

1 SAQ = 4 MARKS

8. GRAVITATION

- Kepler's laws • Universal Law of Gravitation
- Escape speed • Orbital speed • Satellites

SMART SYNOPSIS

1. Kepler's laws:

[SAQ]

- (i) **Law of orbits:** All planets move in elliptical orbits with the sun situated at one of the foci.
- (ii) **Law of areas:** The line that joins any planet to the sun sweeps equal areas in equal intervals of time.
- (iii) **Law of periods :** The square of the time period of revolution of a planet is proportional to the cube of the semi-major axis of the ellipse traced out by the planet.

2. Universal law of Gravitation :

If m_1, m_2 are the masses of two particles and r is the distance between them, then the Gravitational

Force of attraction between them is $F = \frac{Gm_1m_2}{r^2}$. $G = 6.67 \times 10^{-11}$

G is called the Universal Gravitational constant. **SI unit of G :** $\text{N m}^2 \text{kg}^{-2}$

3. Relation between g and G :

From $F = mg$ and $F = \frac{GMm}{R^2}$

$$\Rightarrow \cancel{m}g = \frac{GM\cancel{m}}{R^2} \Rightarrow g = \frac{GM}{R^2} \Rightarrow GM = gR^2$$

4. Orbital speed(V_o) is the minimum horizontal speed required for a body to [SAQ]

revolve around a planet in a circular orbit. **Formula:** $V_o = \sqrt{gR}$.

5. Escape speed (V_e) is the minimum speed required for an body to escape [SAQ]

from the gravitational influence of a planet. **Formula:** $V_e = \sqrt{2gR}$

Escape speed on the earth $v_e = 11.2 \text{ km s}^{-1}$. **Note :** Escape speed = $\sqrt{2} \times$ Orbital speed

6. Geostationary satellite is a high altitude satellite orbiting around earth with [SAQ]

period of revolution equal to the period of rotation of the earth.

It's time period is **24 hours**. It's height is about **35,800 km** above the Earth.

Uses : i) Communication ii) Weather forecasting iii) Broadcasting iv) Disaster management

7. Polar Satellite is a low altitude satellite, orbiting around the poles in a north-south direction.

It's time period is around 100 minutes. It's height is about **500–800 km** above the Earth.

Uses: i) Remote sensing ii) Meteorology iii) Environmental studies iv) Surveillance

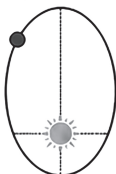
For better concept clarity refer **PHYSI BEATS P.No: 266**

8. GRAVITATION

1. KEPLER'S LAWS

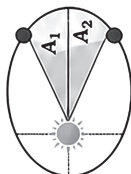
1 Law of Orbits

All planets move in elliptical orbits with the Sun situated at one focus.



2 Law of Areas

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



3 Law of Periods

The square of the time period (T) of revolution of a planet is proportional to the cube of the semi-major axis (a) of the ellipse traced by the planet.

$$T^2 \propto a^3$$

or

$$\frac{T^2}{a^3} = \text{constant}$$

2. UNIVERSAL LAW OF GRAVITATION

If m_1 and m_2 are the masses of two particles and r is the distance between them, the gravitational force of attraction between them is

$$F = \frac{Gm_1m_2}{r^2}$$

G is the Universal Gravitational Constant.

Value of G

$$G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$$

SI Unit of G

$$\text{N m}^2 \text{ kg}^{-2}$$

3. RELATION BETWEEN g AND G

From Newton's Second Law and Universal Law of Gravitation,

$$mg = \frac{GMm}{R^2}$$

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

or

$$GM = gR^2$$

where

M = Mass of the planet

R = Radius of the planet

4. ORBITAL SPEED (V_o)

The minimum horizontal speed required for a body to revolve around a planet in a circular orbit is called orbital speed.

$$V_o = \sqrt{gR}$$

where

R = Radius of the planet

5. ESCAPE SPEED (V_e)

The minimum speed required for a body to escape from the gravitational influence of a planet is called escape speed.

$$V_e = \sqrt{2gR}$$

Escape speed on Earth

$$V_e = 11.2 \text{ km s}^{-1}$$

Note

$$\text{Escape Speed} = \sqrt{2} \times \text{Orbital Speed}$$

9. SUMMARY OF KEY CONCEPTS



Gravitational force acts between any two masses.



g decreases with height and increases as we go below the surface.



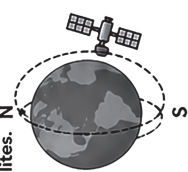
Satellites move under the action of gravity.



Escape speed depends on the mass and radius of the planet.

7. POLAR SATELLITE

Low altitude satellites (about 500–800 km) moving around the Earth in the north-south direction are called polar satellites.



Note

Time period of a polar satellite is about 100 minutes.

6. GEOSTATIONARY SATELLITE

If the period of revolution of an artificial satellite is equal to the period of rotation of the Earth, it is called a geostationary satellite.



Note

Height of geostationary satellite

$$h = 35,800 \text{ km}$$

Orbital radius

$$42,250 \text{ km}$$

