Space

<u>Lesson 1: Gravity</u>

Gravity is a force. It is measured in units called Newtons (N), named after the famous scientist and mathematician Sir Isaac Newton. Gravity, like magnetic and electro-static forces is a non-contact force. That means it can act on you from a distance. You do not have to be touching something to feel its force of gravity. Most forces, such as friction, are contact forces.

Gravity is always an attractive force; it pulls objects towards each other.

All objects that have energy exert the force of gravity on all other objects with energy. However, the force is very, very weak so you normally only feel the force of gravity from objects that are close and have the largest amount of energy. The mass of an object is directly related to its energy so normally we use mass rather than energy when describing an objects gravity. An object with more mass (more massive) has a stronger gravitational force. Massive does **not** mean big. An object can be very large but with very little mass, for example a balloon.

The size of the force is also related to the distance between the objects; the closer they are the stronger the force of gravity they feel. Standing on the surface of the Earth or other planet you feel the strongest pull of its gravity. As you move away from the surface and into space the pull becomes less.

The constant pull of gravity from the Sun, the most massive object in our solar system, causes the planets to move around it in an elliptical (almost circular) path called an orbit.

<u>Mass and Weight</u>

Mass and weight are not the same thing. It is a common misconception because the two words are used interchangeably in everyday situations. However, in science they have specific meanings that are different.

Mass is a measure of the amount of 'stuff' something is made of; particles, atoms etc.

It is measured in **kilograms** (kg).

It is **Constant**. It does not change depending on your location.

Weight is the force of gravity acting on your mass.

It is measured on **Newtons** (N).

It is **Not Constant**. It does depend on where you are; The Earth, the Moon, in space…

Gravitational Field Strength is given in Newtons per Kilogram (N/kg). For Earth this is 9.8N/kg. For planets with more mass than Earth it is higher, for planets with less mass it is lower.

To calculate the weight of an object you use the formula;

Weight = Mass x Gravitational Field Strength

L2 Days, Years, Seasons

Let's start with the basics: What is a day? A day is the period of time it takes for the Earth to complete one full rotation on its axis. Picture this: imagine yourself standing on a giant spinning top – that's the Earth. As it spins, different parts of its surface are exposed to sunlight, causing day and night.

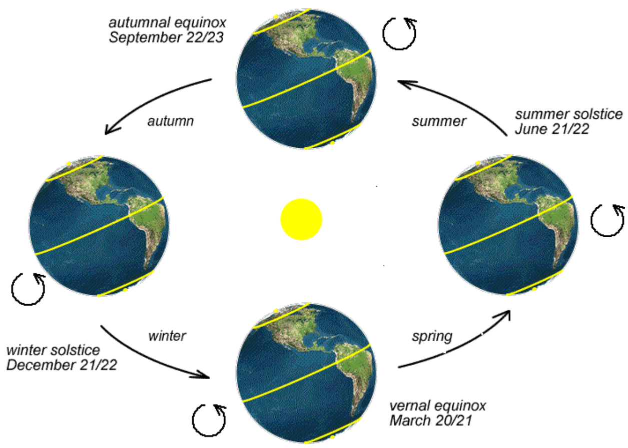
Now, why does it take 24 hours for the Earth to complete one rotation? Well, it's all thanks to the gravitational pull of the Sun and the initial rotation the Earth had when it formed billions of years ago. This rotation speed has remained relatively constant over time, giving us our familiar 24-hour day.

Next up, let's talk about years. A year is the time it takes for the Earth to complete one full orbit around the Sun. Just like how you go around a track in a race, the Earth is constantly circling the Sun in its own cosmic marathon. But why does it take about 365.25 days for the Earth to complete this journey? It's because the Earth's orbit around the Sun isn't a perfect circle; it's slightly elliptical, or egg-shaped. This means that sometimes the Earth is a little closer to the Sun, and other times it's a bit farther away.

However, the Earth's distance from the Sun isn't the only factor affecting the length of a year. There's also the leap year phenomenon. To keep our calendars in sync with the Earth's orbit, we add an extra day – February 29th – to the calendar every four years. This balances out the extra quarter day from each year, making our calendars accurate.

Now, let's delve into the enchanting world of seasons. Seasons occur because of the tilt of the Earth's axis. Imagine the Earth as a spinning top once again, but this time, it's tilted on its axis by about 23.5 degrees. This tilt means that as the Earth orbits the Sun, different parts of the planet receive varying amounts of sunlight throughout the year.

When the Northern Hemisphere is tilted towards the Sun, it experiences summer because the Sun's rays hit it more directly, making it warmer. Meanwhile, the Southern Hemisphere is tilted away from the Sun, experiencing winter due to the indirect sunlight and cooler temperatures.



As the Earth continues its journey around the Sun, the tilt causes the seasons to change. During the equinoxes, which occur around March 20th and September 22nd, the Earth's axis is neither tilted towards nor away from the Sun. This results in roughly equal day and night lengths across the globe, marking the beginning of spring and autumn respectively.

During the solstices, which occur around June 21st and December 21st, one hemisphere is tilted towards the Sun, experiencing its longest day (summer solstice) or shortest day (winter solstice) of the year. These days mark the official start of summer and winter.

But what about those regions near the poles? They experience something unique called polar day and polar night. During polar day, the Sun doesn't set for several months, while during polar night, it doesn't rise for an extended period. This phenomenon occurs because of the extreme tilt of the Earth's axis in relation to the Sun's position during certain times of the year.

In summary, days, years, and seasons are all interconnected phenomena driven by the Earth's rotation, orbit around the Sun, and axial tilt. From the mesmerizing dance of day and night to the enchanting spectacle of changing seasons, the universe never fails to astound us with its wonders.

Independent Practice

1. What is a day, and how is it defined in relation to the Earth's rotation?
2. Why does the Earth take approximately 365.25 days to orbit the Sun, leading to the need for leap years?
3. Explain the role of the Earth's axial tilt in causing seasons. How does this tilt affect different regions of the Earth?
4. Describe the differences between equinoxes and solstices. What happens during these events?
5. How do regions near the poles experience polar day and polar night, and what causes these phenomena?
6. Can you explain why it's important for our calendars to remain synchronized with the Earth's orbit around the Sun? What might happen if this synchronization were disrupted?

Scientific Extended Writing Questions:

7. Discuss the impact of axial tilt on the climate and seasons of different regions on Earth. How does the tilt contribute to the diversity of climates experienced around the globe?
8. Explore the concept of leap years in greater detail. How does the addition of an extra day to the calendar every four years help maintain its accuracy? Discuss any potential challenges or alternative solutions to keeping our calendars in sync with the Earth's orbit.

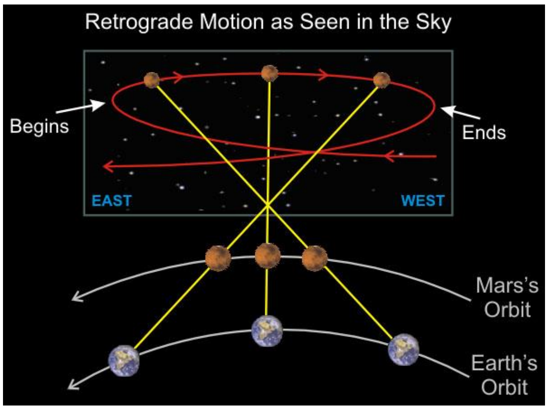
L3 The motion of the planets

The Naked-Eye Planets:
Let's start by talking about the planets visible to the naked eye: Mercury, Venus, Mars, Jupiter, and Saturn. These celestial bodies are like Earth in many ways, but they orbit the Sun at different distances. When we look up at the night sky, we can see them shining brightly, sometimes appearing like twinkling stars.

Changing Positions:
Have you ever noticed that the planets don't stay in one place among the stars? That's because they're constantly moving in their orbits around the Sun, just like Earth. As they orbit, they seem to change their positions relative to the fixed stars. This apparent movement is called "planetary motion."

Understanding Retrograde Motion:
Now, here's where things get interesting! Sometimes, as we observe the planets' movements, they appear to move backward, opposite to their usual path. This peculiar motion is known as "retrograde motion." But why does it happen?

Imagine you're in a car on a highway, and you're passing another car. As you overtake it, the other car seems to move backward relative to you, even though it's actually moving forward on the same road. The same principle applies to retrograde motion in the sky.



To understand this better, let's consider Earth and Mars. Earth orbits the Sun faster than Mars because it's closer to the Sun. Sometimes, Earth catches up with Mars in its orbit, just like our car overtaking another on the highway. As Earth passes Mars, Mars appears to move backward against the backdrop of stars. This creates the illusion of retrograde motion.

The same thing can happen with other planets, like Jupiter and Saturn, but the patterns are more complex due to their longer orbits and interactions with Earth's orbit.

Visualizing Retrograde Motion:
Imagine playing a game of cosmic hide-and-seek with Mars. When Earth and Mars are on the same side of the Sun, Mars appears to move in its usual direction. But as Earth overtakes Mars in its orbit, Mars seems to move backward, entering a period of retrograde motion. After a while, Earth moves ahead of Mars again, and Mars resumes its normal forward motion.

Conclusion:
Congratulations, young scientist! You've just unlocked the secrets of planetary motion, from the mesmerizing dance of the naked-eye planets to the curious phenomenon of retrograde motion. Next time you gaze up at the night sky, remember that each twinkle of light holds a story of celestial motion waiting to be discovered.

Independent Practice

1. Which planets can be seen with the naked eye?
2. What is planetary motion, and why do planets seem to change their positions among the stars?
3. What is retrograde motion, and why does it occur?
4. Can you give an example of retrograde motion using Earth and Mars?
5. Why do the patterns of retrograde motion appear more complex for outer planets like Jupiter and Saturn?
6. How is retrograde motion similar to passing another car on a highway?
7. What advice would you give to someone who wants to observe retrograde motion in the night sky?

Extended Scientific Writing Questions:

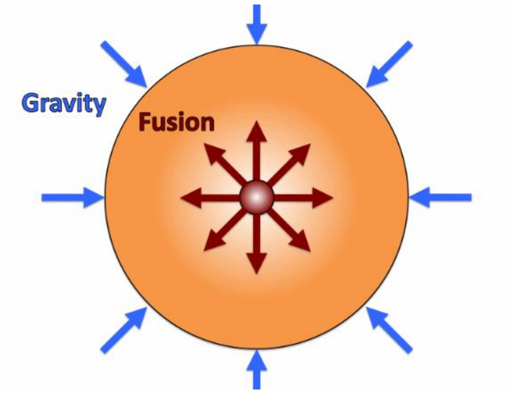
1. Imagine you are an astronaut on a mission to explore Mars. Write a journal entry describing your observations of retrograde motion from the Martian surface and explain how understanding this phenomenon helps in planning future space missions.
2. Design an experiment using simple materials to demonstrate the concept of retrograde motion. Write a step-by-step procedure explaining how you would conduct the experiment, what materials you would need, and what observations you would make to understand retrograde motion better.

Lesson 4: The Universe

Our Sun is a star. It is much bigger and brighter than the other stars we see in the sky because it is very much closer than them.

A star is the term used to describe a cloud of hydrogen gas that has collapsed under its own gravity to the point that **nuclear fusion** can occur in its core. This is where atoms are forced together to make larger atoms and, in the process, release huge amounts of energy. This energy is then released into the surroundings as electromagnetic radiation.

The balance between these 2 forces causes a star to assume a spherical shape. Our Sun has been doing this for approximately 5 billion years and will continue to do so for at least another 4 billion.



Our solar system is huge in comparison to the distances between places on Earth that we are used to using. Units such as the metre and kilometre are very impractical.

The average distance between the Earth and Sun is 149,600,000,000 m.

We call this distance 1 Astronomical Unit (AU).

We can use this measurement for comparing distances within the solar system.

Planet	Distance from Sun in AU
Mercury	0.39
Venus	0.72
Earth	1.00
Mars	1.52
Jupiter	5.20
Saturn	9.58
Uranus	19.20
Neptune	30.05

The inner rock planets are all relatively close to the Sun. The outer gas giant planets are very much further away. The distances between the outer planets is also huge. This means that most of our solar system is empty space.

However, this unit of distance also becomes impractical when we want to measure distance to nearby stars. The next nearest star to Earth is Proxima Centauri. It is 268,770 AU away. For these distances we need a unit of measurement that is even bigger.

Light travels at 300,000,000 m/s in empty space.

It takes 8 minutes and 18 seconds for light to reach the Earth from the surface of the Sun. For that same light to reach the dwarf planet Pluto takes 5 hours!

The unit of measurement we use to measure distance to other stars is called the **light year**. It is the distance travelled by light in one year.

1 light year = 9,460,800,000,000,000 m

Proxima Centauri, our nearest neighbour, is 4.24 light years away from the Earth.

Sirius, the brightest star in the sky, is 8.61 light years away from Earth.

Betelgeuse, the red star in the top left corner of the constellation Orion is 624.5 light years away.

Independent practice

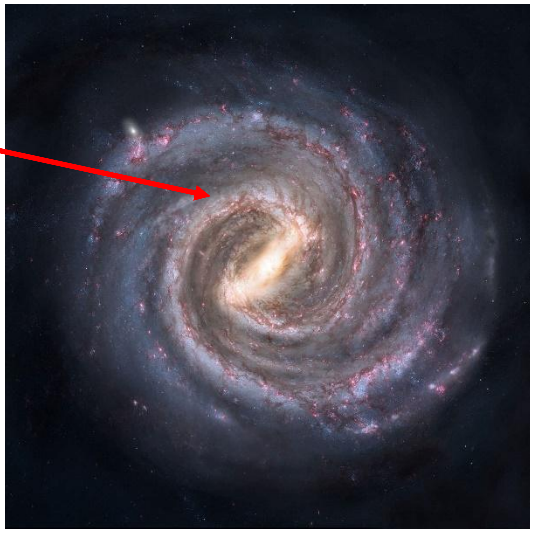
1. What is a star, and what process allows it to emit energy?
2. Why does our Sun appear much larger and brighter than other stars in the sky?
3. What unit of measurement is used to describe the average distance between the Earth and the Sun, and what is its value?
4. Name three inner planets of our solar system and their respective distances from the Sun in Astronomical Units (AU).
5. Explain why the unit of Astronomical Units (AU) becomes impractical for measuring distances to nearby stars.
6. How does the concept of light years help us measure distances to other stars, and what is the distance to Proxima Centauri in light years?

Longer Answer Questions:

1. Describe the process of nuclear fusion that occurs in the core of a star like our Sun and explain why it is essential for a star's energy production. How does this process contribute to the Sun's longevity?
2. Compare and contrast the distances between the inner rocky planets and the outer gas giant planets in our solar system. Discuss the significance of these differences in terms of the distribution of mass and empty space.
3. Discuss the practical implications of using light years as a unit of measurement for distances to stars. How does the vastness of space affect our understanding of stellar distances and exploration beyond our solar system?
4. Imagine you are planning a space mission to explore Proxima Centauri, the nearest star to Earth. Outline the challenges and considerations involved in such a mission, including the duration of the journey, propulsion methods, and potential scientific discoveries.

The Milky Way Galaxy

we are here



There are approximately 250 billion stars in our Galaxy, The Milky Way. It is 105,700 light years in diameter. It is one on of the over 100 billion galaxies that are known in the observable universe.

The closest galaxy to the Milky Way is the Andromeda Galaxy which is 2.5 million light years away.

Time Travel

When we look at light coming from another star, we are seeing that star as it was in the past. The light we see today coming from Proxima Centauri left that star over 4 years ago. The light coming from Betelgeuse left that star 642 years ago. When we look at the light from distant galaxies we are looking at them as they were before the time of the dinosaurs.

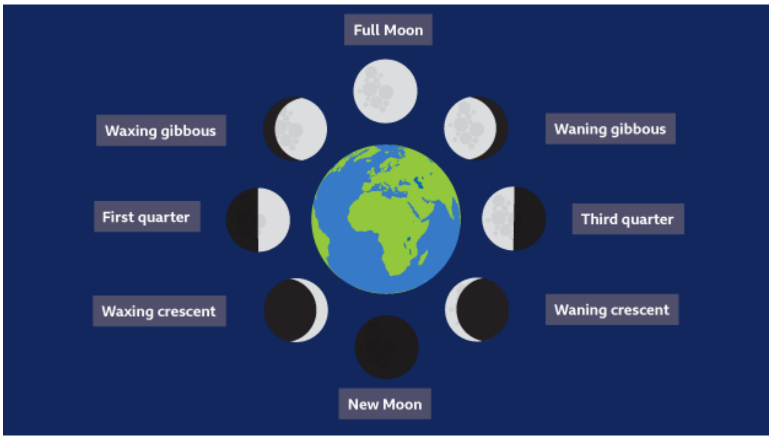
11. Put the following words in order of size from smallest to largest:
    Planet, galaxy, universe, solar system, star
12. What is the relationship between the distance a planet is from the sun and the length of its year.
13. What defines a day?
14. What defines a year?
15. Why is mars' gravity lower than earths?
16. What is a largest distance 1 light year, 500AU or 9million KM

Lesson 5 – The moon

The Moon reflects light from the Sun and that is why we can see it. It is not a source of light but acts like a mirror.

The Moon's appearance changes over time when viewed from Earth. Sometimes, the Moon is not visible at all and at other times it can appear as a thin crescent, a full circle – or somewhere in between.

A Moon phase is the shape of the visible part of the Moon, and this changes gradually over the course of a lunar month. A lunar month lasts around 29.5 days and starts with a new Moon – when the Moon is not visible at all. As the Moon moves around Earth, the illuminated section of the Moon's surface starts to become visible and we see a thin crescent Moon appear.
Over the course of a lunar month, the Moon goes through the following phases:



What causes tides?
Tides in the ocean are caused by the gravity of the moon pulling the Earth towards it.
Where oceans face the moon, the earth is pulled most and builds up in a bulge. This is a **high tide**. The Earth is pulled towards the moon more than the ocean on the opposite side of the planet. This causes another high tide. As the moon moves around the planet, these tides move around with it, causes two high tides and two low tides each day.

Questions

1. Why can we see the moon?
2. What shapes does the moon appear when viewed from earth?
3. What is a moon phase?
4. How long is a lunar month?
5. When does a lunar month start and when does a lunar month end?
6. Name all of the phases of the moon?
7. What causes tides?
8. What causes a high tide?