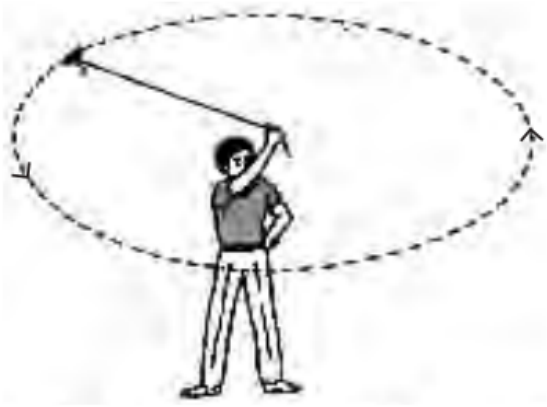
🔹 What is Gravitation?

🟦 **Definition:**
Gravitation is the force of attraction between any two objects in the universe due to their masses.

✅ Examples:

- Apple falling from a tree
- Moon orbiting the Earth
- Earth pulling everything downward



📷 *Fig. 9.1 – Stone tied to thread moving in circular motion (Activity 9.1)*

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🔬 Activity 9.1:

- Tie a stone to a string and whirl it in a circle
- Release it suddenly → it flies off tangentially
  ✅ **Reason:**
  The stone stays in circular motion due to a force towards the center (centripetal force). Without it, it moves in a straight line.

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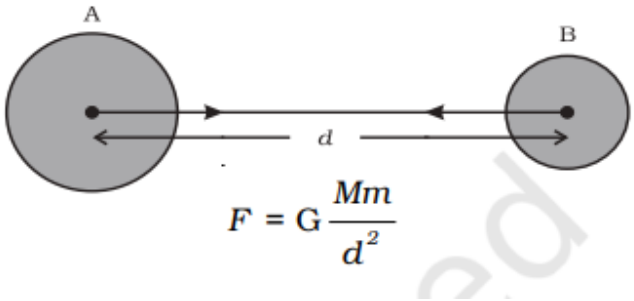
🔹 9.1.1 Universal Law of Gravitation

🟦 **Statement:**
Every object attracts every other object in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

🧮 Formula:
$F = G \times (M \times m) / d^2$
Where:
F = gravitational force
M & m = masses
d = distance between centers
G = gravitational constant = 6.67×10^{-11} $N \cdot m^2/kg^2$



📷 *Fig. 9.2 – Force between two objects along line joining centers*

✅ This law applies to all objects — from small particles to planets → it's universal!

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🔸 Importance of Universal Law of Gravitation

1. Explains why objects fall to Earth
2. Explains orbits of planets around the Sun
3. Explains Moon's orbit around Earth
4. Explains tides due to Sun & Moon

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🔹 9.2 Free Fall

🟦 **Definition:**
When objects fall only under gravity (no air resistance), it's called free fall.

🟦 **Acceleration due to gravity (g):**
Acceleration of falling object due to Earth's gravitational pull.
g = 9.8 m/s² near Earth's surface

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🔬 **Activity 9.2:**

- Throw a stone up → it rises and falls
  ✅ Reason:
  Earth's gravity causes the downward motion → it's under free fall.

🟦 Formula:
F = mg
g = GM / R²

M = Earth's mass, R = Earth's radius

🟦 Calculated Value:
g = 9.8 m/s² (using M = 6 × 10^{24} kg, R = 6.4 × 10^{6} m)

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🔬 **Activity 9.3:**

Drop paper & stone together
✅ Paper falls slower due to air resistance
If no air, both fall at same rate (Galileo's idea)

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🟦 Equations of motion during free fall (replace a with g):

1. **v = u + gt**
2. **s = ut + ½gt²**
3. **v² = u² + 2gs**

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🧮 Example:
A car drops in 0.5 s →
(i) Final speed: v = 5 m/s
(ii) Avg speed: 2.5 m/s
(iii) Height = 1.25 m

🧮 Another Example:
Object reaches 10 m high:
(i) u = 14 m/s
(ii) Time = 1.43 s

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🔹 9.3 Mass

🟦 **Definition:**
Mass is the amount of matter. It is a measure of inertia and does not change with location.

Unit: kg
Same on Earth, Moon, or anywhere else.

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🔹 9.4 Weight

🟦 **Definition:**
Weight is the force with which an object is attracted towards the Earth.
W = mg

🟦 Unit: newton (N)
Weight is variable (depends on g)

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🔸 Weight on Moon

🟦 Moon has lower mass & radius → less gravity
g(moon) ≈ (1/6) × g(earth)

🟦 So,
W(moon) = (1/6) × W(earth)

🧮 Example:
Object with mass 10 kg
Weight on Earth = 98 N
Weight on Moon = 16.3 N

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🔹 9.5 Thrust and Pressure

🟦 Thrust:
Force acting perpendicular to a surface

🟦 Pressure = Thrust / Area
Unit: pascal (Pa) or N/m²

📷 *Fig. 9.3 – Pressing drawing pins → pressure applied on sharp tip*

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🧮 Example:
Block of 5 kg kept on table
When laid on 0.02 m² → Pressure = 2450 N/m²
When laid on 0.08 m² → Pressure = 612.5 N/m²

✅ Smaller area → more pressure

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🔹 9.5.1 Pressure in Fluids

🟦 Liquids & gases exert pressure in all directions
This pressure increases with depth

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🔹 9.5.2 Buoyancy

🟦 Buoyant Force:
Upward force exerted by fluid on an immersed object

🔬 **Activity 9.4:**

Push an empty bottle in water
→ Feels upward force → This is buoyant force
🟦 Depends on fluid's density

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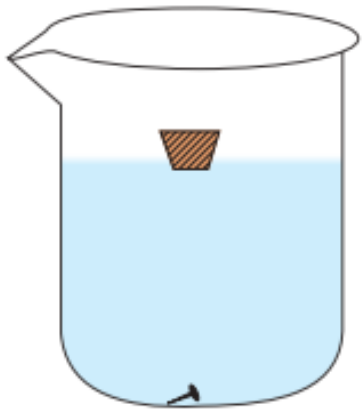
🔬 **Activity 9.5:**

Iron nail sinks, cork floats
→ Cork has lower density than water
→ Nail's density > water → sinks



📷 *Fig. 9.5 – Cork floats, nail sinks*

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🔹 9.6 Archimedes' Principle

🟦 Statement:
When a body is immersed in fluid, it experiences an upward buoyant force equal to the weight of the fluid displaced.

🔬 **Activity 9.6:**

Place iron nail and cork in water → cork floats, nail sinks (density based)

🔬 **Activity 9.7:**

Tie stone to spring → note extension
Now dip in water → extension decreases
✅ Reason: Upward buoyant force reduces net weight

🟦 **Applications:**

- Ship/Submarine design
- Hydrometer, Lactometer
- Used to measure fluid density

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📑 **Summary – What You Have Learnt**

- Gravitation is universal → every object attracts others
- Free fall → gravity only
- Weight = mass × g
- Mass is constant, weight varies
- Pressure = Force / Area
- Buoyancy → upward force in fluid
- Archimedes' principle → upward force = fluid displaced