Laws of Motion

- Force is a push or pull upon an object resulting from the object's interaction with another object. The various effects of force are:
- Force can move a body initially at rest.
- Force can bring a moving body to rest.
- Force can change the direction of a moving body.
- Force can change the speed of a moving body.
- Force can change the shape of a body.
- Force can change the size of a body.

- **Muscular force –** It involves the action of muscles.
    - Animals make use of muscular force to carry out their physical activities and other tasks.
- **Friction –** It is an opposing force that acts between surfaces in contact moving with respect to each other.
    - Frictional force always acts between two moving objects, which are in contact with one another.
    - Frictional force always acts opposite to the direction of motion.
    - Frictional force depends on the nature of the surface in contact.
- **Tension Force -** This force appears in a string, attached to a rigid support, when an object is suspended by it.
- **Mechanical Force** - It involves the force generated by machines.
- **Force exerted during collision -**Two objects push each other with an equal but opposite forces if collision occurs between them. These forces are known as the force of action and force of reaction.
- **Combined Forces** - When two or more forces are acting on the same object.

- Non-contact force come into play even when the bodies are not in contact.

- **Magnetic force –** Force acting between two magnets or a magnet and a magnetic material (eg. iron, steel, nickel, cobalt etc.). It can be attractive and repulsive.
- **Electrostatic force –** Force due to electric charges. It can be attractive and repulsive.
- **Gravitational force –** It is a kind of attractive force that comes into play because of the mass of a body. (eg. earth's gravitational attraction).

- **First law of motion**
    - A body at rest remains at rest and a body in uniform motion continues its uniform motion unless an external force is applied.

- **Inertia:**
    - It is the tendency of a body to resist any change in its state of rest or of uniform motion along a straight line.
    - Mass of an object is the measure of its inertia, more is the mass more is the inertia.
    - Types of inertia: Inertia of rest and motion

- Momentum is the product of the mass of the body and its velocity. It is a vector quantity.
- Momentum = Mass × Velocity
- SI unit of the momentum is kg m/s.

- **Second law of motion**

    - The second law of motion says, when a force F is subjected to a body of mass m, an acceleration a is gained by the body in the direction of the force and the magnitude of acceleration is directly proportional to the F and inversely proportional to the m.

    - Rate of change of momentum $\propto$ Applied unbalanced force

- Direction of change in momentum is the same as the direction of unbalanced force

  $F = ma$

  Unit of force is Newton

  $1\ \text{N} = 1\ \text{kg} \times 1\ \text{m} / \text{s}^2$

- **Third law of motion**
  - For every action force there is an equal and opposite reaction force.
  - The horse and the cart: From the third law of motion the pull by the horse in the forward direction is equal to the pull by the cart in the backward direction. The sum of these forces is therefore zero. Why should then the cart accelerate forward? Apart from the pulls of the horse and the cart there is frictional force and the reaction of the ground on the horse and the cart is also present. The resultant force of this normal reaction and the friction together helps the horse to move the cart in the forward direction.

- **Universal law of gravitation**

$$\left|\bar{F}\right| = \text{G}\frac{m_1 m_2}{r^2}$$

$$\bar{F} = \text{G}\frac{m_1 m_2}{r^2}(-\hat{r}) = -\text{G}\frac{m_1 m_2}{r^2}(\hat{r})$$

- **For a point mass**
  - The point of attraction between a hollow spherical shell of uniform density and a point mass situated outside is just as if the entire mass of the cell is concentrated at the center of the shell.
  - The force of attraction due to a hollow spherical shell of uniform density, on a point mass inside it is zero.

- **Gravitation Constant, G** = $6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2$

- **Free Fall: A body is said to be free falling if it begins to fall downward towards the earth due to earth's gravity only.**

mg=GMmR2g=GMR2

'g = 9.8 m/s^2' is the acceleration due to gravity, it is the acceleration of a freely falling body.

- **Tips to solve numerical**
  - For upward motion take g = –9.8m/s^2 and final velocity at the highest point as 0.
  - For downward motion take g = 9.8m/s^2 and for a freely falling body take initial velocity as 0.

Equations of motion of an object under the influence of the earth's gravity

for downward motion of the particle

v=u+gts=ut+12gt2v2=u2+2gs

for upward motion of the particle

v=u-gts=ut-12gt2v2=u2-2gs

- **Mass:** It is the amount of matter contained in the body
- **Weight:** It is the force exerted on a body due to the gravitational pull of another body such as the earth, the sun etc.

$$\frac{\text{Weight of the object on the moon}}{\text{Weight of the object on the earth}} = \frac{1}{6}$$