PHYSICS

FORCE AND PRESSURE

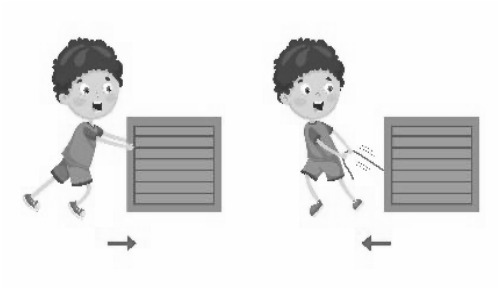
Concepts Covered

- Basic introduction to motion,
- Basics of force and its types, Pressure.

Force

Force is a push or a pull which changes or tends to change the state of rest or motion, direction of motion, or the shape and size of a body".

It is a vector quantity.



Example:

1. When we push a ball lying on the ground, it starts rolling. The force exerted has thus produced motion in the ball. However, when we push a heavy stone, it does not move. The effort made in this case has only tried to produce motion but has not succeeded.
2. A ball falling downwards can be easily caught by our hands. The motion of the ball has thus been destroyed. However, a big piece of rock rolling down a hill cannot be stopped even when we try our best to stop it.

Units of Force

Mathematically,

$F = ma$

Absolute units

$1N = 1kg \times 1ms^{-2} = 1kgms^{-2}$

Remember that in all numerical problems, we have to use only the absolute units of force.

Effects of Force

1. Produces or tries to produce motion in a body at rest.

2. Stops or tries to stop a moving body.

3. Changes or tries to change the direction of motion of the body.

4. Changes or tries to change the speed of a moving body.

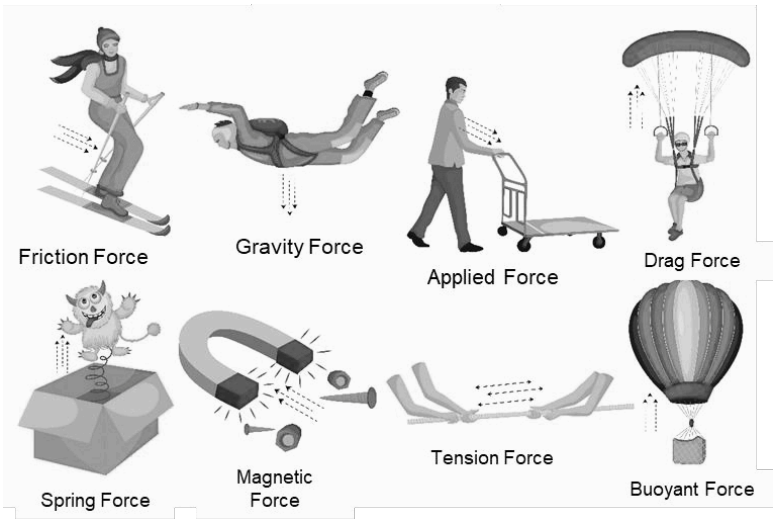
Slow

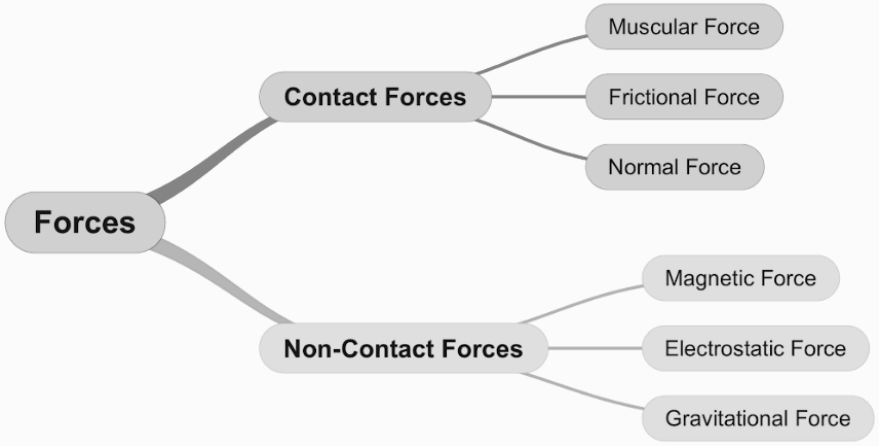
Fast

5. Changes or tries to change the shape of a body.

Roller coasters use the force of gravity to make a rip-roaring ride. When the roller coaster cars get to the top, gravity pulls them down the track toward the ground, getting faster and faster.

Types of Forces



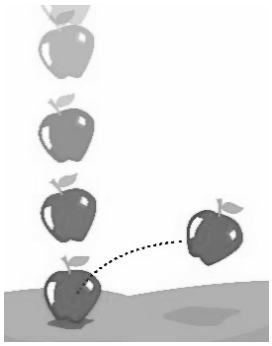


(a) Non Contact Forces

These are the forces in which contact between two objects is not necessary.

Gravitational Frce

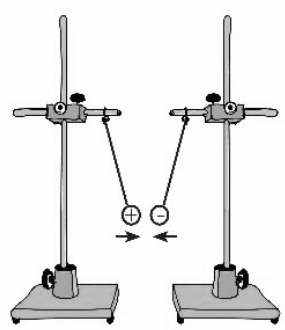
- The force of attraction that one body exerts on the other because of its mass is called gravitational force.
- The uniform acceleration produced in a freely falling body due to the gravitational force of the earth is known as acceleration due to gravity.

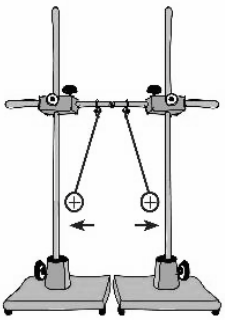


A collapsed star, known as a neutron star, has the strongest magnetic force of any object in the universe.

Electrostatic Force

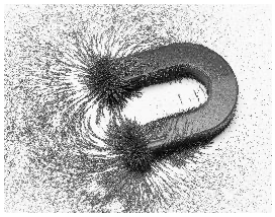
- Force between two charged particles is known as electrostatic force.
- The electrostatic force between similar charges is called force of repulsion and between opposite charges is called force of attraction.
- If we rub a plastic object like a pen or a comb with hair and bring it close to tiny bits of paper, the bits of paper get attracted to the plastic object. This is due to electrostatic force.





Magnetic Force

- Magnetic force can be defined as the attractive or repulsive force that is exerted between the poles of a magnet.
- Since magnets attract iron, magnets are used to separate waste iron objects from garbage dumps so that they can be recycled.

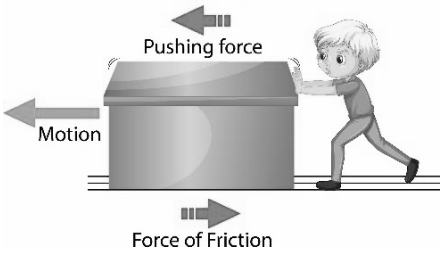


(b) Contact Forces:

Contact force is any force that requires physical contact to occur. For example, pushing a car, pulling a box, etc.

Frictional Force

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



Muscular Force

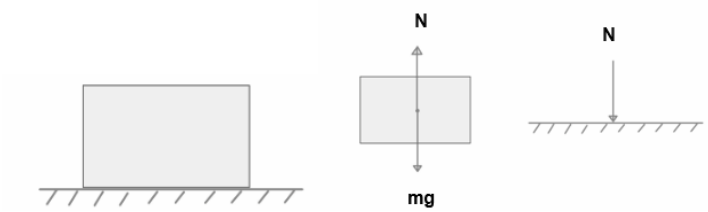
Force resulting due to the action of muscles is known as muscular force.

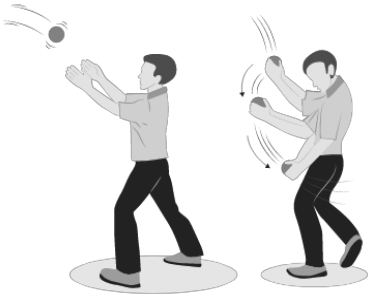
DID you KNOW

A robotic arm can be utilized to perform certain tasks in a factory. A robotic arm creates some force while performing tasks. This force created by a machine is known as a mechanical force.

Normal Force

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





Balanced and Unbalanced Forces:

If a set of forces acting on a body produces no acceleration in it, the forces are said to be balanced. If it produces a non-zero acceleration, the forces are said to be unbalanced. A set of unbalanced forces produces acceleration in the body.

Balanced Force

Unbalanced Force

Thrust and Pressure

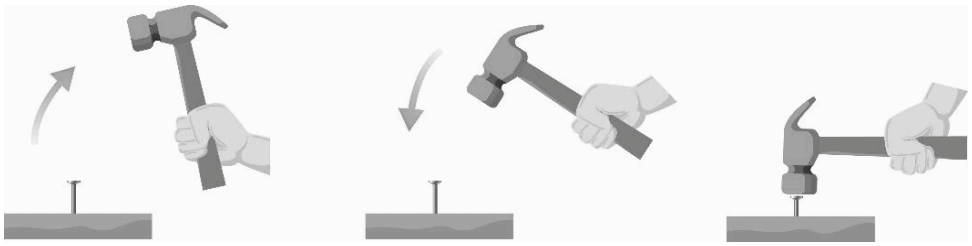
(A) Thrust

- The force acting normally on the surface is called thrust.
- It is a vector quantity.
- It is measured in newton (N).

The barometer was invented in 1643 by an Italian scientist named Evangelista Torricelli.

(B) Pressure

The thrust on a unit area of a surface is called pressure.



Mathematically,

$$\textbf{Pressure} = \frac{\textbf{Thrust}}{\textbf{Area}} \quad \text{or } P = \frac{F}{A}$$

Unit: The SI unit of pressure is newton per meter square or N/$\mathbf{m^2}$. Other units of pressure are pascal and bar.

One Pascal: One pascal is defined as the pressure exerted on a surface area of 1$\mathbf{m^2}$, by a thrust of 1 newton.

i.e. 1 Pascal = 1 N/$\mathbf{m^2}$.

Examples:

- Inserting a pointed nail in a wooden block is easier than inserting a rod inside a wooden block with the same force because the nail has a smaller area and thus, it will experience more pressure.
- A sharp knife cuts better than a blunt knife.
- While walking, a man exerts more pressure on the ground in comparison to when he is standing.

Solved Examples

(1) In a tug of war, when one team is pulling with a force of $200\ \text{N}$ and the other with $120\ \text{N}$ in the opposite direction, what is the net force?

Solution: Force of Team 1 = 200 N

Force of Team 2 = 120 N

So, 200N - 120N = 80N

Net force is 80 N.

(2) How much the total force is required to accelerate a car of mass 200 kg to 3.00 m/s^2?

Solution: Force = mass × acceleration

⇒ F = ma

⇒ F = 200 × 3.00

⇒ F = 600 N

Hence, Force (F) is 600 Newtons.

(3) If you apply a net force of 2 N on a 100 g box, what is the acceleration of the box?

Solution: It is given that,

The net force acting on the box, F = 2 N

Mass of the box, m = 100 g = 0.1 kg

Let a be the acceleration of the box. It can be calculated using the second law of Newton:

F = ma

$$\mathbf{a} = \frac{\mathbf{F}}{\mathbf{m}}$$

$$\mathbf{a} = \frac{\mathbf{2\ N}}{\mathbf{0.1\ kg}} = \mathbf{20\ m/s^2}$$

So, the acceleration of the box is $\mathbf{20\ m/s^2}$.

(4) The edge of a drawing pin is a sharp and pointed. Why?

Answer: The edge of a drawing pin is a sharp and pointed to increase the pressure of applied force. As a result, the drawing pin easily pierces into the cardboard sheet.

(5) We cannot walk comfortably on sand but camels can run in a desert easily. Explain the reason in brief.

Answer: The surface area of the feet of the camel is much more than that of a human being. When a camel walks/runs in a desert, the pressure due to its weight is much less. As a result, the camel can run easily in a desert.

(6) A force of 100 N is applied on an area of $5\ \text{m}^2$.Calculate the pressure being applied on the area.

Solution: Given, Force $= \mathbf{100\ N}$

and Area $= \mathbf{5\ m^2}$

$$\therefore \text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\mathbf{100\ N}}{\mathbf{5\ m^2}} = \mathbf{20Pa}$$

(7) If 700 N force is applied on a liquid and it experiences 50 N/m^2 pressure. Find out the area on which the force is Applied.

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

Given: Pressure $= \mathbf{50\ N/m^2}$

Force $= \mathbf{700\ N}$

Hence, $\text{Area} = \frac{\text{Force}}{\text{Pressure}} = \frac{\mathbf{700}}{\mathbf{50}}\ \mathbf{m^2} = \mathbf{14\ m^2}$.

(8) Give reasons for the following:

(i) Cutting and piercing tools are made sharp.

(ii) An egg sinks in freshwater but floats in highly salty water.

Solution: (i) Cutting and piercing tools are made sharp to have greater pressure at the edge of the tool even for a small applied force. As a result, its cutting/ piercing action is sharp and quick.

(ii) An egg sinks in freshwater because its density is more than that of freshwater. However, it floats in highly salty water. because the density of an egg is less than that of highly salty water.

(9) If 100 N force is applied on a liquid and it experiences 25 N/m^2 pressure. Find out the area on which the force is applied.

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

Given: Pressure $= \mathbf{25\ N/m^2}$

Force $= \mathbf{100\ N}$

Hence, Area $= \frac{\text{Force}}{\text{Pressure}} = \frac{\mathbf{100}}{\mathbf{25}}\ \mathbf{m^2} = \mathbf{4\ m^2}$.

(10) The force of $\mathbf{150\ N}$ is applied to an object of area $\mathbf{3\ m^2}$. Calculate the pressure.

(A) $\mathbf{25\ N/m^2}$ (B) $\mathbf{50\ N/m^2}$

(C) $\mathbf{100\ N/m^2}$ (D) $\mathbf{147\ N/m^2}$

Answer: (B)

Explanation: Given: Force $= \mathbf{150\ N}$, Area $= \mathbf{3\ m^2}$

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

Pressure $= \frac{\mathbf{150}}{\mathbf{3}} = \mathbf{50}\ \text{N/m}^2$

Thus, the pressure is 50 newtons per square meter or 50 pascals.

Exercise

FILL IN THE BLANKS

(1) Gravitational force is always an _____ force.

(2) Muscular force is _____force.

(3) Frictional force is_____ force.

(4) Force is a _____ and _____ on an object.

(5) SI unit of force is _____.

OBJECTIVE TYPE QUESTIONS

(1) A ball is thrown in upward direction then, the force(s) acting on it is (are)

(A) gravitational force (B) mechanical force

(C) frictional force (D) Both (A) and (C)

(2) 20 Pa pressure is applied on the head of a nail placed perpendicular to the surface of a wall. If the area of cross-section of the tip of the nail is 1/10 the area of cross-section of the head of the nail, the pressure exerted at the wall is ___Pa.

(A) 20 (B) 2

(C) 200 (D) 100

(3) The force of attraction between an electron revolving around the nucleus and the nucleus is _____ force.

(A) A magnetic (B) An electrostatic

(C) A gravitational (D) A mechanical

(4) What is the force required to move and object of mass 5 kg with an acceleration of 3 m/s^2?

(A) 20 N (B) 15 N

(C) 12 N (D) 10 N

(5) What is the pressure on a surface of area 20 m^2 if force applied on it is 50 N?

(A) 5 Pa (B) 1000 Pa

(C) 2.5 Pa (D) 500 Pa

(6) Which of the following is a Non-Contact force?

(A) Muscular Force (B) Frictional Force

(C) Normal Force (D) Magnetic Force

(7) Which of the following is a Contact force?

(A) Electrostatic Force (B) Gravitational Force

(C) Magnetic Force (D) Tension Force

(8) Which force acts between two charged particles

(A) Gravitational Force (B) Electrostatic Force

(C) Magnetic Force (D) Frictional Force

Answer key

(I) FILL IN THE BLANKS

(1) Attractive

(2) Contact

(3) Contact

(4) Push, Pull

(5) Newton

(II) OBJECTIVE TYPE QUESTIONS

(1)	(A)	**(2)**	(C)	**(3)**	(B)	**(4)**	(B)	**(5)**	(C)
(6)	(D)	**(7)**	(D)	**(8)**	(B)				