

Section 1: Comets

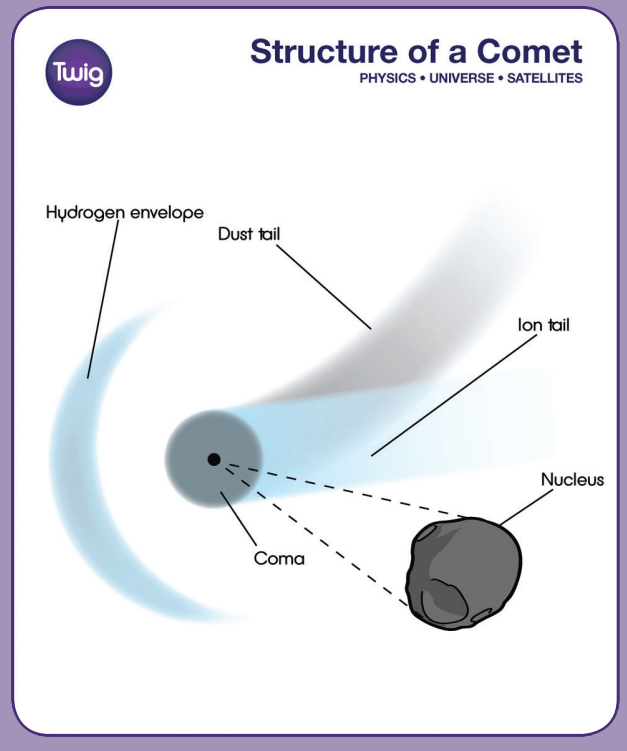
• What are comets?

Planets are not the only objects to orbit the Sun; others include asteroids, dwarf planets and comets. Comets are relatively small, icy objects that are thought to originate beyond the outer planets. Sometimes their orbits bring them close enough to be observed from Earth. Comets can be a few hundred metres to tens of kilometres wide. They are composed of ice and frozen gases, like ethane and ammonia, as well as rocks and dust. The surface of a comet is extremely dark, and when far from the Sun they are very difficult to see. However, when they pass close to the Sun the frozen material begins to vaporise and dust and gas stream out of the nucleus, forming the 'tail' of the comet. The tail can be enormous, extending hundreds of millions of kilometres. A thin atmosphere called a 'coma' also forms around the nucleus. These both reflect sunlight and so the comet can be very bright.



Throughout history, comets have been regarded as bad omens

DIAGRAM 01:



• Suggested Film

- What Are Comets?

Extension Question

Q1. Can you see comets with the naked eye?

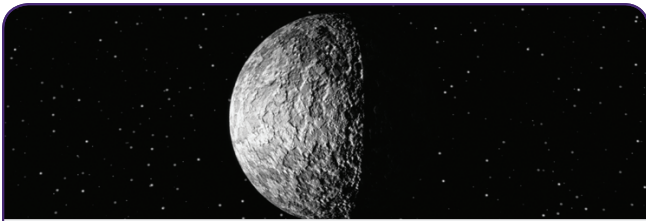
Occasionally comets are visible to the naked eye, although this is not common. Throughout history, comets have generally been regarded as bad omens.

Halley's comet orbits the Sun with a period (the time taken for the comet to complete one orbit) of around 75 years, and was last visible in 1986. Halley's comet was also visible before the Battle of Hastings in 1066 and appears on the Bayeux tapestry. More recently, in 1997, the comet Hale Bopp was clearly visible in the night sky in the northern hemisphere, outshining almost every star in the sky. Comet Hale Bopp is a long period comet and has a period of thousands of years. It is thought that it was previously visible on Earth in 2215 BC, but no records of this survive. It has been calculated that it will return in around 4385.

• Where do comets come from?

Beyond the orbit of Neptune there are objects called Trans-Neptunian Objects (TNOs). These are found in three regions: the Kuiper belt, the Scattered Disc and the Oort Cloud.

Pluto is a TNO and is found in the Kuiper Belt, and objects in the Kuiper Belt are thought to have stable orbits. Beyond the Kuiper Belt there is another region known as the Scattered Disc, and it is thought that comets originate in this region. The orbit of Neptune can disturb the Scattered Disc objects, meaning this region is not as stable as the Kuiper Belt. Far beyond the Kuiper Belt and Scattered Disc there is thought to be another region, the Oort Cloud, where it is considered that some comets may come from.



Pluto is considered a dwarf planet

• Suggested Film

- What Are Comets?

Extension Questions

Q2. Is Pluto a planet?

No. Until recently Pluto was considered a planet. However, in 2005 Eris was discovered in the Scattered Disc and is larger than Pluto. As a result of this it was felt that more objects would be discovered, leading to perhaps 50 objects having to be classed as planets. As a result, the definition of a planet was changed in 2006, which now states that an object must have cleared its neighbourhood around its orbit with its gravitational pull. This means that Pluto, along with several other objects in the Solar System, is now considered a dwarf planet. In 2005 it was announced that two other dwarf planets had been discovered in the Kuiper Belt: Haumea and Makemake, which are both around one third of the mass of Pluto.

Q3. What is the Kuiper Belt?

The Kuiper Belt is a doughnut shaped region of thousands of small, frozen objects, which extends from beyond the orbit of Neptune. These objects are thought to have stable orbits. With a diameter of around 2000km (about 60% of the diameter of Earth's Moon), Pluto is the largest Kuiper Belt object. There are thought to be tens of thousands of Kuiper Belt objects with a diameter of over 100km. One of Neptune's moons, Triton, is thought to be a Kuiper Belt object captured by Neptune's gravity.

Q4. What is the Scattered Disc?

The Scattered Disc partly overlaps with the Kuiper Belt, but it extends further out to around three times Neptune's distance from the Sun. It is thought that objects in the Scattered Disc have unstable orbits and can be sent towards the Sun, becoming comets. The Scattered Disc is the likely source of short period comets, which by definition have a period of less than 200 years.

Q5. What is the Oort Cloud?

Astronomers believe many comets originate in the Oort Cloud. This is thought to lie about 20 times further away from the Sun than the Scattered Disc, and extend to almost 1000 times further. This is an enormous distance and would mean that it extends to almost a quarter of the distance to the nearest star outside our Solar System. If the Oort Cloud exists it likely contains trillions of frozen objects. It is assumed to be the source of long period comets, which can have a period of thousands or even millions of years.

• How have comets affected Earth?

The source of all the water on Earth is not clear. One theory is that a large amount of water was deposited by comet impacts while the Earth was forming. However, this cannot account for all water on Earth. Water contains hydrogen and oxygen, but there are three types of hydrogen atom: protium, deuterium and tritium. Tritium rarely occurs in nature, and although deuterium does occur naturally on Earth it is in relatively small quantities. Measurements of the deuterium to protium ratio (usually just called hydrogen) for comets and the Earth's oceans, show that the ratios are not the same, suggesting that the water in the oceans cannot all have come from comets.

• Suggested Films

- How the Oceans Formed
- Shoemaker-Levy

Extension Question

Q6. Have we ever sent probes to comets?

There have been several missions to comets. In 1986, the European Space Agency (ESA) probe Giotto conducted a flyby of Halley's Comet, passing within 600km of the nucleus and returning pictures. It was the first spacecraft to take pictures of a comet nucleus.

In 2004, the ESA launched the Rosetta probe. In November 2007, as the probe performed a flyby of Earth, it was briefly, and mistakenly, identified as a dangerous near Earth object with a possibility of colliding with Earth.

In 2005, NASA's Deep Impact probe released an impactor into the comet 9P/Tempel. This created a crater on the comet, throwing up debris. The results showed that the comet contained more dust and less ice than expected.

In 2006, after a journey lasting almost seven years, NASA's Stardust probe successfully collected dust samples from the coma of the comet Wild 2 and returned them to Earth.

Section 2: Satellites

• What is a satellite?

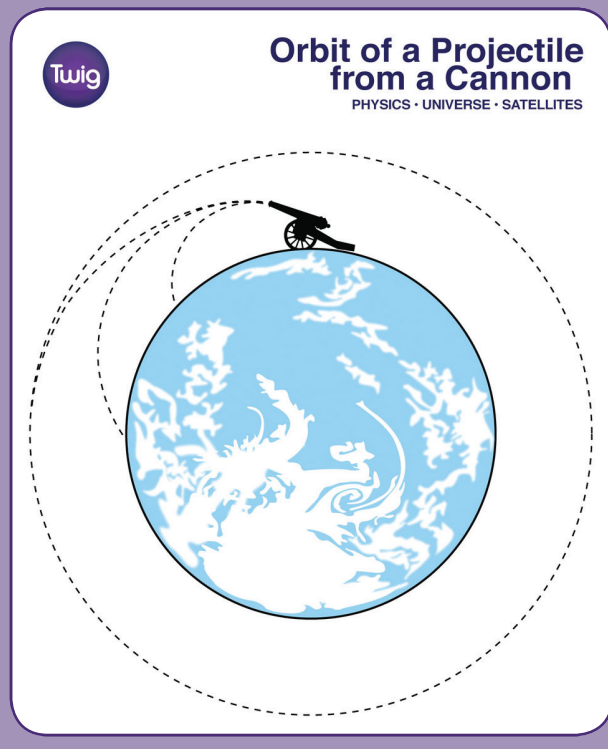
A satellite is an object which orbits a larger object. The Earth is a satellite of the Sun, and the Moon is a satellite of the Earth. However, when we talk about satellites we usually mean man-made objects which are put into orbit around Earth or another body.

The first satellite, Sputnik 1, was put into orbit by the Soviet Union in 1957. Although the principles behind satellites and satellite communication had been understood long before this. Thousands of satellites are currently in orbit around Earth, occupying a wide range of orbits.

• Suggested Film

- The Satellite Story

DIAGRAM 02:



Extension Questions

Q7. How do satellites stay in orbit?

As satellites travel horizontally they fall towards the Earth.

As the Earth is a sphere its surface curves away from the satellite as it falls. For each height there exists a velocity where the trajectory of the satellite is such that as it falls, the Earth curves away at the same rate so it never strikes the surface of the Earth.

The period of the satellite is dependent upon the height at which the satellite is orbiting. If a satellite is far away from the Earth it will have a long orbital period.

At a distance of 36,000km above the Earth a satellite will have a period of 24 hours. If a satellite is put into orbit above the equator then, as the Earth rotates once every 24 hours, it will stay above the same point on the Earth. These satellites are known as geostationary satellites and are very important for communication.

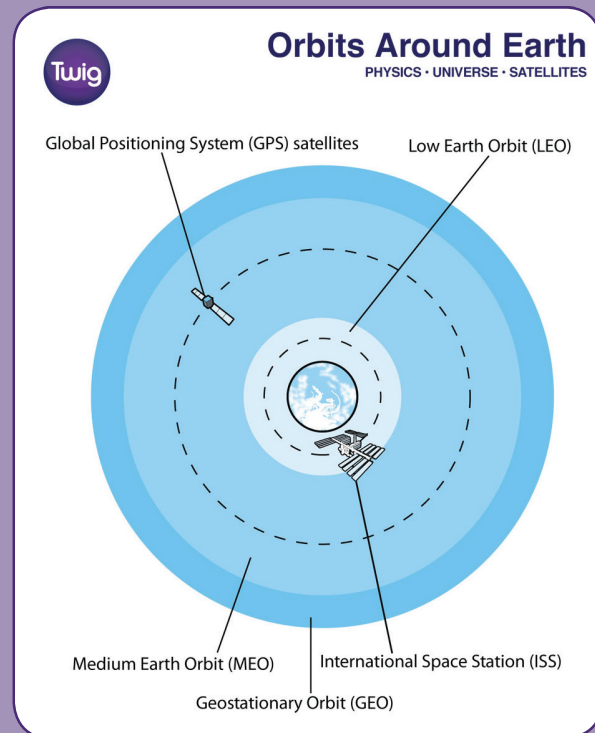
Q8. Are satellites visible to the naked eye?

Some satellites are visible to the naked eye. There are dozens of Iridium satellites orbiting the Earth, which are used for satellite phone communications. Each Iridium satellite has three polished, door-sized antennas. Because of this, the satellites reflect light down onto the Earth and to an observer this appears as a bright flash in the sky which lasts for a few seconds. The occurrence of these Iridium flares can be predicted accurately and are sometimes so bright that they are visible during daytime.

Q9. What is space junk?

There is a large amount of 'space junk' in orbit. This ranges from small pieces of dust and paint flecks, to dead satellites and parts of failed rocket boosters. In 1978, the NASA scientist Donald Kessler raised the possibility of an 'ablation cascade', where a collision between objects in orbit would create debris, which would create more collisions, which would lead to even more debris. In an extreme case this could lead to so many satellites being destroyed that the resulting debris could make space exploration impossible.

DIAGRAM 03:



• How are satellites used?

Satellites perform various functions including monitoring the weather, imaging the Earth's surface, facilitating communication and helping navigation.

One famous satellite is the International Space Station (ISS) which orbits the Earth. The space station is a joint project involving several countries including the USA, Russia and Japan. The space station has a crew of six astronauts at any one time, and allows experiments to be conducted in zero gravity. The station also tests technologies for future, long duration missions to the Moon and Mars.

• Suggested Film

- What Is GPS?

Extension Questions

Q10. What is GPS?

The Global Positioning System (GPS) is a system of satellites used for navigation. It was originally a military system, but the US government made it available for civilian use in the 1980s after an incident where a Korean airliner accidentally entered Soviet airspace and was shot down.

The system requires 24 satellites. The satellites need replaced over time and so replacements are launched as required and spare satellites are kept in orbit in case of failure. Eight of these satellites should be visible from a given point on the Earth at any time. GPS has many uses, including in car navigation systems.

The system works by measuring the time delay between the signal being sent and it being received. This allows the receiver to calculate the distance from the transmitting satellite. Using only one satellite does not uniquely define a position, as the receiver could lie anywhere on a sphere which has that distance as a radius. However, if two satellites are used the two spheres intersect, providing a ring of possible positions. A third satellite provides a third sphere which then defines two possible points. It is likely that the system will be able to determine which of these is correct, but adding the signals from more satellites helps to define an accurate position.

GPS is not the only satellite navigation system. Russia operates a similar system called GLONASS, and the European Union, along with other international partners, is planning to construct a civilian system called Galileo.

Q11. How accurate is GPS?

GPS is accurate to within about 10m. Originally a system called Selective Availability (SA) was used, which deliberately limited its accuracy to guard against enemy attacks on US forces and using GPS for weapons guidance. This meant that civilian GPS was only accurate to around 100m. By 2000, a technique called Differential Global Positioning System (DGPS) was available. DGPS services used ground stations to measure the SA value and helped GPS receivers correct for it. On May 1st 2000 the US government switched off SA, and civilian GPS became more accurate.

Q12. What can spy satellites see?

There have been claims that images from military spy satellites are good enough to read number plates and newspapers. This is very unlikely to be true. Although the exact capabilities of spy satellites are classified, even the best systems in ideal conditions are only likely to be able to distinguish between two objects around 10cm apart.

Spy satellites are like large telescopes which are put into orbit a few hundred kilometres above the Earth and take images of the surface. Before spy satellites were put into orbit, the USA used spy planes to conduct surveillance over the Soviet Union. The first spy satellites were launched in 1959 and operated throughout the 1960s. They took pictures using film which was then ejected and collected by aircraft as they fell to Earth. Later, satellites sent pictures back to Earth via radio links.



The exact capabilities of spy satellites is classified

• Quizzes

What Are Comets?

Basic

• How did comets form?

- A – they were formed when objects collided with planets
- B – they form all the time, outside the Solar System
- C – they are left over from when the Solar System formed

• How many comets are there in the Solar System?

- A – hundreds
- B – thousands
- C – hundreds of millions

• Which of these is not found in the tail of a comet?

- A – dust
- B – water
- C – copper

• Where do most comets come from?

- A – the Oort Cloud
- B – the Kuiper Belt
- C – the Asteroid Belt

• What are comets mostly made of?

- A – rock
- B – ice and water
- C – gas

Advanced

• When is Halley's comet due to return?

- A – 2021
- B – 2061
- C – 2091

• What is the centre of a comet called?

- A – nucleus
- B – core
- C – heart

• What is the name of the cloud surrounding the comet?

- A – the coma
- B – the envelope
- C – the veil

• How far away is the Oort Cloud from the Sun?

- A – twice as far as the Earth
- B – 50 times as far as the Earth
- C – 50,000 times as far as the Earth

• How far away is the Kuiper belt from the Sun?

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• Quizzes

The Satellite Story
Basic

• What is a satellite?

- A – any object which orbits the Earth
- B – any object which orbits a planet
- C – any object which is man-made which orbits the Earth

• How many moons does Jupiter have?

- A – 1
- B – about 20
- C – more than 60

• How many satellites orbit the Earth?

- A – dozens
- B – hundreds
- C – thousands

Advanced

• What was the name of the very first satellite?

- A – Sputnik
- B – Telstar
- C – Soyuz

• When was the first satellite put into orbit?

- A – 1957
- B – 1969
- C – 1978

• When was the International Space Station launched?

- A – 1989
- B – 1991
- C – 1998

• Answers

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