

Grade 12 Earth and Space Science

SES4U

Qinghao Hu

November 5, 2025

Contents

1 Unit 1: Astronomy	2
1.1 Episode 1: Standing up in the Milky Way	2
1.2 Episode 4: A Spacetie Odyssey	2
1.3 Measuring the Universe	3
1.3.1 Some important constants	3
1.3.2 Unit Conversion	3
1.3.3 Radar	3
1.3.4 Parallax	4
1.4 Cepheid Variable Stars, Redshift and Hubble's Law	5
1.4.1 Apparent Magnitude and Absolute Magnitude	5
1.4.2 Cepheid Variable stars	5
1.4.3 Determining absolute magnitudes using Cephed Variables	5
1.4.4 Hubble's Law	6
1.4.5 Redshift	6
1.4.6 Overall summary of this section	6
1.5 Cosmology	7
1.5.1 Some stupid theories	7
1.5.2 Is our Universe finite?	7
1.6 Developments in Cosmology	7
2 Our Solar System	9
2.1 The Wonders of the Solar System	9
2.2 Newton's Law of Gravitation	10
2.3 Kepler's Law of Planetary Motion	10
2.3.1 Kepler's first law	11
2.3.2 Kepler's second law	11
2.3.3 Kepler's Third Law	11
2.4 Sun-Earth-Moon System	11
2.4.1 Earth's Rotationsc	11
2.4.2 Earth's Orbit	12
2.4.3 Tide	12
2.4.4 Eclipses	12
2.4.5 SOLAR ECLIPSE	13
2.5 The wonders of the Solar System: Episode: 5	13

Chapter 2

Our Solar System

2.1 The Wonders of the Solar System

Q1

The further a planet is from the sun, the **slower** it's speed, and the **longer** one revolution around the Sun takes.

Q2

The type of celestial object appears to change its position amongst the stars from night to night is called **planet**

Q3

When the Earth "overtakes" Mars in orbit, Mars appears to move **backward** against the backgrounds of the stars.

Q4

Everything in our solar system was formed from a **nebula**, a giant **cloud** of gas and dust.

Q5

What type of event is thought to have disturbed the nebula and to have led to the formation of the solar system?

- A shock wave from a nearby supernova explosion.

Q7

The ring **nearest** Saturn are the farthest., just like planets orbiting the Sun.

Q8

Whater material makes up Saturn's rings? **Water ice**

2.2 Newton's Law of Gravitation

Remark. If you took or are taking SPH4U, the easiest way to review this section is "Go check your physics note"

The equation for the Gravity:

$$F_g = \frac{GMm}{R^2} \quad (2.1)$$

The gravitational force acting between two objects is proportional to the **mass** of each object and inversely proportional to the **distance** between them squared"

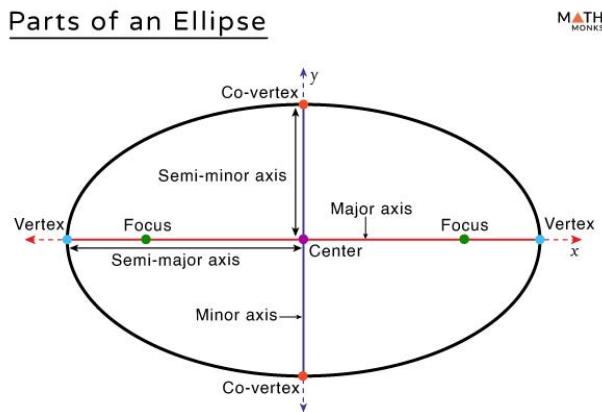
The alrger the mass, the more force is required to accelerate it.

"Accelerate" means to change **speed** or **direction**

When two objects are closer related in mass, they will orbit each other!

Try to do some physics questions before the unit test.

2.3 Kepler's Law of Planetary Motion



The sun is at one focus

There are two points in this diagram:

- The point closet to the Sun is called **Perihelion**. *Peri* means *near* in the Latin.
- The point farthest from the Sun is called **Aphelion**. *Ape* means *far* in the Latin.

2.3.1 Kepler's first law

Definition 2.3.1. *Planet's orbit in ellipses with the Sun at one focus*

Ellipses can be classified based on their **eccentricity**

$$e = \frac{c}{a}$$

e = Eccentricity

c = Distance from centre to a focus (in m(or Au))

a = Length of semi-major axis (in m(or Au))

The eccentricity of Earth's orbit is 0.02.

The most eccentric planetary orbit in our solar system is *Mercury*, which has a eccentricity of 0.2.

Comets tend to have the largest eccentricity very close to 1.

Here I want to discuss about the meaning of eccentricity:

- If an ellipse has an eccentricity of **0**, the object is orbit its sun in a **perfect circle**.
- If an ellipse has an eccentricity of **1**, the object is not in an **orbit**.

2.3.2 Kepler's second law

Definition 2.3.2. *A line segment joining a planet and the sun sweeps out equal areas in equal amount time*

By the second law, we can make a conclusion. A planet moves fastest with it is at the **perihelion** and slowest when it is at the **aphelion**.

2.3.3 Kepler's Third Law

Definition 2.3.3. *The square of the orbital period of a planet directly proportional to the cube of the length of the semi-major axis of its orbit*

$$p^2 = a^3$$

p = orbital period in (years)

a = Length of semi-major axis (in Au)

The semi-major axis of an orbit is sometimes referred to as the **average** distance from the sun.

2.4 Sun-Earth-Moon System

2.4.1 Earth's Rotations

Foucault Pendulum

The direction that a pendulum swings appears to change as the Earth rotates under it.

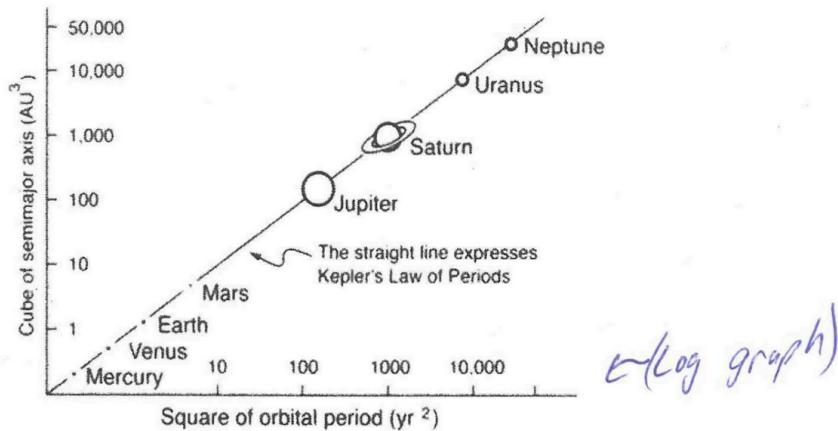


Figure 2.1: This is a log graph

One rotation of the earth takes **23hrs 56 minutes**

However, we define one day as the time it takes the **Sun** to return to the same position in the sky. This time takes **24 hrs**, longer than one rotation due to Earth's motion around the sun.

2.4.2 Earth's Orbit

The **Ecliptic plane** is an imaginary plane on which Earth's orbit lies. The Earth is tilted by 23.5 degree in relation to this plane. One orbit the Earth takes 365.25 day.

The tilt changes the Sun's position in the sky throughout the year and accounts for the change of seasons.

The tropics is defined as the region between 23.5 degree north and 23.5 degree south latitude. Outside of the tropics, it is impossible for the sun to appear at exactly 90 degree.

2.4.3 Tide

The tides happen due to the moon's **gravitational pull** on the Earth.

Spring tides happen when the Sun and moon align. The tides are **higher** than normal.

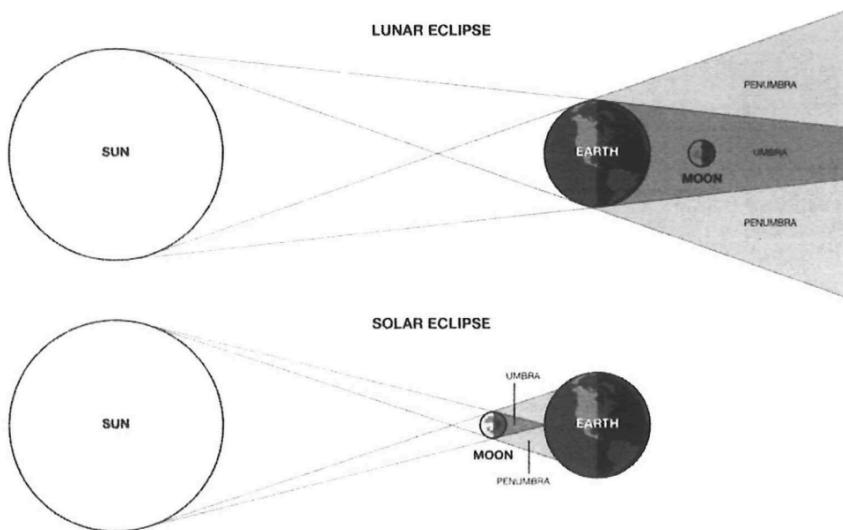
Neap tides happen when the Sun and moon are perpendicular. These tides are **lower** than normal.

One cycle of the tide happens every **12** cycles.

2.4.4 Eclipses

Definition 2.4.1. *Eclipses occur when one object passes through the **shadow** of another object.*

A full shadowm is called the **umbra** and a partial shadow is called the **penumbra**.



LUNAR ECLIPSE

The moon is in the **Earth's shadow**.

2.4.5 SOLAR ECLIPSE

The Earth is in the **Moon's shadow**.

2.5 The wonders of the Solar System: Episode: 5

Q1

- After he sees the tubeworms at the bottom of the ocean... The underwater city is one of the most bizarre environments on our planet. It's built around a **Hydrothermal bent**, a volcanic opening in the Earth's crust that pumps out clouds of sulphurous chemicals water heated to nearly 300 Celsius.

Q2

For life to exist, we only need three things:

- right **chemistry** set. Human body is made up with 40 elements, but actually 96% of human is only made of four of them, carbon, nitrogen, oxygen and hydrogen.
- We need a **power source**. We need a battery, something to make a flow of electrons that powers the processes of life. Most life on Earth uses the power of the sun.
- We need some kind of **medium** for life to play itself out in, for process to happen. On the Earth, the medium is **water**.

Q3

What is the **fundamental link** that is driving the search for life in our solar system?

- The link between liquid water and life.

Q4

For life to get a foothold, you need more than that. You need areas of **standing water**.

Q7

Which of the Jupiter's moons has the greatest chance of finding life? **Europa**