



Educational Services

(A step to success)

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Force, Pressure and Friction

Force

Pushes and pulls are forces. Thus when a force is applied to an object, it may have the following effects.

- (i) Start moving an object or stop a moving object
- (ii) Speed up or slow down a moving object
- (iii) Change the direction of motion of a moving object
- (iv) Change the shape of an object

Force is that which changes or tends to change the state of rest or of uniform motion of a body in a straight line, or changes the shape of a body. The SI unit of force is the Newton (N).

Contact and non-contact forces

Forces which act only when there is physical contact between two interacting objects are known as **contact forces**. Forces which can act without physical contact between objects, *i.e.* those that can act from a distance, are called **non-contact forces** or **field forces**.

Types of forces

1. Muscular force

This is the force we can exert with our bodies by using our muscles, e.g. pull, push, kick etc. These are contact forces

2. Magnetic force

Magnets exert forces of attraction or repulsion on other magnets. An important feature of magnetic force is that it can act from a distance, and is therefore of a non-contact force.

3. Electrostatic force

The comb acquires an exert a force called **electrostatic force**. Electrostatic force can also act from a distance and is therefore a non-contact force. A body with electrostatic charge can either attract or repel another charged body. Electrostatic force is used to separate solid pollutant particles from smoke given out from factories.

4. Gravitational force

All objects in the universe exert a force on all other objects. This is called **gravitational force**. The gravitational force exerted by the Earth on all the bodies on its surface is called **gravity**.

5. Frictional force

The fact that the rolling ball comes to rest after some time shows that there must be a force acting on it which tends to slow it down. This force seems to be more on rough surfaces than on smooth surfaces. The force acting against the relative motion of surfaces in contact is called **frictional force** or **friction**.

Static friction

The block remains at rest because a force of friction, equal but opposite to the applied pull, comes into action between the surfaces. Increase the force a little. The block does not move. This means that the force of friction has increased to balance the pulling force on the block. If the pulling force P is increased further, at a certain stage the block begins to move on the table. At this point the friction developed has reached the maximum value F for the two surfaces. This is called *static friction*.

Kinetic or sliding friction

Continue pulling the block with the spring balance, so that it slides at a steady speed. The reading on the spring balance is also steady and is slightly less than the static friction. This is a measure of the kinetic or sliding friction between the two surfaces.

Kinetic or sliding friction is less than static friction.

Rolling friction

Repeat the above procedure using an identical wooden block provided with wheels on either side. The reading on the spring balance when the block moves with a steady speed is much less than the sliding friction measured above.

Rolling friction is less than sliding friction.

Advantages of friction

Friction plays an important role in our daily life.

- 1) Without friction we would slip and fall every time we attempt to walk or run. There is very little friction on a wet polished floor. That is why it is easy to slip on such a floor.
- 2) Friction causes nails and screws to hold on to walls.
- 3) It would not be possible to light a matchstick without friction between its head and the side of the matchbox.
- 4) Cars and buses are able to run on roads because of friction between the tyres and the road.
- 5) Without friction writing on paper would be impossible as the tip of the pen will slip on paper.
- 6) It is because of friction between the brake 'shoes' and wheels that bicycles and automobiles stop when brakes are applied.

Disadvantages of friction

Friction is a nuisance in some circumstances.

- 1) The heat produced in the moving parts of machinery due to friction results in wear and tear of the parts.
- 2) Forest fires are caused due to friction between branches of trees rubbing against each other.
- 3) Tyres of vehicles and soles of footwear wear out because of friction.
- 4) Energy is wasted in overcoming the force of friction.

Minimizing friction

- 1) By using a suitable lubricant, like oil (for light machinery) or grease (for heavy machinery). This helps because fluid friction is less than solid friction
- 2) By using wheels and ball bearings.
Use of wheels between surface moving over each other reduces friction. Ball bearings have small balls of steel between steel surfaces. Because of the balls the steel surfaces can easily move over each other.
- 3) By making the rubbing surfaces smooth by polishing them.
- 4) Friction due to air (air resistance) or water is reduced by using streamlined shapes in aeroplanes or ships. A streamlined shape is narrow in front and broader at the back. Birds and aquatic animals have streamlined shapes which help them in flying or swimming.

Increasing friction

- 1) By making the moving surfaces rough, e.g. tyres have designs and patterns with grooves on the surface to increase resistance with the road. This prevents slipping of the tyres on a wet road.
- 2) Sand and gravel is strewn on slippery ground during the rainy season to increase friction. It is then easier to walk on the ground.
- 3) To increase friction, spikes are provided in the soles of shoes used by players and athletes.

Pressure

Pressure is used to find the effect force acting on a surface has. Pressure is defined as force per unit area.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

If the force increases the pressure increases.

If the area over which the force acts decreases, the pressure increases

Unit of pressure

The SI unit of pressure is the **pascal (Pa)**. It is the pressure exerted by a force of 1 N acting over an area of 1 m^2 .

Thus $1 \text{ Pa} = 1 \text{ N/m}^2$

Everyday examples

- When you cut an apple with a knife, the sharper the knife, the smaller is the area of contact of the knife with the apple. Thus a sharper knife exerts a greater pressure making it easier to cut the apple.

- It is easier to pierce a piece of cardboard with a pin if the pin has a sharp point, as the area of contact is then smaller.
- School bags and shopping bags have broad belts or straps as handles. Narrow string-like handles cause severe pain in the hand because the weight of the bag acts on a small area and so the pressure is considerably higher.
- Porters wear turbans when they have to carry heavy loads on their heads, to increase the area of contact. This reduces the pressure on the head.
- Lorries and trucks carrying heavy loads have 8 tyres instead of four, and the tyres are broader. This increases the area of contact with the ground, this reducing the pressure exerted on the ground.
- War tanks move on caterpillar tracks which are broad and chain-like and cover the wheel. This causes large increase in the area of contact with the ground. The pressure on the ground reduces so much that tanks can even move on soft wet ground without sinking.

Atmospheric Pressure

The Earth is surrounded by air and this covering of air is known as the atmosphere. The atmospheric air exists to height of about 1000 km. But beyond 100 km the air is very thin. The force exerted by the atmosphere on unit area is called **atmospheric pressure**.

Liquid Pressure

- a) Water exerts pressure downwards
- b) Water exerts pressure in the upward direction
- c) Water exerts pressure in all directions on the sides. This is called **lateral pressure**.
- d) Liquid pressure increases with depth.

Pressure at the bottom of the ocean is very high. Deep sea divers wear steel diving suits to prevent their bodies from being crushed by the tremendous pressure of water exerted on all sides.

Submarines are built of hard thick sheets of metal to withstand the high pressure under water. For the same reason dams are broader at the base than at the top.

Measuring liquid pressure – the manometer

An instrument called a manometer is used to measure liquid pressure.

- A liquid exerts pressure in all directions (downward, upward and sideways).
- The pressure is the same in all directions at the same depth.
- Pressure increases with depth.

The pressure exerted by water in the oceans increases with depth. Very deep down the pressure is enough to crush the human body. That is why deep-sea divers wear special suits, which can withstand such high pressures.

Short answer questions

1. What is meant by force?
2. What changes can a force produce to the motion of an object?
3. What is elastic force? Give two examples.
4. How is pressure related to the area over which a force acts?
5. What is the relation between pascal and N/m^2 ?
6. If you wear pointed heels in one leg and slippers on the other leg, which leg exerts greater pressure on the ground?
7. What is atmospheric pressure?
8. Explain how it is possible to drink a liquid by using a straw.
9. Why are dams over rivers made broader at the bottom than at the top?
10. Differentiate between mass and weight. What are the SI units?

Long answer questions

1. Explain contact and non-contact forces. Give two examples for each.
2. What are the advantages and disadvantages of friction?
3. Illustrate static, kinetic and rolling friction with an example. Which is the highest?
4. (a) How can friction be reduced? (b) How can it be increased?