Force, Motion and Energy

Motion and Rest

- Motion is the change in the position of object with respect to its surroundings.
- An object which do not change their position is said to be at rest.
- Motion is a relative phenomenon

An object appearing to be in motion to one person can appear to be at rest as viewed by another person.

Example: Trees on road side

- Force is a push or pull.

Newton's law of motion:

This law states that energy body continues to be us its state of rest or the state of uniform motion along a straight line unless it is acted upon by some external force.

It gives the definition of force and inertia

Inertia

The inherent property of a body to resist any change in its state of rest or state of Uniform motion unless it is influenced upon by an external unbalanced force is known as inertia.

2nd law of motion:

The force acting on a body is directly proportional to the rate of change of linear momentum of the body and change in momentum tooks place in the direction of force

$$\text{Force} = \text{Mass} \times \text{acceleration}$$

Linear Momentum:

The impact of force is more of the velocity and mass of the body is more to quantity the impact of a force a physical quantity linear momentum is defined.

P = Mass × Velocity
P = M × V
Unit is Kg m/s

Impulse:

A large force acting for a very short interval of time is called impulsive force.

$$J = F \times t$$

3rd law of motion:

For every action there is as equal and opposite reaction. They always act on two different bodies.

$$F_B = -F_A$$

Principle of Linear Momentum

There is no change in the linear momentum of a system of bodies as long as not net external force acts on them.

Rocket Propulsion:

- Newton's third law of motion
- Principle of linear momentum

While in motion, the mass of the rocket gradually decreases until the fuel is completely burnt out. Since, there is no net external force acting on it, the linear momentum of the system is conserved. The mass of the rocket decreases with the attitude which increases velocity of the rocket and at one stage it just escapes from the gravitational pull of the earth. This velocity is called escape velocity.

$$V_e = \sqrt{\frac{2GM}{r}}$$

1. Which of the following law undergoes rocket propulsion?
   a. Newton 1st law of motion
   b. Newton 2nd law of motion
   c. Newton 3rd law of motion
   d. None of these

(Group 2, 2013)

2. Inertia of a body depends upon
   a. weight of the object
   b. Acceleration due to gravity of planet
   c. mass of the object
   d. Both a & b

3. Newton's III law is applicable
   a. for a body is at rest
   b. for a body is motion
   c. Both a & b
   d. only for bodies with equal masses

Distance and Displacement

The actual length of the path travelled by a moving body irrespective of the direction is called distance travelled by the body.

S.I Unit is meter

Displacement is defined as the change in position of a moving body in a particular direction. It is a vector quantity.

S.I Unit is meter

Speed, Velocity and Acceleration:

i) Speed $= \frac{\text{Distance}}{\text{Time}}$

SI Unit is ms^{-1}

ii) Velocity is the rate of change of displacement.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time Taken}}$$

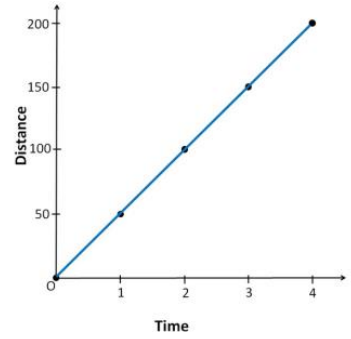
iii) Acceleration is the rate of change of velocity.

$$\text{Acceleration} = \text{Change in velocity}$$

$$a = \frac{\text{final velocity - initial velocity}}{\text{Time Taken}}$$

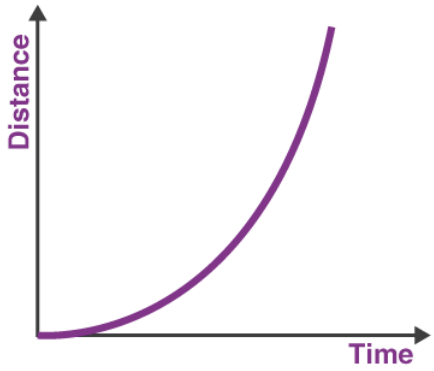
SI Unit – ms^{-2}

Distance – Time graph for uniform motion



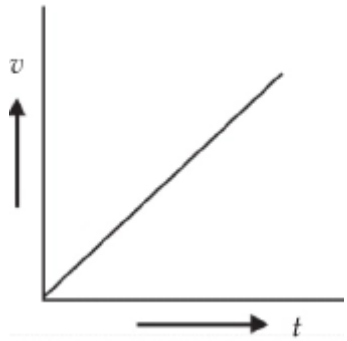
equal distance in equal intervals at time, it is a straight line.

Distance – Time graph for non- uniform motion



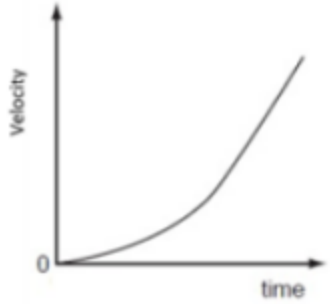
Non-linear variation

Velocity – Time graph for Uniform acceleration



(i) It is a straight line

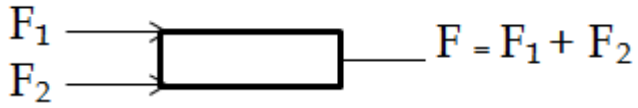
Velocity – Time graph for Non-Uniform acceleration



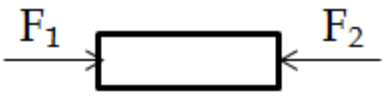
- There is no shape. It can have any shape.

Types of Forces:

(i) Parallel Force



(ii) Unlike Parallel Force



$F = F_1 - F_2 (F_1 > F_2)$
$F = F_2 - F_1 (F_2 > F_1)$
$F = 0 (F_1 = F_2)$

(iii) Rotational effect of force.

(iv) Torque: The turning (or) rotating effect of a force about a fixed point (or) Fixed axis is called Torque.

$l = F \times d$ It is a vector quantity

(v) Couple: two equal and unlike parallel forces applied simultaneously at two distinct points constitute a couple.

$M = F \times s$ Nm → Unit

Factors affecting Force

- Value
- Area of contact

Thrust

It is a force acting perpendicular to an object.

Pressure

The Force per unit area acting on an object concerned is called pressure.

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

S.I Unit Pressure is Pascal.

1 Pascal = 1 Nm^{-2}

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

Atmosphere Pressure:

The amount of force or weight of the atmosphere air that acts downwards on unit surface area of the earth is known as Atmospheric Pressure.

It is measured by using barometer device. It is invented by 'Torvicelli'. S.I Unit Nm^{-2} (or) Pascal

$$1 \text{ atomic Pressure} = 1.01 \times 10^{-5} \text{ Nm}^{-2}$$

Factors affecting pressure exerted by liquids:

(i) Depth (h)
(ii) Density
(iii) It will exerts in all direction

PASCAL'S LAW:

Pressure applied at any point of a liquid at rest, in a closed system will be distributed equally through all regions of the liquid

Application:

- Hydraulic lift (in service station, JCB)
- Brake system (Car, Bus, Lorry etc)
- Hydraulic press (a large word, steel, sugarcane machine)

Surface Tension:

It is the property of a liquid where the molecules of a liquid experience a force, which contracts the extent of surface area so as to have the minimum value.

The amount of force acting per unit – length on the surface of the liquid. Unit is Nm^{-1}

Applications:

- Rains are spherical in shape
- In plants water from the grounds are absorbed through the xylem tissues.
- Water strides insects slides on the water easily.
- During a heavy storm sailors pour soap powder or oil into the sea to decrease the surface tension of sea water.

Viscosity:

Frictional force between successive layers of liquids to oppose relative motion of layer.

SI unit is Nsm^{-2}
CGS → $kgm^{-1}s^{-1}$

Friction:

- When two or more bodies in contact tends to move relative to each other frictional forces arises.
- It is produced due to the geometrical dissimilarities of the surface of the bodies.

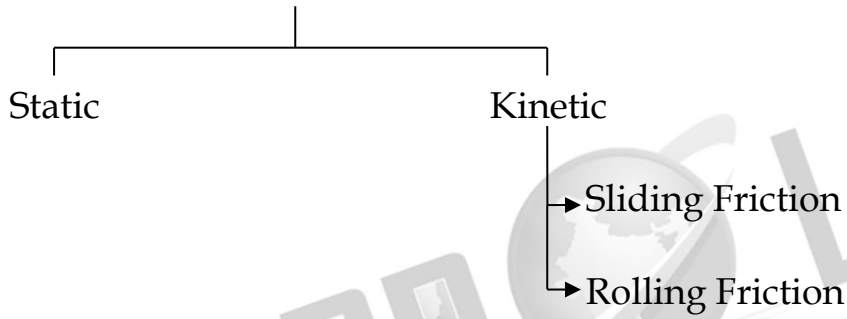
Effects:

- Opposes motion
- It causes wear and tear of the surface in contact.
- It produces heat.

Factors affecting Friction:

i) Area of contact
ii) Nature of a surface
iii) Weight of the body.

Types of Friction:



- Static – Friction experience by the bodies which are at rest.
- Kinetic – Friction existing during the motion of bodies.
- Sliding Friction – Friction between the surfaces in contact when a body slides over the surface of another body.

- Rolling Friction – Friction acting between the surfaces, when a body rolls over the surfaces.

  Sliding Friction > Rolling Friction

Increasing and decreasing of Friction:

- Area of contact
- Using lubricants (oil)
- Using ball bearing

ARCHIMEDES PRINCIPLE:

It states that "a body immersed in a field experiences a vertical upward buoyant force equal to the weight of the fluid it displaces".

Laws of Flotation:

1. The weight of a floating body in a fluid is equal to the weight of the fluid displaced by the body.

2. The centre of gravity of the floating body and the centre of buoyancy are in the same vertical line.

Electricity

Electric charge:

Inside each atom there is a nucleus with positively charges protons and chargeless neutrons and negatively charged electrons orbiting the nucleus.

If an electron is removed from the atom, the atom becomes positively charged. It is called positive ion. If an electron is added in excess to an atom then the atom is negatively charged and it is called negative ion.

It is measured in coulomb.

$q = 1.6 \times 10^{-19}$ C
$q = ne$
$n \rightarrow$ whole number
e – charge of an electron

Electric Force:

There are two types of electric force (F)
Attractive Force – Unlike charges are attract
Repulsive Force – like charges repel

The Force existing between the charges is called as 'electric force'.

Electric Field:

The region in which a charge experiences electric force forms the electric field around the charge. The lines representing the electric field are called 'electric lines of force'. They are imaginary lines.

Electrostatic force between two-point charges obeys Newton's third law. The force on one charge is the action and on the other is reaction and vice versa.

Electric Potential:

Electric potential is a measure of the work done on unit positive charge to bring it to that point against all electrical forces.

Electric Potential Difference:

It is the difference between two points and is defined as the amount of work done in moving a unit Positive charge from one point to another point against the electric force.

$$V = \frac{\text{Work done (W)}}{\text{Charge Q}}$$

SI unit is volt.

OHM's LAW:

At a constant temperature the steady current 'I' flowing through a conductor is directly proportional to the potential difference 'v' between the two ends of the conductor.

$I \alpha v, \ \frac{I}{V} = \text{Constant}$

$I = \frac{1}{R} V$

$V = IR$ $\quad R \rightarrow$ Resistance of the conductor

Resistance of a material:

It is its property to oppose the flow of charges and hence the passage of current through it. It is different for different materials.

$\frac{V}{I} = R$ Ohm (S.I Unit)

Electrical Resistivity and Electrical Conductivity:

Resistance of any conductor 'R' is directly proportional to the length of the conductor 'L' and is inversely proportional to its area of cross section 'A'.

$R \alpha L, \qquad R \alpha \frac{L}{A}$

$R = P\frac{L}{A}$, P = Constant called as electrical resistivity or specific resistance of the conductor

$$P = \frac{RA}{L}$$

Conductance of a material is mathematically defined as the reciprocal of its Resistance (R).

$G = \frac{1}{R}$ Unit is ohm^{-1}

The reciprocal of electrical resistivity of a material is called its electrical conductivity.

$\sigma = \frac{1}{P}$ Unit is $ohm^{-1}\ m^{-1}$,

Nichrome is a conductor with highest resistivity equal to $1.5 \times 10^{-6}\ \Omega$. Hence it is used in making heating elements.

Nature the material	Material	Resistivity
Conductor	Copper	1.62×10^{-8}
	Nickel	6.84×10^{-8}
	Chromium	12.9×10^{-8}
Insulator	Glass	10^{10} to 10^{14}
	Rubber	10^{13} to 10^{16}

System of Resistors:

i) Resistance in series

$$R_3 = R_1 + R_2 + R_3$$

ii) Resistance in Parallel

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Heating Effect of Current:

Generally, a source of electrical energy can develop a potential difference across a resistor which is connected to that source. This potential difference constitutes a current through the resistor. For continuous drawing of current, the source has to continuously spend its energy. A part of the energy from the source can be converted into useful work and the rest will be converted into heat energy. This effect is used in electric heater, electric iron, electric oven, toaster etc.,

Joule's law of heating:

$H = W = VQ$

$H = VIt$ $\quad (Q = It)$

$H = I^2Rt$ $\quad (V = IR)$

This is known as Joule's law of heating.

Applications:

i) Electric Heating device
ii) Fuse wire
iii) Filament in bulbs.

Electric Power - $\boxed{P = V \times I}$

S.I Unit is Watt