Gravitation

- **Universal law of Gravitation:**

- Gravitational force of attraction between two masses is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

  $F \propto M \times m$ M and m are masses of two bodies.

  F∝1r2F=GMmr2

  G = 6.673×10^{-11} $Nm^2 kg^{-2}$

  - Inverse square law $F \propto \frac{1}{r^2}$

  - Weight is the gravitational force on an object.

  - The weightlessness in outer space happens because the weight of the orbiting body is used to provide the centripetal force required to remain in that particular orbit of rotation. This is the reason why moon doesn't fall down to earth, the gravitational pull of earth on moon is used up in maintaining the centripetal force to keep the moon in its orbit of rotation around the earth

- **Kepler's law of planetary motion**

  - Orbits of planets are elliptical.
  - Planet covers equal area in equal time intervals
  - r^3T^2 = constant

- **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 = $-9.8 m/s^2$ and final velocity at the highest point as 0.

  - For downward motion take g = $9.8 m/s^2$ 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.

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

- **Thrust** – Force acting perpendicular to a surface

- **Pressure =** Perpendicular force per unit area

$$= \frac{\text{Thrust}}{\text{Area}} \left[\text{N/m}^2 = \text{Pascal (Pa)}\right]$$

  - Lesser is the area more is the pressure; this is the reason why we prefer to use sharp knives over the blunt ones to cut objects. This pressure is again the reason why it is difficult to hold a school bag having a strap made of a thin and strong string.

- **Density of a substance-** mass per unit volume**.** It is expressed as

$$\boxed{\text{Density} = \frac{\text{Mass}}{\text{Volume}}}$$

  The SI unit of density is kg/m^3.

- If density of body > density of fluid, then the body will sink in the fluid.
- If density of body < density of fluid, then the body will float in the fluid.

  (Density of cork) < (density of water), so cork floats.
  (Density of iron) > (Density water), so iron sinks.

- Relative density $= \frac{\text{Density of a substance}}{\text{Density of water}}$

  Relative Density of a Solid Substance by Archimedes' Principle
  R.D. **=**W1W1−W2
  where W_1 is the weight of the body in air and W_2 is the weight of the body in water.

  (1) Relative density of a solid denser than water and insoluble in it

R.D.=Weight of solid in airLoss in weight of solid in water=W1W1−W2R.D.=Weight of solid in airLoss in weight of solid in water=W1W1-W2

(2) Relative density of a solid denser than water and soluble in it

R.D.=Weight of solid in airLoss in weight of solid in liquid×R.D. of liquidR.D.=Weight of solid in airLoss in weight of solid in liquid×R.D. of liquid

Relative Density of a Liquid Substance by Archimedes' Principle

If a solid is immersed in a liquid or water, it displaces the liquid or water equal to its own volume.

R.D.=Weight of a liquid displaced by a bodyWeight of water displaced by the same body=Weight of the body in air − Weight of the body in liquidWeight of the body in air − Weight of the body in water=W1−W2W1−W3R.D.=Weight of a liquid displaced by a bodyWeight of water displaced by the same body=Weight of the body in air - Weight of the body in liquidWeight of the body in air - Weight of the body in water=W1-W2W1-W3

- **Buoyancy**

  - Buoyant force = Up thrust by a fluid on a partially or fully immersed object is buoyancy or buoyant force. [Depends on fluid density]
  - Buoyant force = Weight of displaced liquid
  - Buoyant force = Volume of the object immersed in liquid × Density of the liquid × Acceleration due to gravity
  - This is the reason why an object immersed in water weighs comparatively lesser than its weight when it is outside water**.**

- **Archimedes' principle**

  - Upward force experienced by a body immersed in fluid = Weight of the displaced fluid
  - Lactometer measures purity of milk