# Physics 8: Space

## Section 1: Key words and definitions

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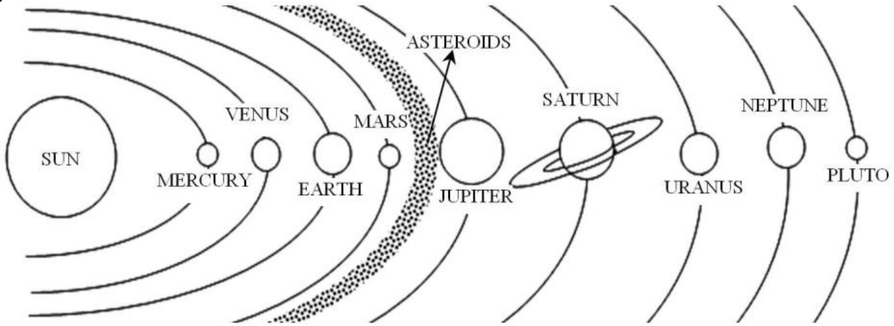
|---|---|
| Artificial satellite | A satellite that we have put into orbit to do a job, e.g. GPS satellites |
| Asteroid | A rock orbiting the Sun – most are between Mars and Jupiter |
| Big bang | The most likely theory of how the universe began |
| Black dwarf | The remains of a small mass star that has become a white dwarf then cooled |
| Black hole | The remains of a very large mass star that has exploded in a supernova |
| Comet | A ball of ice that has a very elliptical orbit with the Sun at one focus |
| Doppler effect | Sound waves are squashed up in front of a moving source and stretched out behind it and we hear a change in pitch as it passes us (e.g. an ambulance siren) |
| Geostationary orbit | A satellite orbit where the satellite completes one orbit in 24 hours, so it looks as if the satellite is in the same place in the sky. Used for transmitting satellite TV signals. |
| Gravitational field | Any place where an object with mass feels a force – its weight. |
| Gravitational field strength | The amount of weight that a 1kg mass has because of the gravitational field. Symbol "g". On Earth, g = 9.8 N/kg but we often round to 10N/kg |
| Natural satellite | A natural object that orbits a planet, e.g. our Moon |
| Nebula | A cloud of dust and gas in space – mostly hydrogen |
| Neutron star | A very dense object that remains after a star with a large mass explodes in a supernova |
| Nuclear fusion | The source of energy inside a star. When two small nuclei join together to make a larger one. E.g. hydrogen nuclei fuse to make helium |
| Polar orbit | A satellite orbit that passes over the north and south poles. Used for satellites that survey the Earth e.g. for weather forecasting. |
| Protostar | A ball of hydrogen gas that is pulled together by gravity but has not yet started nuclear fusion. |
| Red giant | A **small mass** star that has run out of hydrogen and has expanded and cooled. Our Sun will become a red giant in about 5 billion years. |
| Red shift | Light waves are stretched out behind a moving source (e.g. a distant galaxy) and are "shifted" to longer wavelengths. |
| Red **super**giant | A **large mass** star that has run out of hydrogen, expanded and cooled. |
| Satellite | An object that is orbiting a planet |
| Supernova | The stage in the life cycle of a very **large mass** star where it explodes. The outer layers are thrown off and the core collapses into a neutron star or a black hole. |
| Weight | The force on an object because of a gravitational field acting on its mass. |
| White dwarf | The stage in the life cycle of a **small mass** star when a red giant cools and shrinks. |

## Section 2: Equations to learn

| Calculation | Equation | Symbol equation | Units |
|---|---|---|---|
| Weight | weight = mass x gravitational field strength | W = m x g | N |
| mass | mass = weight ÷ gravitational field strength | m = W ÷ g | kg |
| Gravitational field strength | Gravitational field strength = weight ÷ mass | g = W ÷ m | N/kg |

## Section 3: The Solar System




The Solar System consists of:

- one star (The Sun) at the centre,
- Four small, rocky planets – *Mercury, Venus, Earth Mars,*
- The Asteroid Belt,
- Four gas giant planets – *Jupiter, Saturn, Uranus, Neptune*
- Several dwarf planets e.g. *Pluto*
- Comets
- Some of the planets have moons

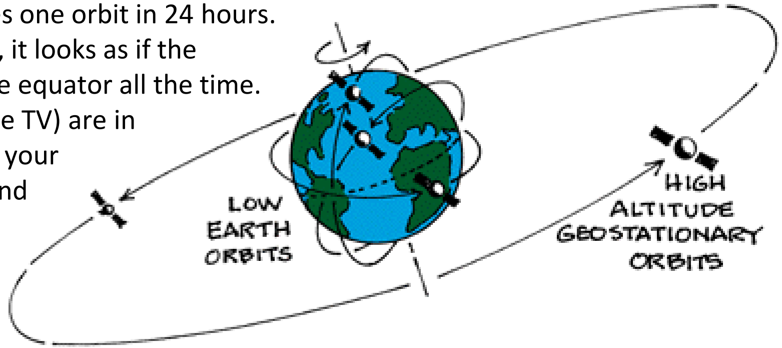
We have studied the Solar System by: naked eye (i.e. just looking at the night sky), using telescopes on the ground, using telescopes in space (e.g. the Hubble Space Telescope), sending out probes to look closer at distant planets (e.g. Cassini mission studied Saturn in 2017, Voyager 1 & 2 launched in the early 1970s sent back detailed photographs of the gas giants in the 1980s and 1990s), and by sending robotic craft to Mars. *(Did you know that Mars is, as far as we know, the only planet entirely inhabited by robots? How cool is that!)*

## Section 4: Satellites

There are two satellite orbits you need to know about*:* *(The International Space Station is in a low earth orbit)*

(1) **Polar orbits** – satellites in a polar orbit are in a "low earth" orbit that passes over the north pole and the south pole while the Earth rotates underneath. They are fast moving, orbiting the Earth in as little as 90 minutes. This means they can cover the entire surface of the Earth in a day. Polar orbits are used for weather forecasting, analysing land use, anything that involved studying the Earth's surface.

(2) **Geostationary orbits** are high above the equator: 36,000km up! A satellite in geostationary orbit completes one orbit in 24 hours. As the Earth also rotates once in 24 hours, it looks as if the satellite stays above the same point on the equator all the time. Communications satellites (e.g. for satellite TV) are in geostationary orbits so that you can point your satellite dish at the same part of the sky and the satellite will always be there.




The further away a satellite is from the Earth, the slower its speed.
The closer it is, the faster it goes.

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## Section 5: The Life Cycle of Stars

- **Nebula –** cloud of hydrogen → **Protostar** – gravity pulls the hydrogen together → **Main sequence star** stable because the forces are balanced (weight & radiation pressure)
  - → **Red giant** – SMALL MASS star runs out of hydrogen & swells up → **White dwarf** – core of red giant shrinks and cools → **Black dwarf** – white dwarf cools down
  - → **Red supergiant** – a LARGE MASS star swells and cools → **supernova** – a red supergiant explodes → **Neutron star OR black hole**

Our Sun is a small mass star. It will expand to form a red giant, then shrink and cool to form a white dwarf. The white dwarf will cool further to form a black dwarf. Once it is a black dwarf it is at the same temperature as space. Much larger star swell to form a red supergiant, which explodes in a supernova/ The outer layers are thrown off into space but the core collapses to form a neutron star or, if the mass is high enough, a black hole. All elements up to iron were formed by nuclear fusion inside a main sequence star. All elements more massive than iron were formed in a supernova. The atoms in your body were made inside a star. *How cool is that (again)!*

## Section 6: The Big Bang

The "Big Bang" says that the universe began about 14 billion years ago as a single point and has been expanding ever since. It is still expanding today. Evidence for the Big Bang includes:

(1) Red shift – wherever we look in the universe, light from distant galaxies shows a red shift.
This means that all galaxies are moving away from us, and from each other. The further away a distant galaxy is, the bigger its red shift is. This means that more distant galaxies are moving away faster than closer galaxies. We can use the red shift to tell us two things: the distance away a galaxy is and the speed of a galaxy.

(2) CMBR – Cosmic Microwave Background Radiation.
Everywhere we look in space, we see microwave radiation left over from the Big Bang. Originally this was gamma rays but as space has stretched, the waves got stretched too and now they have much longer wavelength than they had when they were formed.

## Section 7: Scientific Process (Or – what makes scientists decide which theory is correct?)

Scientists rely on evidence to support their theories. When new evidence is found, it will either support the theory or not. If new evidence does not support the theory, then scientists must modify the theory. Example: Astronomers once thought that the universe had always existed in a "steady state" - its present form. But when evidence of red shift was published, "steady state" theory was replaced by the "Big Bang" theory that the universe began as a single point and is expanding, because there was more evidence to suggest that the Big Bang is likely to be correct. If more new evidence is discovered in the future, even Big Bang theory might have to change!

## Test your knowledge

What stages will the Sun go through during the next 5 billion years?

What will happen to a star much more massive than the Sun once it reaches the end of its main sequence stage?

Describe the orbit of a satellite designed to survey the Earth's surface.

Describe a geostationary orbit and give one use of geostationary satellites.

Outline the current theory of how the universe formed.

What evidence is there to support this theory?

What might persuade scientists to change their mind about a theory?