure thereby increasing the area of contact on the road.
2. Broader straps are provided on a back-pack for giving less pressure on the shoulders by providing a larger area of contact with the shoulder.



Bags with broader straps

Pressure exerted by Air:

You all know very well that air fills the space around us. This envelope of air is called as atmosphere. It extends up to many kilometres above the surface of the Earth. All objects on the surface of the Earth experience the thrust or force due to this atmosphere.

The amount of force or weight of the atmospheric air that acts downward on unit surface area of the surface of the Earth is known as atmospheric pressure. It can be measured using the device called barometer. The barometer was invented by Torricelli.

Atmospheric pressure decreases with altitude from the surface of the Earth. It can be measured by the height of the mercury column in a barometer. The height of the mercury column denotes the atmospheric pressure at that place at a given time in 'millimetre of mercury'. Even if you tilt the tube at various angles, you will see that the level of mercury will not vary. At sea level, the height of the mercury column is around 76 cm or 760 mm. The pressure exerted by this mercury column is considered as the pressure of magnitude 'one atmosphere' (1 atm).

One atmospheric pressure (1 atm) is defined as the pressure exerted by the mercury column of height 76 cm in the barometer. It is equal to $1.01 \times 10^5 \text{ Nm}^{-2}$.

In the SI system 1 atm = 1,00,000 pascal (approximately). SI unit of atmospheric pressure is Nm^{-2} or pascal.

Force and Pressure in Liquids:

You would have noticed that an upward force is exerted by water on a floating or a partly submerged body. This upward force is called buoyant force. This phenomenon is known as buoyancy. This force is not only exerted by liquids, but also by gases.

This upward force decides whether an object will sink or float. If the weight of the object is less than the upward force, then the object will float. If not, it will sink.

Pressure exerted by Liquids:

Liquids exert a pressure not only on the base of the container/vessel in which they are kept, but also on the side walls. The pressure exerted by a liquid depends on the depth of the point of observation considered in it.

This activity confirms that the pressure in a liquid varies with the depth of the point of observation in it. This shows that the pressure exerted by a liquid at the bottom of a container depends on the height of the liquid column in it.

Thus, we can conclude that liquids exert the same pressure in all directions, at a given depth.

Pascal's Law:

You can see identical streams of water flowing in all directions from the holes. This is due to the fact that the pressure, which is applied on the liquid, is equally transmitted in all direction. This concept was first given by the French scientist Blaise Pascal.

Pascal's law states that the pressure applied at any point of a liquid at rest, in a closed system, will be distributed equally through all directions of the liquid.

Applications of Pascal's Law:

The applications of Pascal's law are:

- In automobile service stations, the vehicles are lifted upward using the hydraulic lift which works as per Pascal's law.
- Automobile brake system works according to Pascal's law.
- The hydraulic press is used to compress the bundles of cotton or cloth so as to occupy less space.

Surface Tension:

How is it possible? This is because the water molecules on the surface which tend to contract themselves like the molecules of an elastic membrane. A force exists on them, which tends to minimize the surface area of water. The paper clip is balanced by the molecules on the water surface that is now behaving like a stretched elastic membrane. So, it does not submerge.

Have you ever wondered why rain drops are spherical in nature? How does the water rise upward in a tree or plant against the force of gravity? These are all due to surface tension.

Surface tension is the property of a liquid. The molecules of a liquid experience a force, which contracts the extent of their surface area as much as possible, so as to have the minimum value. The amount of force acting per unit length, on the surface of a liquid is defined as surface tension. Its unit is Nm^{-1} .

Applications of surface tension:

Surface tension is the reason for many events we see in our daily life.

- In plants, water molecules rise up due to surface tension. Xylem tissues are very narrow vessels present in plants. Water molecules are absorbed by the roots and these vessels help the water to rise upward due to 'capillarity action', which is caused by the surface tension of water.
- During heavy storm, ships are damaged due surface tension of water. By pouring oil or soap powder into the sea, sailors reduce its impact.
- Water strider insect slides on the water surface easily due to the surface tension of water.



Water strider

Viscous Force or Viscosity:

Each liquid moves with a different speed. Water flows faster than other liquids. Coconut oil flows with a moderate speed. Ghee flows very slowly. Between the layers of the liquid, which is in motion, there is a frictional force parallel to the layers of the liquid. This frictional force opposes the motion of the liquid layers while they are in motion.

The frictional force acting between the successive layers of the liquid which acts in order to oppose the relative motion of the layer is known as viscous force. Such a property of a liquid is called viscosity. Viscous force is measured by the unit called poise in CGS system and $\text{kgm}^{-1}\text{s}^{-1}$ or Nsm^{-2} in SI system.

Friction:

We walk on roads without falling. But, we tend to fall when we walk on wet surfaces. Why? We walk on the roads safely because of the friction between the feet and the road. But, the friction is less when we walk on wet surface and so we tend to fall.

Frictional force or friction arises when two or more bodies in contact move or tend to move, relative to each other. It acts always in the opposite direction of the moving body. This force is produced due to the geometrical dissimilarities of the surface of the bodies, which are in relative motion. Friction can produce the following effects.

- Friction opposes motion.
- It causes wear and tear of the surfaces in contact.

- It produces heat.

Types of Friction:

Friction can be classified into two basic types: static friction and kinetic friction.

Static friction:

The friction experienced by the bodies, which are at rest is called static friction. Eg. All the objects are rigidly placed to be at rest on the earth.

Kinetic friction:

Friction existing during the motion of bodies is called kinetic friction. Kinetic friction can be further classified into sliding friction and rolling friction.

When a body slides over the surface of another body, the friction acting between the surfaces in contact is called sliding friction. When a body rolls over another surface, the friction acting between the surfaces in contact is called rolling friction. Rolling friction is less than sliding friction. That is why wheels are provided in vehicles, trolleys, suitcases etc.

Factors affecting Friction:

Some of the factors which affect friction are given below.

a. Nature of a surface:

Moving an object on a rough surface will be difficult, but we can easily move it on a smooth surface. It is because, friction varies between the surfaces.

b. Weight of the body:

It is easy to pedal your cycle without any load on its carrier. With a load placed on its carrier, it is difficult to move it because the weight on the carrier increases the friction between the surface of the tyre and the road.

c. Area of contact:

For a given weight, the friction is directly related to the area of contact between the two surfaces. If the area of contact is greater, then, the friction will be greater too.

A road roller has a broad base, so it offers more friction on the road. But, a cycle has the least friction, since the area of contact of the tyre with the surface of the road is less.

Advantages of Friction:

Friction is necessary for our day to day activities. It is desirable in most of the situations of our daily life.

- We can hold objects in our hand due to friction.

- We can walk on the road because of friction. The friction between footwear and the ground help us to walk without slipping.
- Writing on the paper with a pen is easy due to friction.
- Automobiles can move safely due to friction between the tyres and the road. Brakes can be applied due to frictional resistance on brake shoes.
- We are able to light a matchstick, sew clothes, tie a knot or fix a nail on the wall because of friction.

Though friction makes our life easy, it has some negative effects also. So, it is called as 'necessary evil'.

Disadvantages of Friction:

- Friction wears out the surfaces rubbing with each other, like screws and gears in machines or soles of shoes.
- An excess amount of effort has to be given to overcome the friction while operating a machine. This leads to wastage of energy.
- Friction produces heat, which causes physical damage to the machines.

Increasing and decreasing Friction:

a. Area of contact:

Friction can be increased by increasing the area of the surfaces in contact. For example, brake shoes in a cycle have to be adjusted so that they are as close as possible to the rim of the wheel, in order to increase the friction.

b. Using lubricants:

A substance which reduces the frictional force is called a lubricant. Eg. Grease, coconut oil, graphite, castor oil, etc. The lubricants fill up the gaps in the irregular surfaces between the bodies in contact. This provides a smooth layer thus preventing a direct contact between their rough surfaces.

c. Using ball bearing:

Since rolling friction is smaller than sliding friction, sliding is replaced by rolling with the usage of ball bearings. For the same reason, lead shots are used in the bearing of a cycle hub.

Points to Remember:

- Force acting on a body tends to change its state of rest or of motion or its shape. The SI unit of force is newton.
- Force acts only when two or more objects interact with one other.
- The effect of force can be measured using the physical quantity called pressure.
- Liquids, gases and air also exert pressure.
- All objects on the surface of the Earth experience a constant thrust or force due to the atmosphere.
- Atmospheric pressure can be measured by a device called barometer.

- Friction is the force that opposes the motion of an object.
- Friction is caused by irregularities on the surfaces, which are in contact.
- Friction depends on the nature of the surfaces and mass of the bodies in contact.
- Friction is classified into two types: static friction and kinetic friction. Kinetic friction can be further classified as rolling friction and sliding friction.
- Surface tension is the tendency of liquid surfaces to shrink to have minimum surface area as much as possible.
- When liquids are flowing there is a frictional force between the layers of the liquid, which oppose their relative motion. This force is called viscous force and the phenomenon is known as viscosity.
- Viscosity is measured by the unit called poise in CGS system and $\text{kgm}^{-1}\text{s}^{-1}$ and Nsm^{-2} in SI.

GLOSSARY

Buoyant force - An upward force exerted by liquid on a floating body.

Force - Action of push or pull

Friction - Force produced due to the geometrical dissimilarities of the surface of the bodies which are in relative motion.

Pressure - Force acting on unit area.

Surface tension - Force which contracts the surface area of the liquids

Thrust - Force acting perpendicularly on any given surface area.

Do You Know?

Problem 1:

The average weight of an elephant is 4000 N. The surface area of the sole of its foot is 0.1m^2 . Calculate the pressure exerted by one foot of an elephant.

Solution:

Average weight of the elephant = 4000 N

Weight of one leg = Force exerted by one leg

= $4000/4 = 1000\text{ N}$

Area of the sole of one foot = 0.1 m^2

Pressure = Force/Area

= $1000/0.1 = 10000\text{ N/m}^2 = 10^4\text{ Nm}^{-2}$

Pressure exerted by one leg of the elephant is 10,000 newton on one square metre.

It is very difficult for us to walk on sand. But, camels can walk easily on it because they have large padded feet, which increase the area of contact with the sandy ground. This reduces the pressure and enables them to walk easily on the sand.

Cooking in a place located at a higher altitude is difficult. Why? At a higher altitude, due to lack of atmospheric pressure the boiling point of a substance reduces. So, water boils even at 80°C. The thermal energy that is produced at this temperature is not sufficient enough for baking or cooking. So, cooking is difficult at higher altitude.

Why dams are made stronger and broader at the bottom than at the top? Why do scuba divers wear a special suit while they go into deep sea levels?