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Physics Topic P16 Waves, electromagnetism & space – Space (triple)

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Section 1: Space Key Terms (triple)	
Star	A **self luminous gaseous** spheroidal celestial body of great mass which **produces energy** by means of **nuclear fusion** reactions
Sun	The star around which **Earth orbits**
Planet	An astronomical object that orbits a **star**, has enough mass to be round and **does not emit its own light**. It removes debris from around its orbit. It can be terrestrial (dense and rocky) or Jovian (gas giant)
Dwarf planet	An object which **doesn't quite meet the criteria for a planet**, it hasn't cleared debris from its orbit path
Universe	**All of space** and everything in it (including stars, planets and galaxies)
Asteroid	**Irregularly shaped rock** that **orbits** the sun
Orbit	A curved path of a **planet**, **satellite** or spacecraft around an object such as the sun (due to attraction of gravity)
Comet	A celestial object consisting of a **nucleus of ice and dust**. When near the sun, a "tail" of gas and dust particles point away from the sun
Natural satellite	Any celestial body in space that **orbits** about **a larger body**. Moons are called natural satellites as they orbit planets
Artificial satellite	An object that **people have made** and **launched into orbit** using rockets
Galaxy	A **system** of millions or billions **of stars** that **extends** over many **billions** of **light-years**. Held together by **gravity**
Big Bang	The leading explanation about **how** the **universe began**
CMBR	**C**osmic **m**icrowave **b**ackground **r**adiation, a remnant from the very early stage of the universe which is only explained by the big bang theory
Nuclear fusion	A **nuclear reaction** in which atomic nuclei of low atomic number **fuse** to form a **heavier nucleus with** the **release** of **energy**
Protostar	A star-to-be. A concentration of gas and dust that becomes hot enough to cause nuclear fusion
Solar system	Our solar system is made up of **the sun** and **all** the **objects that orbit** around it
Light year	The **distance light travels** in a **year**
Dark matter	Matter in a galaxy that cannot be seen
Nebula	Interstellar cloud of dust, hydrogen, helium and other ionised gases

Section 1: Space Key terms (triple) Continued	
Supernova	The explosion of a red supergiant after it collapses
White dwarf	A star that has collapsed from the red giant stage to become much more hotter and denser
Black dwarf	A star that has faded out and gone cold
Neutron star	The highly compressed core of a massive star that remains after a supernova explosion
Black hole	An object in space that has so much mass that nothing, not even light can escape its gravitational field
Red giant	A star that has expanded and cooled, resulting in it becoming red and much larger and cooler than it was before it expanded.
Centripetal force	The resultant force towards the centre of a circle acting on an object moving in a circular path
Red shift	Increase in the wavelength of electromagnetic waves emitted by a star or galaxy due its motion away from us

Section 2: Formation of the Solar System (triple)

Within our **solar system** there is **one star**, the **Sun**, plus the **eight planets** and **the dwarf planets** that orbit around the Sun. **Natural satellites**, the **moons** that orbit planets, are also part of the solar system.

Our solar system is a small part of the **Milky Way galaxy**.

The Sun, was formed form a cloud of dust and gas (**nebula**) pulled together by **gravitational attraction**. This causes **fusion reactions** which lead to an **equilibrium** between the **gravitational collapse** of a star and the **expansion of a star** due to **fusion energy**.

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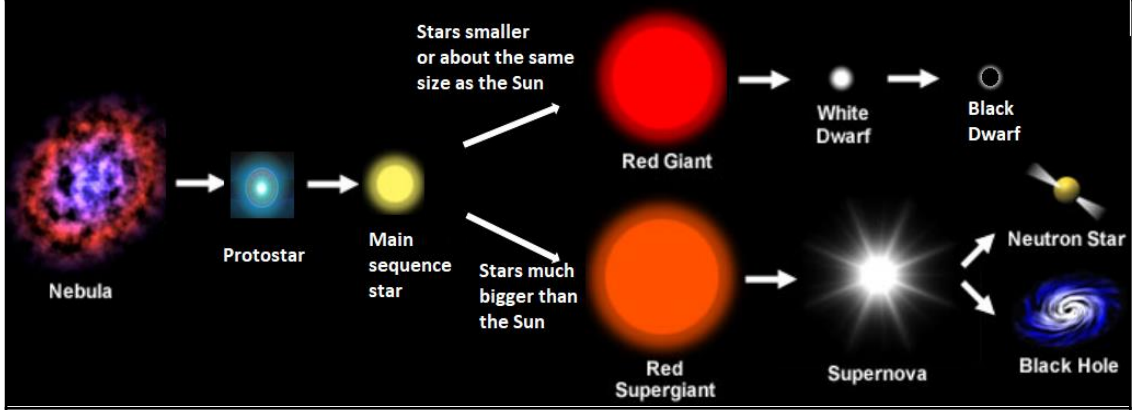
Section 3: The life history of a star (triple)



1. All stars (including the Sun) form out of clouds of dust and gas called **nebula**
2. The **force of gravity** makes the dust and gas spiral in together to form a **protostar**
3. **Gravitational energy** is converted into **thermal** energy so temperature rises. When temperature gets hot enough, **hydrogen nuclei** undergo **nuclear fusion** to form **helium nuclei** and **give out** massive amounts of **heat and light**. A **star** is born.
4. Eventually the **hydrogen begins to run out**. **Heavier elements** are made by **nuclear fusion of helium**. The star goes from main sequence to **red giant** (if it's a small star) or a **red super giant** (if it's a big star). The **surface temperature decreases** and **relative luminosity decreases**.

Small stars

5. When there is **no more light elements** in the core to use, **fusion stops** and because of its **own gravity**, the **star collapses and shrinks** becoming a **white dwarf**. The surface temperature increases and the relative luminosity decreases.
6. The star then **cools, fades** and **stops emitting energy & radiation** and becomes a **black dwarf**.

Big stars

5. Big stars undergo **more fusion** and form heavier elements like iron. They swell out to become **red super giants**.
6. Eventually they explode in a cataclysmic explosion called a **supernova**.
7. The exploding supernova throws its outer layers of dust and gas into space leaving a very **dense core** called a **neutron star**.
8. If the star is **big enough** this will become a **black hole**.

Fusion processes in stars produce all the naturally occurring elements. **Elements heavier** than **Iron** are **produced** in a **supernova**. **Supernova explosions distribute** all the **elements throughout** the known **universe**.

Section 4: Planets, satellites and orbits (triple)

A **planet** is an astronomical object that **orbits a star** e.g. The Earth. A natural satellite is any **celestial body** in space that **orbits** about **a larger body** e.g. the **Moon**. An **artificial satellite** is a **man-made** object that has been **launched into orbit using rockets** e.g. communication satellites.

The **force of gravity** between:

- A **planet** and the **Sun** keeps the **planet moving** along its **orbit**.
- A **satellite (e.g. the Moon)** and the **Earth** keeps the **satellite moving** along its **orbit.**

Circular orbits (HT)

The planets orbit the Sun in a **circular motion**. Each planet orbits at a different speeds and this is **related** to the **distance** from the Sun.

The **further a satellite** is from the **Earth** (or a **planet** is **from the Sun**):

- the **less the speed** needed for it to stay in orbit and
- the **longer** the time taken for **one orbit**.

The **direction of motion** of any planet in a circular orbit is **continually changing** and is **always at right angles** to the **direction of the force of gravity** on it. This is an example of a **centripetal force**.

The **magnitude of velocity** (**speed**) of a satellite in circular orbit **doesn't change** but **its direction** of its velocity **continually changes**. As velocity is a vector and includes direction, the **satellite must** be constantly **accelerating** in order to change direction.

For a stable orbit, the **radius must change** if the **speed changes**.

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Section 5: The expanding universe – red shift (triple)

People can find out lots of things about stars and galaxies by **studying** the **light** from them. In 1929, the astronomer Edwin Hubble observed that the light from galaxies moving away from the Earth had longer wavelengths than expected.

The **wavelength** of **light** increases across the **spectrum** from **blue to red**.

You can tell if a star or galaxy is moving towards/away from Earth by observing whether the light is **blue shifted** or **red shifted**.

The **red-shift** of a galaxy is the shift to **longer wavelengths** (and lower frequencies) of the **light from** a **galaxy** because it is **moving away** from you.

Speed	The **faster** a distant galaxy is moving away from you, the **greater** its **red-shift** is.
Distance	The **further** away a distant galaxy is, the **greater** its **red-shift** is. Hence the **further away** from the Earth, the **faster** a galaxy is moving.

All the distant galaxies are **moving away** from you because the **universe** is **expanding**. This supports the **big bang theory**.

Section 6: The beginning and future of the Universe (triple)

The **Big Bang theory** was put forward as a model to **explain** the **expansion** of the **universe**. This says that:

- The universe is expanding after **exploding suddenly** (the Big Bang) from a **very small point** and a **extremely hot and dense region**.
- **Space, time and matter** were **created** in the Big Bang.
- The universe has **been expanding ever since** the Big Bang.

The **red shifts** of the **distant galaxies** provide **evidence** that the **universe** is **expanding**.

CMBR	In 1965, Scientists detected **C**osmic **m**icrowave **b**ackground **r**adiation (CMBR) coming from **every direction** in **space**. The existence of CMBR can **only be explained** by the **Big Bang theory**. CMBR was created as **high energy gamma** radiation **just after** the **big bang**. It has been travelling through space since then. As the universe has expanded, the CMBR has stretched out from Gamma into longer wavelengths and is now **microwave** radiation.

Section 6: The beginning and future of the Universe (triple) cont.'

The future of the universe	Will the universe expand forever? Or will the force of gravity between distant galaxies stop them moving away from each other? **The answer depends on** the **density of the universe** which takes into account: • Total **mass** of galaxies • How much **matter** is between them • How much **space** they take up Astronomers know that the galaxies would spin much faster if their stars were the only matter in galaxies. The missing matter is called **dark matter**. Depending on how much dark matter there is, the universe may have different possible futures. • If **density** of the universe **is less** than a particular amount, it **will expand forever** and the **stars will** eventually **die** out (as will everything else) – **the big yawn**. • If **density** of the universe is **greater** than a particular amount, it will **stop expanding** and go **into reverse** – **the big crunch.** Observations that the **distant galaxies are accelerating away** has led astronomers to **conclude** that the **universe is heading** for **the big yawn**. They think that an **unknown** source of **energy** must be **causing this accelerating** motion – **dark energy**. There is still a lot about the universe, for e.g. dark mass and dark energy, that astronomers don't understand. New telescopes and technologies will help improve understanding and will allow astronomers to observe the universe in a different way and make new discoveries.