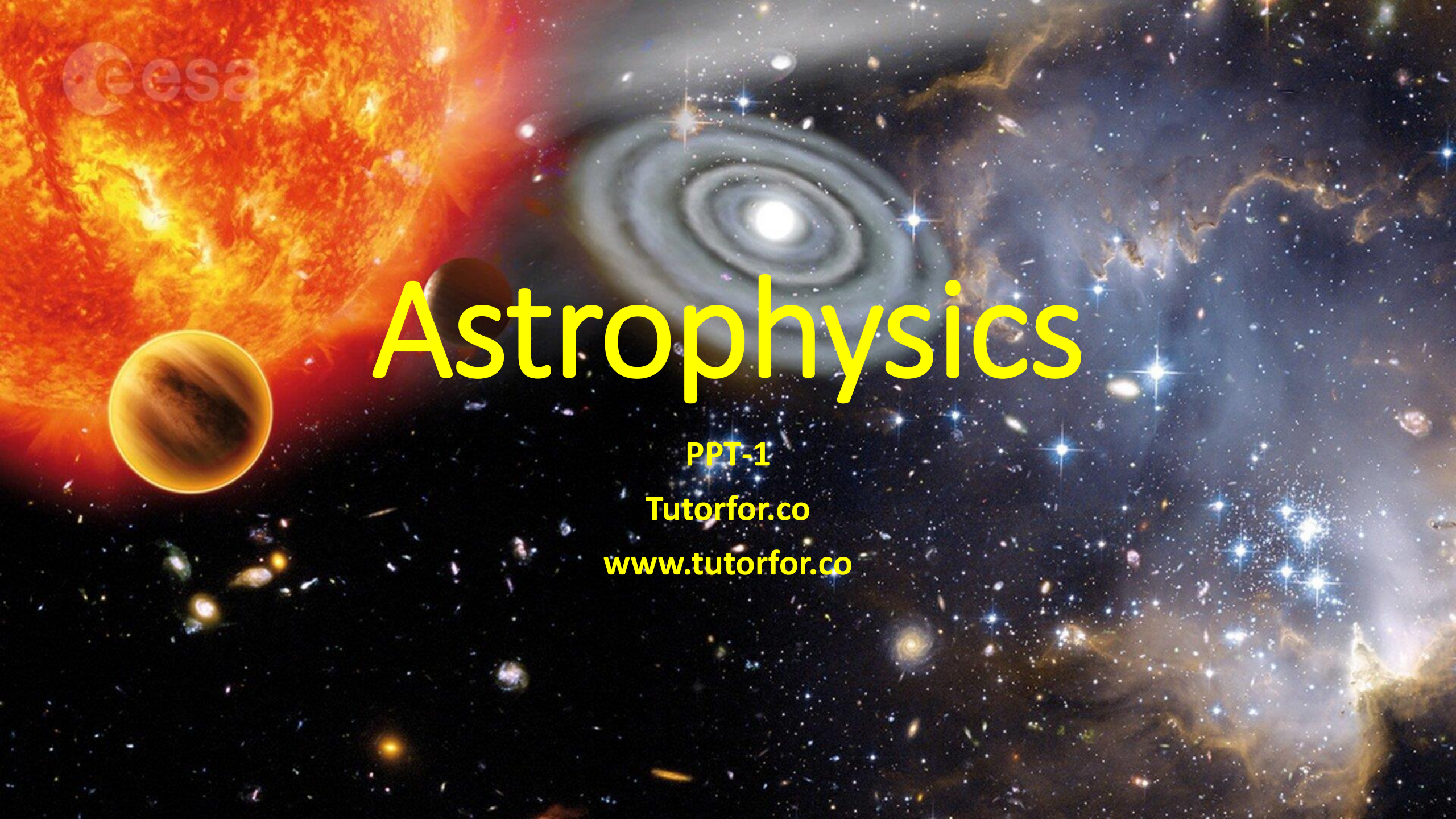

Astrophysics

PPT-1

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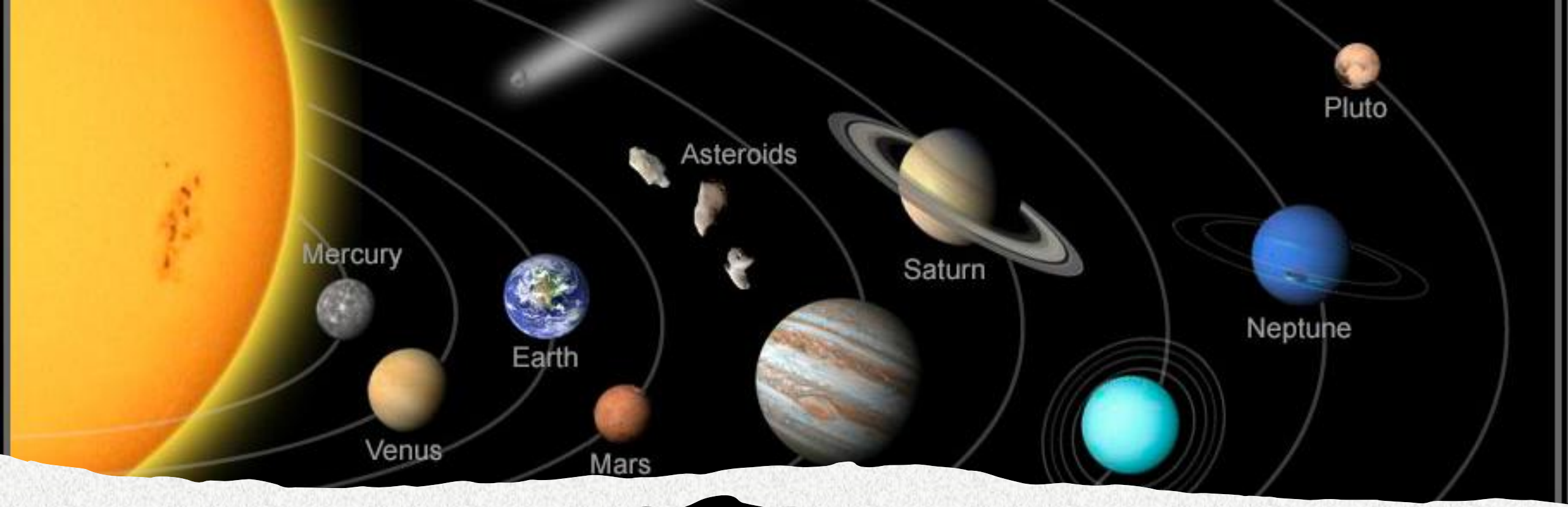
(b)	**Motion in the universe**
Students should:	
8.2	know that: • the universe is a large collection of billions of galaxies • a galaxy is a large collection of billions of stars • our solar system is in the Milky Way galaxy.
8.3	understand why gravitational field strength, g, varies and know that it is different on other planets and the Moon from that on the Earth
8.4	explain that gravitational force: • causes moons to orbit planets • causes the planets to orbit the Sun • causes artificial satellites to orbit the Earth • causes comets to orbit the Sun.
8.5	describe the differences in the orbits of comets, moons and planets
8.6	use the relationship between orbital speed, orbital radius and time period: $\text{orbital speed} = \frac{2 \times \pi \times \text{orbital radius}}{\text{time period}}$ $v = \frac{2 \times \pi \times r}{T}$



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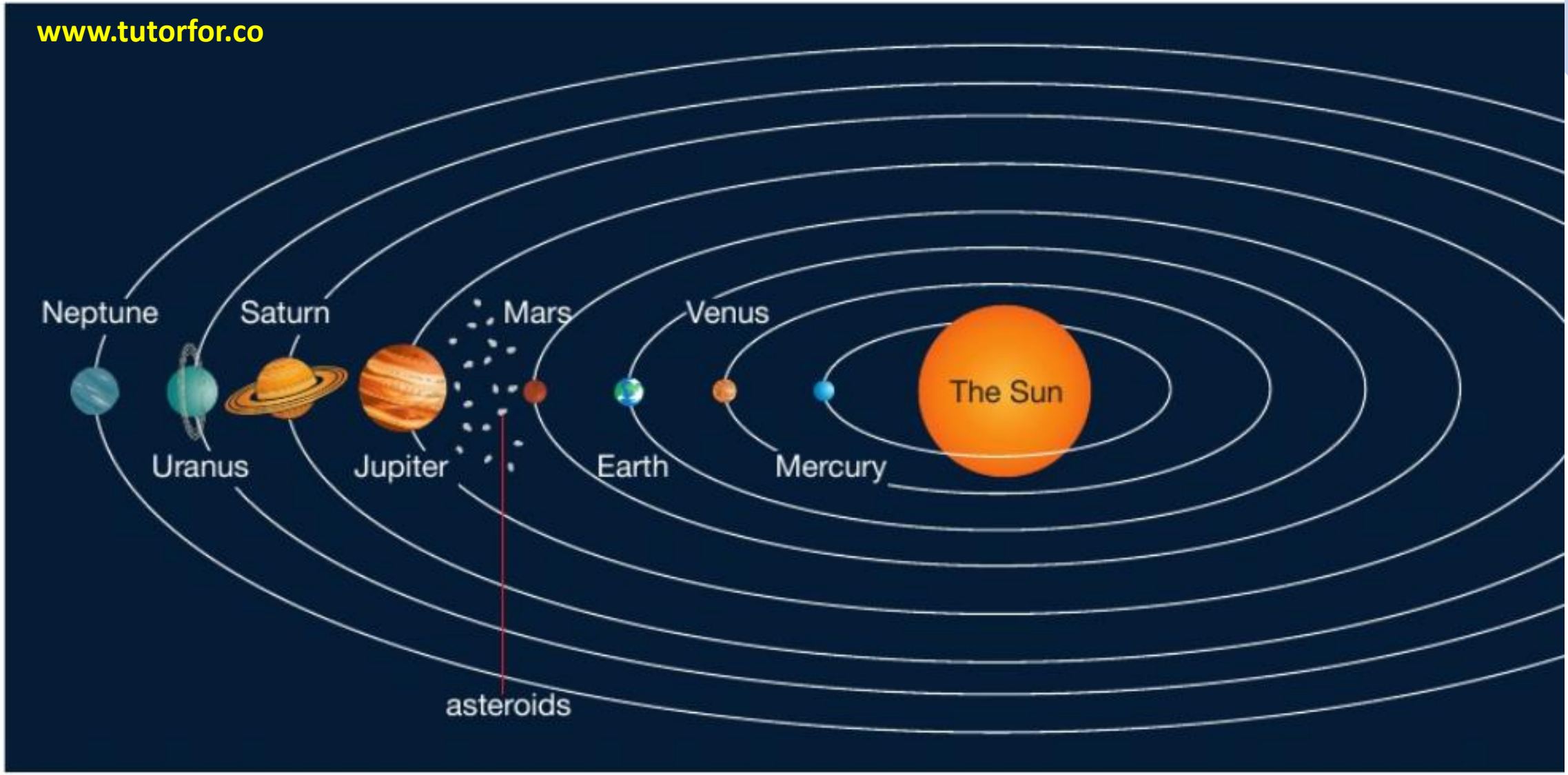
Structure of the Solar System

- The Sun, the Earth's star, is the largest object in the Solar System.
- The Sun’s huge gravitational field keeps many other objects - planets, dwarf planets, asteroids and comets – in orbit around it.



Solar System

The Sun and its planets –
Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune

Planets

- **A big spherical celestial body that orbit around the Sun.**
- The Earth is one of eight planets in the Solar System. The planets orbit the Sun at different distances.

What is a Planet?

This seemingly simple question doesn't have a simple answer. Everyone knows that Earth, Mars and Jupiter are planets. But both Pluto and Ceres were once considered planets until new discoveries triggered scientific debate about how to best describe them—a vigorous debate that continues to this day. The most recent definition of a planet was adopted by the International Astronomical Union (IAU) in 2006. It says a planet must do three things:

1.It must orbit a star (in our cosmic neighborhood, the Sun).
2.It must be big enough to have enough gravity to force it into a spherical shape.
3.It must be big enough that its gravity cleared away any other objects of a similar size near its orbit around the Sun.

Reference :

The IAU therefore resolves that planets and other bodies, except satellites, in our Solar System be defined into three distinct categories in the following way:

1.A planet is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.

2.A "dwarf planet" is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.

3.All other objects,except satellites, orbiting the Sun shall be referred to collectively as "Small Solar System Bodies"

Reference :

Moons

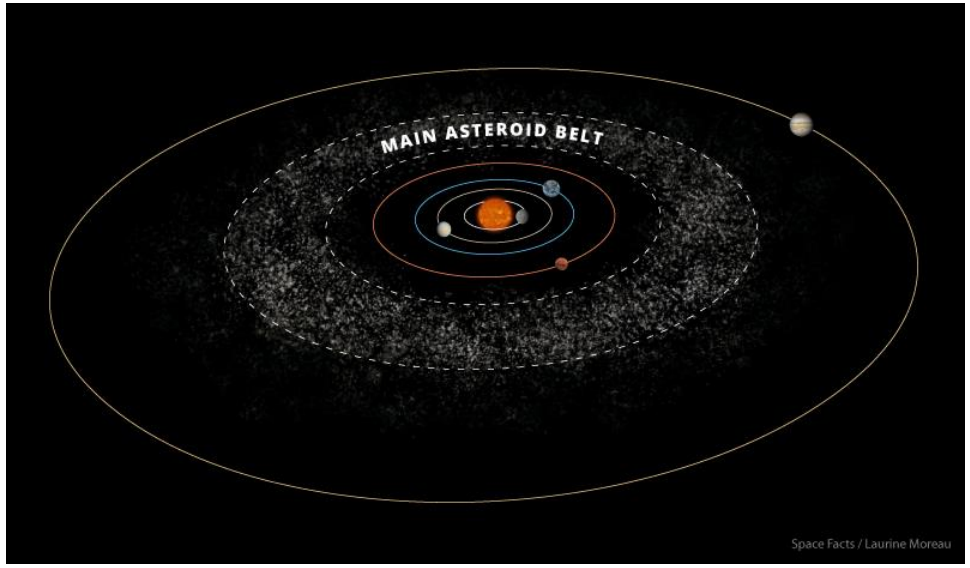
- Moons are natural **satellites** that orbit a planet.
- Many planets have moons, and some planets have many moons - Saturn has more than 50.
- The Earth has just one moon - the Moon.

Dwarf planets

- Pluto is a dwarf planet.
- The gravitational field of a dwarf planet is not strong enough to clear the neighbourhood, so there may be other objects in its orbit around the Sun.
- The Solar System contains hundreds of dwarf planets, including Ceres (the only dwarf planet in the asteroid belt).

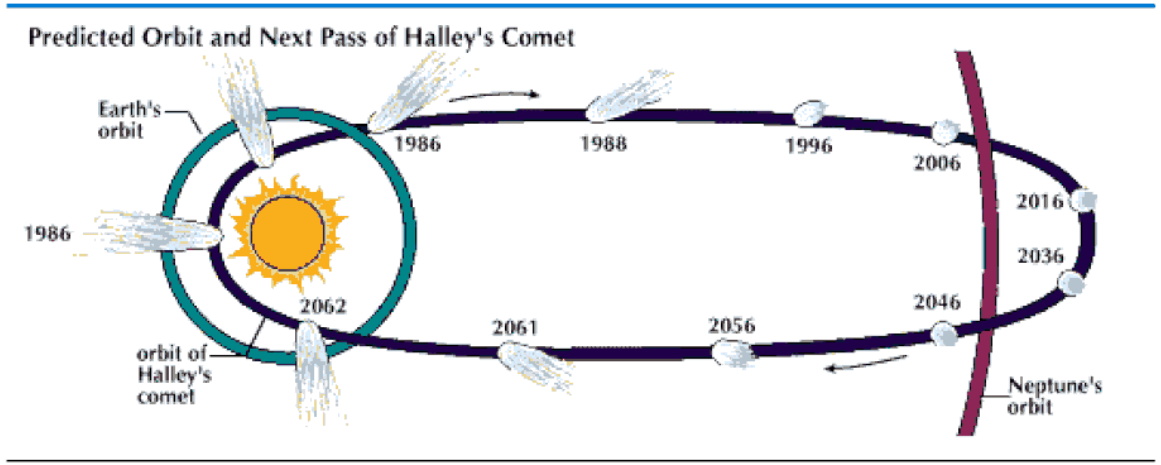
Asteroids

- The Solar System contains smaller objects called asteroids.
- These orbit the Sun in highly elliptical orbits, which are oval or egg-shaped and may take millions of years to complete.
- Asteroids are made of metals and rocky material.
- There are large numbers of asteroids orbiting the Sun in the asteroid belt between Mars and Jupiter. There are also many in a region beyond Neptune called the Kuiper Belt.



Comets

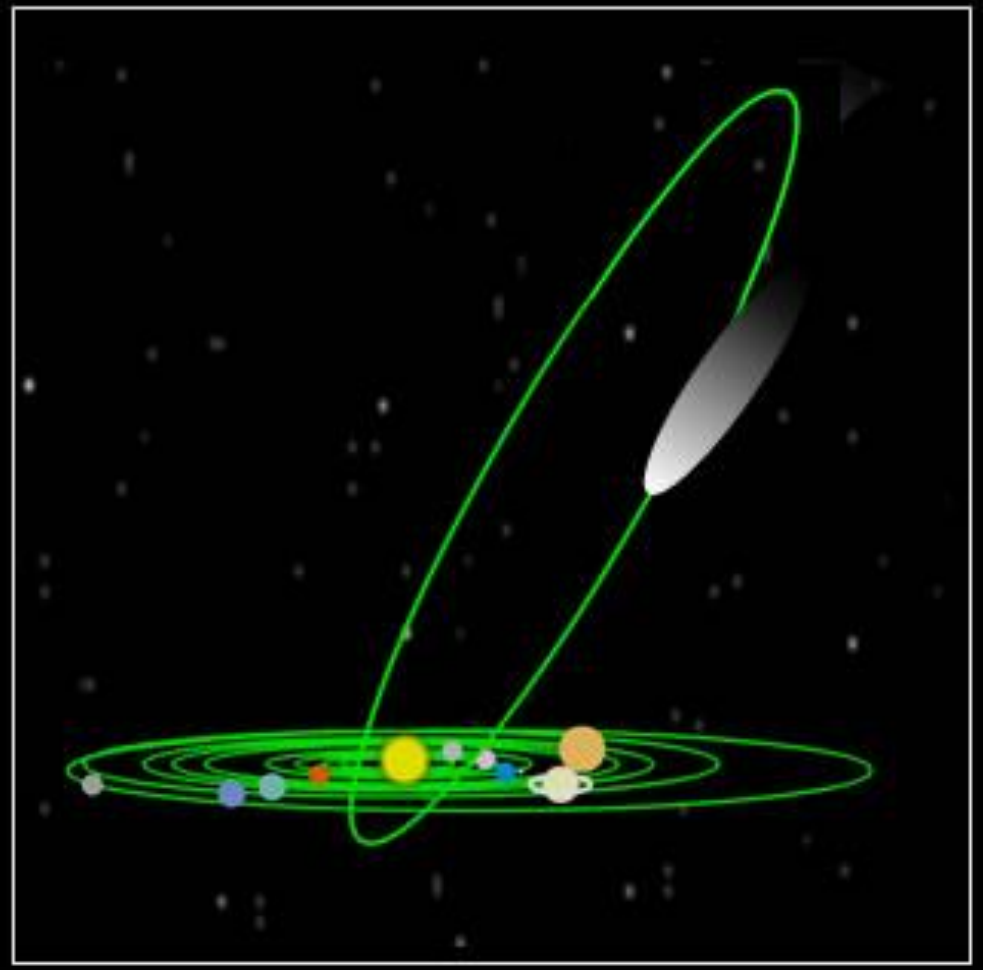
- The Solar System also contains small objects called **comets**.
- Comets are similar to asteroids, but are made of rocky material, dust and ice.
- As a comet approaches the Sun, it begins to **vaporise**, which means that it turns into a gas. It then produces a distinctive tail.



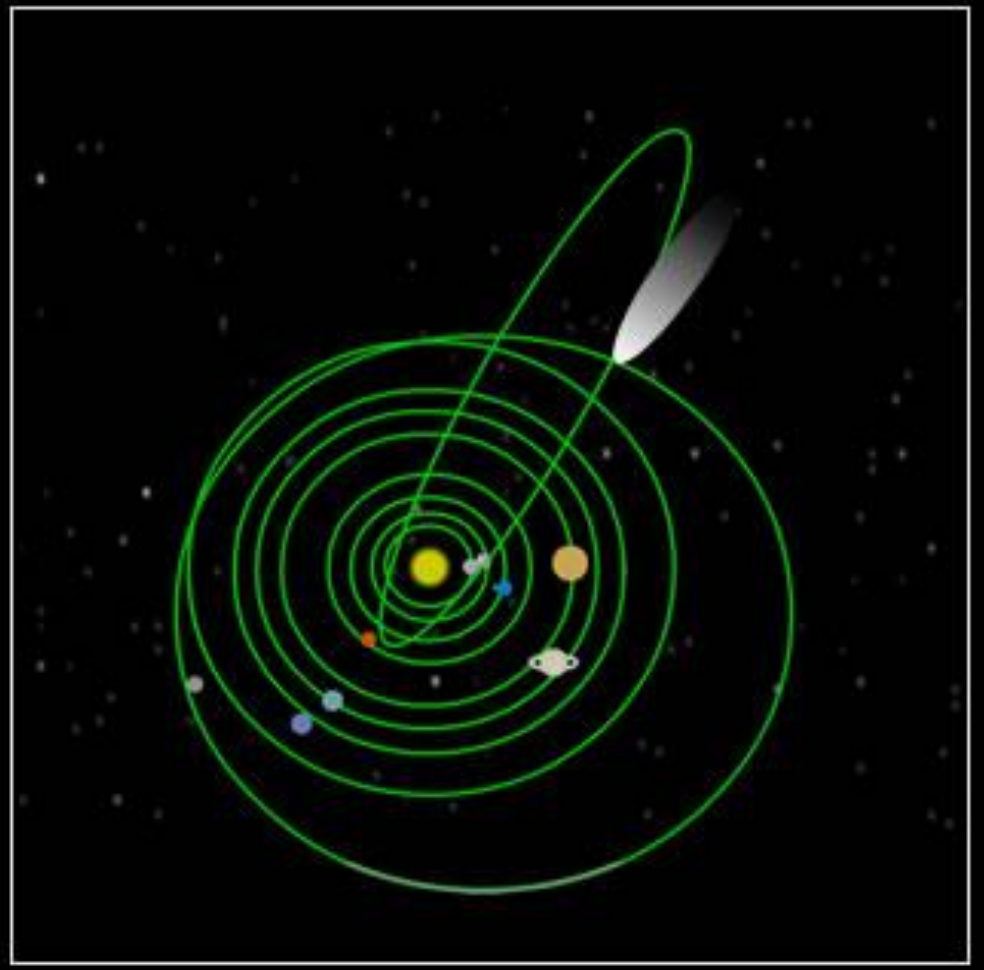
When a comet is in our solar system, most of the gravity affecting the comet's motion is due to the Sun. As a comet gets closer to the Sun it moves faster and faster, because the closer an object is to the Sun the stronger the Sun's gravity acts on it.

COMET ORBITS

Looking along the plane of the solar system



Looking above or below the solar system



space fm

Weight, mass and gravitational field strength

- The weight of an object is the force on it caused by the gravity due to the planet.
- The weight of an object and the gravitational field strength are directly proportional.
- For a given mass, the greater the gravitational field strength of the planet, the greater its weight.

Weight can be calculated using the equation:

weight = mass × gravitational field strength

$W=mg$

This is when:

- weight (*W*) is measured in newtons (N)
- mass (*m*) is measured in kilograms (kg)
- gravitational field strength (*g*) is measured in newtons per kilogram (N/kg)

Concept Learning Questions

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1) An apple has a mass of 100 g. Calculate its weight on Mars (g = 3.7 N/kg)

2) Calculate the weight of a 30 kg dog on the Moon (g = 1.7 N/kg).

GRAVITATIONAL FIELD STRENGTH

The strength of gravity on a planet or moon is called its gravitational field strength, and given the symbol *g*. Different planets have different masses and different radii – both of these will affect their gravitational field strengths.

- The larger the mass of a planet the greater its gravitational field strength.
- The larger the radius of a planet the smaller the gravitational field strength at its surface.

The gravitational field strength on the Earth is approximately 10 N/kg while on the Moon it is approximately 1.6 N/kg.

$g \propto M$

$g \propto \frac{1}{r^2}$

Newton’s law of gravitation

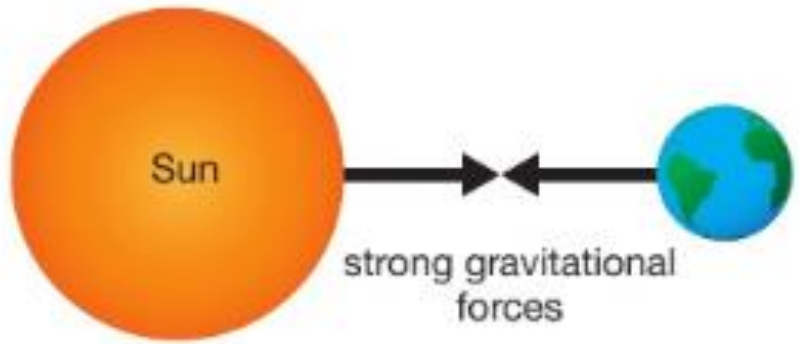
Newton suggested that between any two objects there is always a force of attraction. This attraction is due to the masses of the objects. He called this force gravitational force.

He suggested that the size of this force depends on the:

1 masses of the two objects

2 distance between the masses.

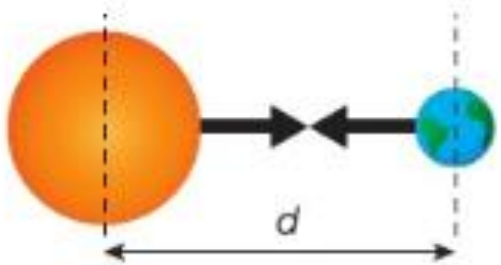
weak gravitational forces



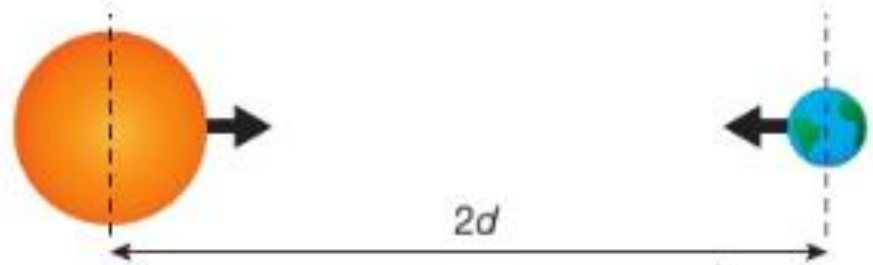
strong gravitational forces

The greater the masses of the two objects the stronger the attractive forces between them.

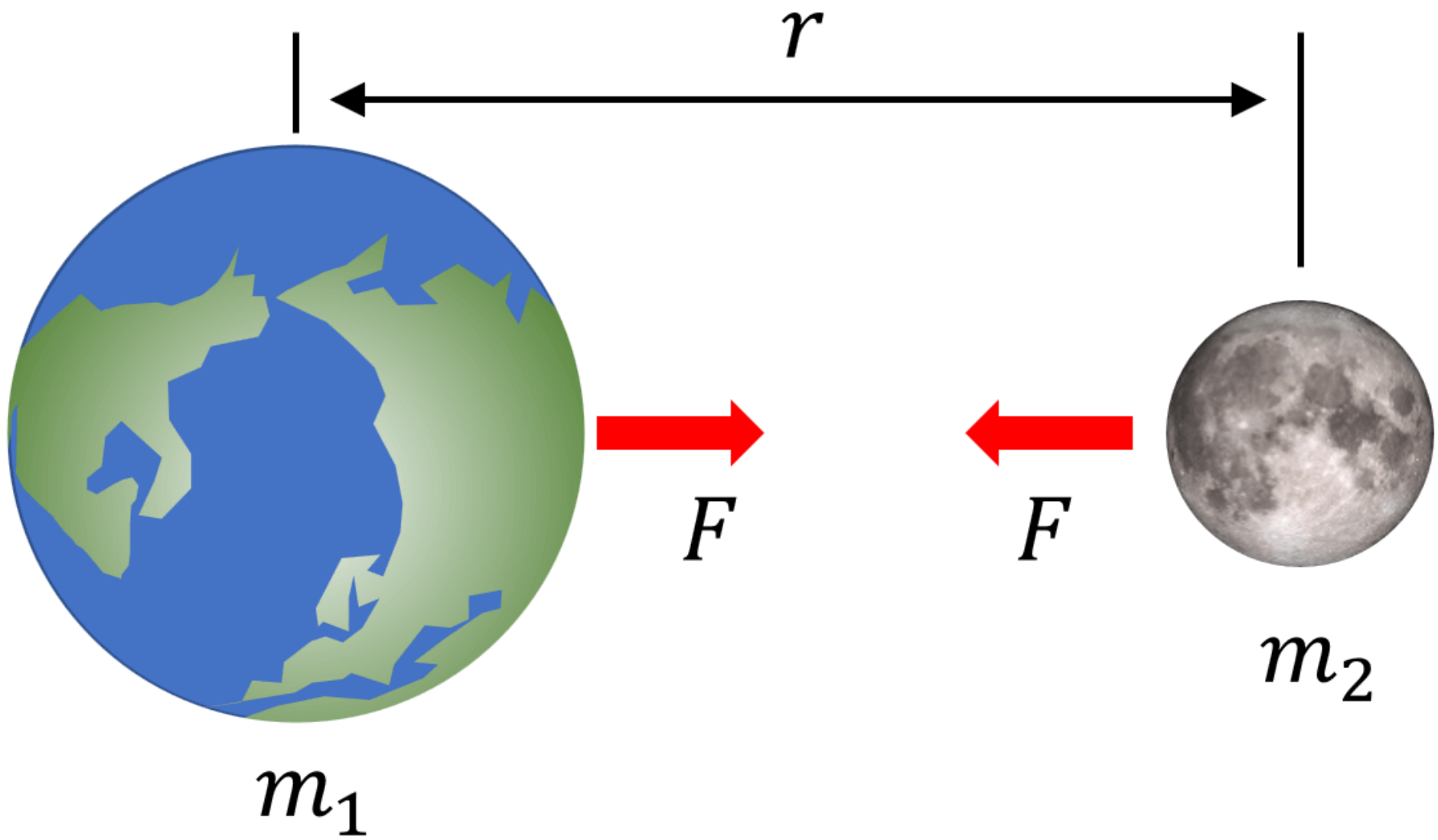
If the distance between the masses is increased the forces between them decrease.



attractive gravitational force = F



attractive gravitational force = $\frac{1}{4}F$


r
F
F
m1
m2

Orbital speed

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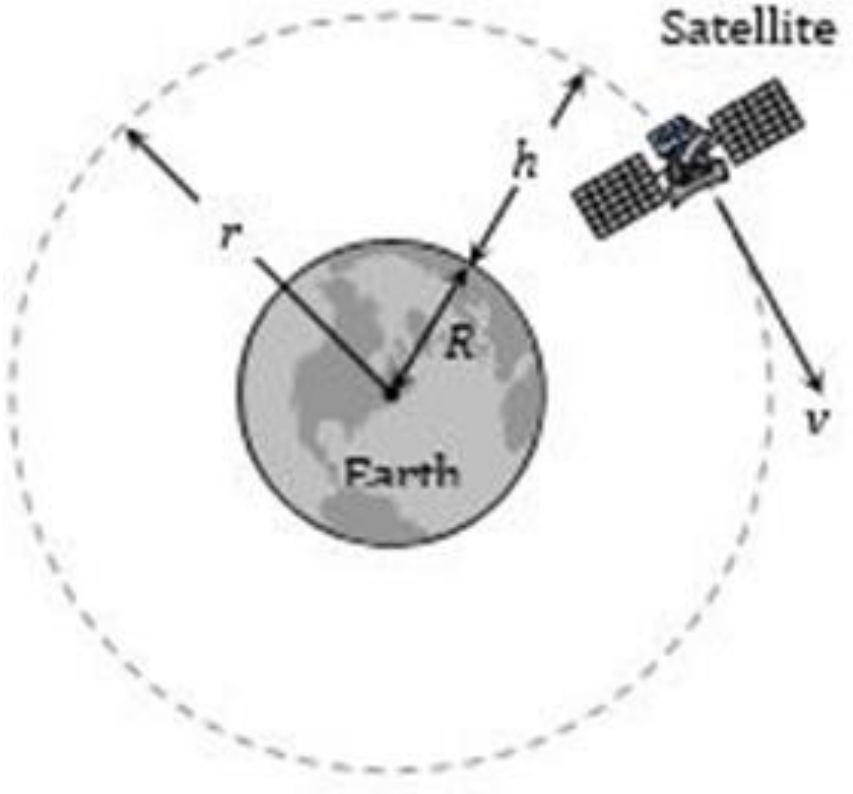

Orbital speed (v) = $2\ \pi \frac{orbitatl\ radius}{Time\ taken}$

$$\mathbf{v = \frac{2\pi r}{T}}$$

Concept Learning Questions

1) The Hubble Space Telescope moves in a circular orbit. Its distance above the Earth's surface is 560 km and the radius of the Earth is 6400 km. It completes one orbit in 96 minutes. Find the orbital speed.