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NOTES

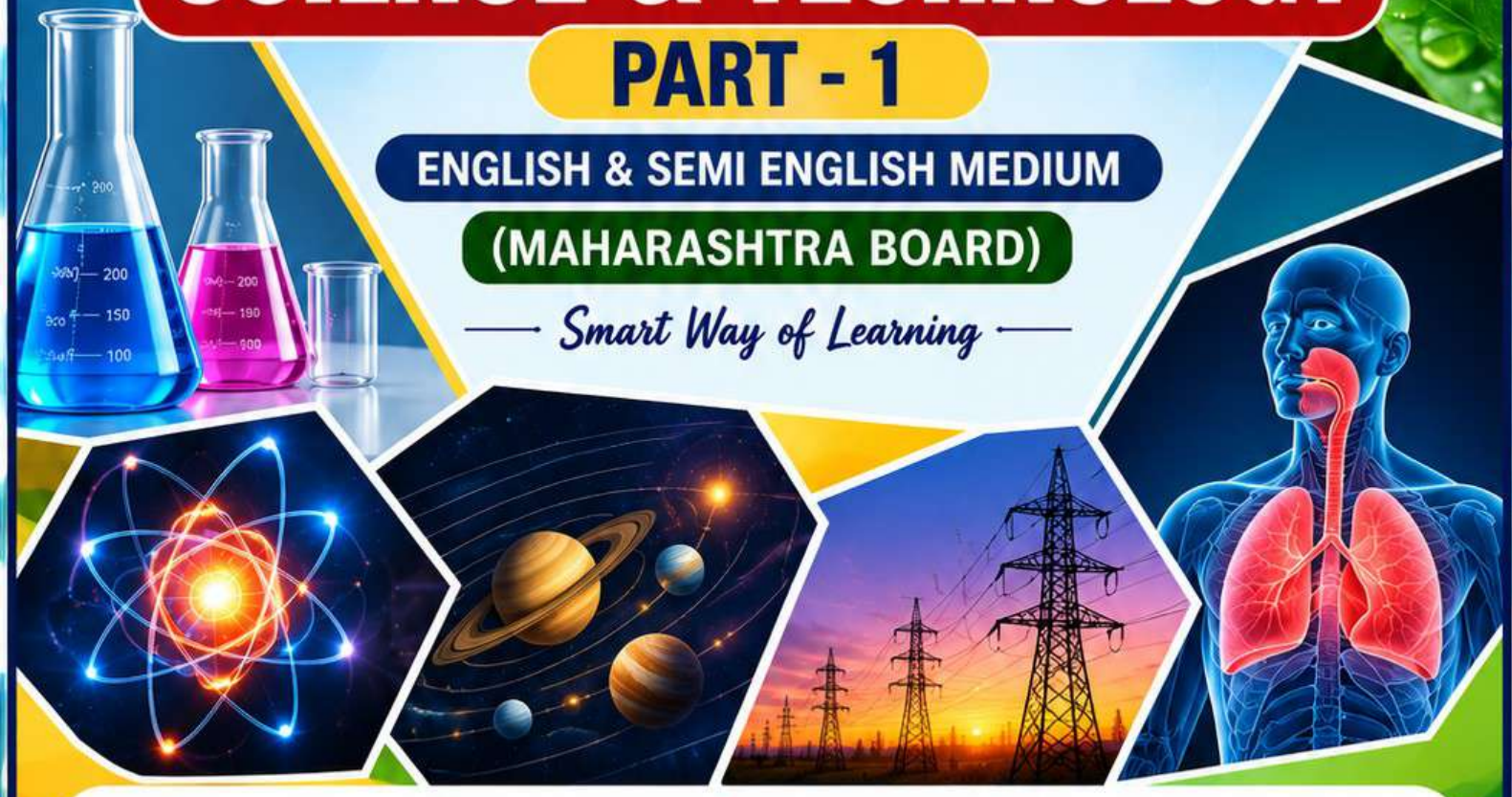
SCIENCE & TECHNOLOGY

PART - 1

ENGLISH & SEMI ENGLISH MEDIUM

(MAHARASHTRA BOARD)

Smart Way of Learning



- Chapterwise Notes
- Important Points
- Diagrams & Tables
- Definitions
- Exam Oriented

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SUCCESS KEY TEST SERIES

Class : 10 (Maharashtra Board) | Subject : Science & Technology – 1

Chapter 1
GRAVITATION



CHAPTER OVERVIEW

- Gravitation
- Circular Motion & Centripetal Force
- Kepler's Laws
- Newton's Universal Law of Gravitation
- Acceleration due to Gravity (g)
- Free Fall
- Escape Velocity

DEFINITION BOX

Gravitation :

The gravitational force is a universal force and acts between any two objects in the universe.

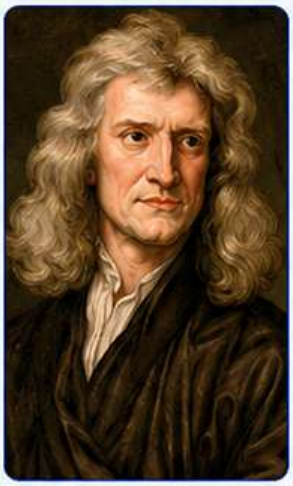
IMPORTANT POINTS

Importance of Gravitation

- Earth attracts all objects towards its centre.
- The moon revolves around the earth due to gravitational force.
- Planets revolve around the Sun due to gravitational force.
- Gravitation holds the atmosphere around the earth.
- Tides in seas and oceans are due to gravitational force.



GREAT SCIENTIST



Sir Isaac Newton (1642–1727)

- The phenomenon of gravitation was discovered by Sir Isaac Newton.
- He observed an apple falling from a tree and concluded that the earth attracts objects towards its centre.
- He gave his laws of motion and the theory of gravitation in his book 'Principia'.
- He is one of the greatest scientists of recent times.

DISCOVERY OF GRAVITATION

Newton observed an apple falling from a tree and wondered why it falls vertically downwards and not at an angle or in a horizontal direction.

He concluded that the earth must be attracting the apple towards itself and this attractive force is directed towards the centre of the earth.

He thought that if this force acts on the apple, then can it act on the moon and other planets also? This led to the discovery of gravitation.

GRAVITATION CONCEPT DIAGRAM



1.1 Concept of the gravitational force and the gravitational force between the earth and the moon.

REMEMBER

Every object in the universe attracts every other object with a definite force.

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Class : 10 (Maharashtra Board) | Subject : Science & Technology – 1

Chapter 1
GRAVITATION

CIRCULAR MOTION

When an object moves along a circular path, its direction of motion and velocity are constantly changing. Hence, a force must be acting on it continuously.

This force acts towards the centre of the circle and is called the **centripetal force.**

1. DIFFERENCE BETWEEN MASS AND WEIGHT

	Mass	Weight
Meaning	Amount of matter present in a body.	Gravitational force acting on a body.
SI Unit	kilogram (kg)	Newton (N)
Nature	Scalar quantity	Vector quantity
Dependence	Constant everywhere	Changes with value of g
Measured by	Beam balance	Spring balance
Formula	—	W = mg

2. IMPORTANT EQUATIONS OF MOTION

A. KINEMATICAL EQUATIONS

- $v = u + at$
- $s = ut + \frac{1}{2} at^2$
- $v^2 = u^2 + 2as$

B. FREE FALLING BODY (u = 0, a = g)

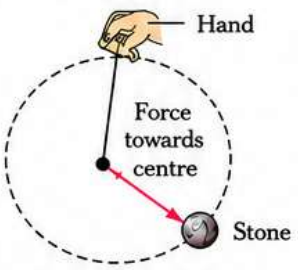
- $v = gt$
- $s = \frac{1}{2} gt^2$
- $v^2 = 2gs$

C. BODY THROWN VERTICALLY UPWARDS (a = −g)

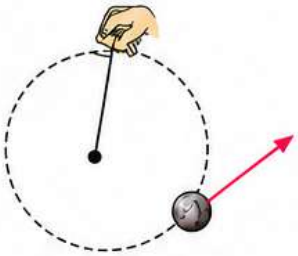
- $v = u - gt$
- $s = ut - \frac{1}{2} gt^2$
- $v^2 = u^2 - 2gs$
- Maximum Height : $H = \frac{u^2}{2g}$
- Time of Ascent : $t = \frac{u}{g}$
- Total Time of Flight : $T = \frac{2u}{g}$

CENTRIPETAL FORCE

A force which acts on an object moving along a circular path towards the centre of the circle is called the centripetal force.



(a) Stone moving in a circular path



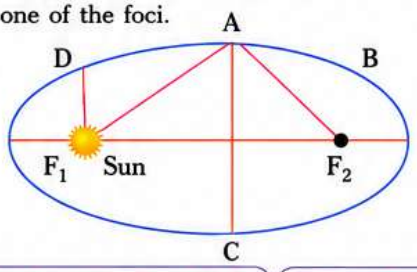
(b) Stone flies off along the tangent when string is released

If the string is released, the centripetal force stops acting and the stone moves along the tangent to the circle at that instant.

KEPLER'S LAWS

1. Kepler's First Law (Law of Orbits) :

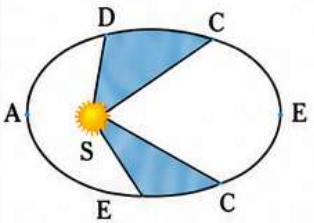
The orbit of a planet is an ellipse with the Sun at one of the foci.



Ellipse with the Sun (at F_1) at one of the foci.

2. Kepler's Second Law (Law of Areas) :

The line joining the planet and the Sun sweeps equal areas in equal intervals of time.



Areas ASB and CSD are equal.

3. Kepler's Third Law (Law of Periods) :

The square of the period of revolution of a planet around the Sun is directly proportional to the cube of the mean distance of the planet from the Sun.

If r = mean distance and T = period of revolution, then

$$\frac{T^2}{r^3} = \text{constant} = K \quad \text{.....(1)}$$

In addition to this, Newton did ground breaking work in several areas including light, heat, sound and mathematics. He invented a new branch of mathematics. This is called calculus and has wide ranging applications in physics and mathematics. He was the first scientist to construct a reflecting telescope.

You know that the moon, which is the natural satellite of the earth, goes round it in a definite orbit. The direction of motion of the moon as well as its speed constantly changes during this motion. Do you think some force is constantly acting on the moon? What must be the direction of this force? How would its motion have been if no such force acted on it? Do the other planets in the solar system revolve around the Sun in a similar fashion? Is similar force acting on them? What must be its direction?

From the above activity, example and questions it is clear that for the moon to go around the earth, there must be a force which is exerted on the moon and this force must be exerted by the earth which attracts the moon towards itself. Similarly, the Sun must be attracting the planets, including the earth, towards itself.

Chapter 1
GRAVITATION

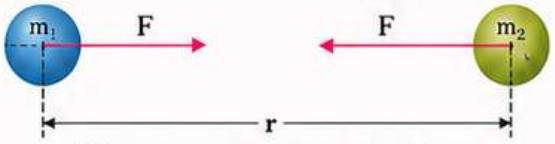
UNIVERSAL LAW OF GRAVITATION

Every object in the universe attracts every other object with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.

MATHEMATICAL FORMULATION

$$F = G \frac{m_1 m_2}{r^2}$$

Where,
F = Gravitational force (N)
m_1, m_2 = Masses of the two objects (kg)
r = Distance between their centres (m)
G = Universal gravitational constant



Two masses attracting each other

UNIVERSAL GRAVITATIONAL CONSTANT (G)

G is the gravitational force between two masses of 1 kg each kept at a distance of 1 m between their centres.

Value of G = 6.67×10^{-11} N m^2 kg^{-2}

Its SI unit is N m^2 kg^{-2}.

EFFECT OF CHANGE IN MASS OR DISTANCE ON FORCE

According to the universal law of gravitation,

- If either of the masses is doubled, the gravitational force becomes double.
- If the distance between the masses is doubled, the force becomes one-fourth.
- If the distance between the masses is halved, the force becomes four times.



EARTH'S GRAVITATIONAL FORCE (WEIGHT)

The gravitational force exerted by the earth on an object on its surface is called the weight of the object.

If 'M' is the mass of the earth, 'm' is the mass of the object and 'R' is the radius of the earth, then using universal law of gravitation,

$$\text{Weight, } W = F = \frac{GMm}{R^2}$$

Its SI unit is Newton (N).



Factors affecting weight

- Weight depends on the mass of the object.
- Weight depends on the value of g at that place.
- Weight is a vector quantity and always acts towards the centre of the earth.

ACCELERATION DUE TO GRAVITY (g)

The acceleration produced in an object due to the earth's gravitational force is called acceleration due to gravity (g).

From $W = mg$ and $W = \frac{GMm}{R^2}$, we get

$$g = \frac{GM}{R^2}$$

Its SI unit is m s^{-2}.

Values of g at different places

Place	Height (km)	g (m/s^2)
Surface of the earth (average)	0	9.8
Mount Everest	8.8	9.8
Maximum height reached by man-made balloon	36.6	9.77
Height of a typical weather satellite	400	8.7
Height of communication satellite	35700	0.225

RELATION BETWEEN G AND g

The relation between universal gravitational constant (G) and acceleration due to gravity (g) is

$$g = \frac{GM}{R^2}$$

Where, M = mass of the earth
R = radius of the earth

CHANGE OF g WITH HEIGHT

As we go above the earth's surface, the value of g decreases. At a height h above the surface,

$$g' = g\left(\frac{R}{R+h}\right)^2$$

Where, g = value of g on the surface of the earth
R = radius of the earth, h = height above the surface

10. ESCAPE VELOCITY

- The minimum velocity required to escape from the gravitational pull of a celestial body without any further propulsion is called escape velocity (v_e).
- For the Earth, escape velocity is 11.2 km/s.
- It depends on the mass and radius of the celestial body.

Formula

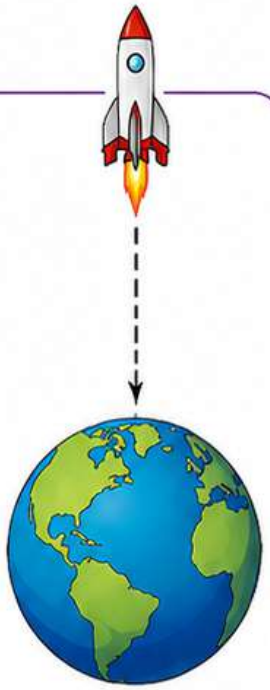
$$v_e = \sqrt{\frac{2GM}{R}}$$

Where,

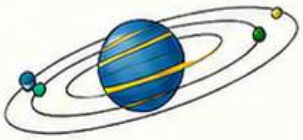
G = Universal gravitational constant
$= 6.67 \times 10^{-11}$ N m^2 kg^{-2}

M = Mass of the Earth (kg)

R = Radius of the Earth (m)



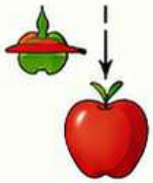
11. APPLICATIONS OF GRAVITATION



Keeps planets in their orbits around the Sun.



Keeps the Moon in its orbit around the Earth.



Causes objects to fall towards the Earth.



Causes tides in the oceans.

12. QUICK REVISION

- Gravitation is a mutual force of attraction between any two bodies.
- It acts along the line joining the centres of the two bodies.
- Kepler's three laws describe the motion of planets around the Sun.
- Newton's universal law is $F = G\frac{m_1 m_2}{r^2}$,
- Acceleration due to gravity on Earth, $g = 9.8$ m/s^2.
- Weight of a body, $W = mg$.
- In free fall, $s = \frac{1}{2}gt^2$.
- Escape velocity from Earth, $v_e = 11.2$ km/s.
- Gravitation has many natural applications.