KNOWLEDGE

Physics Paper 2 Topic 8: Space

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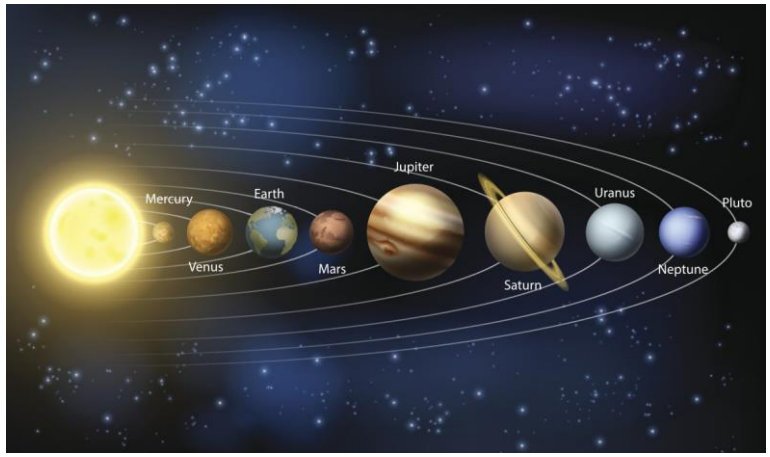
Section 1: Key Terms and Definitions

1.	Star	A self-luminous gaseous spheroidal celestial body of great mass which produces energy by means of nuclear fusion reactions
2.	Sun	The star around which Earth orbits.
3.	Planet	An object that orbits the sun, has enough mass to be round (or nearly round) and is not a satellite of another object and has removed debris and small objects from around its orbit.
4.	Dwarf Planet	An object that doesn't quite meet the criteria for a planet, it hasn't cleared debris from its orbit path. Pluto was degraded from a planet to a dwarf planet in 2006.
5.	Asteroid	A small rocky body orbiting the sun.
6.	Comet	A celestial object consisting of a nucleus of ice and dust and, when near the sun, a 'tail' of gas and dust particles pointing away from the sun.
7.	Natural Satellite	A natural satellite is any celestial body in space that orbits around a larger body. Moons are called natural satellites because they orbit planets.
8.	Artificial Satellite	An artificial satellite is an object that people have made and launched into orbit using rockets.
9.	Galaxy	A system of millions or billions of stars, together with gas and dust, held together by gravitational attraction. Our galaxy is called the Milky Way.
10.	Big Bang	The Big Bang Theory is the leading explanation about how the universe began.
11.	CMBR	Cosmic Microwave Background Radiation, a remnant from the very early stage of the universe which is only explained by the Big Bang Theory.
12.	Nuclear Fusion	A nuclear reaction in which atomic nuclei of low atomic number fuse to form a heavier nucleus with the release of energy

Section 2: Structure of the Solar System

- Our solar system consists of one smallish star (the Sun), eight planets, a few billion asteroids and a few more billion comets.
- Closest to the sun are the four small, rocky planets, Mercury, Venus, Earth and Mars.
- Between Mars and Jupiter is the asteroid belt.
- Beyond the Asteroid Belt are the Gas Giants, Jupiter, Saturn, Uranus and Neptune
- Our Solar System is one of billions within our local galaxy, the Milky Way.



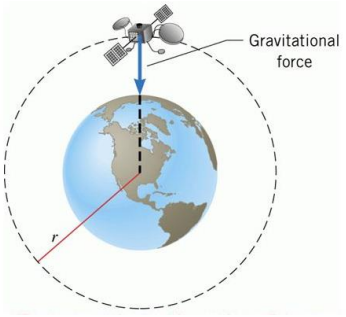
Section 3: Circular Motion of Satellites

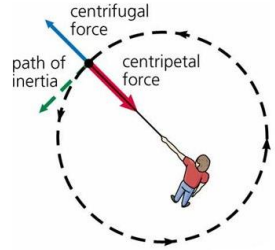
Planets are kept in orbit of the sun due the large gravitational force of the sun. This force exists due to the sun having a huge mass, 330,000 times that of the Earth.

Each planet orbits at a different speed and this is directly related to the planet's distance from the Sun.

Satellites, either natural like Earth's Moon or artificial, orbit at a constant speed and distance in a circular motion.

As velocity is a vector and includes direction, the satellite must be constantly accelerating in order to change direction.





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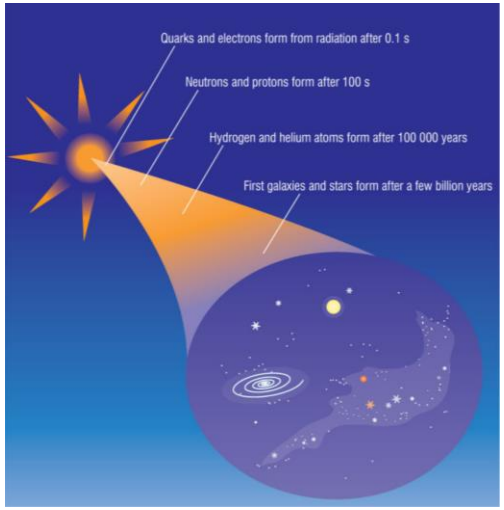
Section 4: Formation of the Universe

- The universe started with the Big Bang, which was a massive explosion from a very small point.
- The universe has been expanding ever since the Big Bang.
- The red-shifts of distant galaxies provide evidence that the universe is expanding.
- In 1965 cosmic microwave background radiation (CMBR) was detected. This is electromagnetic radiation that was created just after the Big Bang. The existence of CMBR can only be explained by the Big Bang Theory.
- Astronomers know that galaxies would spin much faster if their stars were the only matter in galaxies. The missing mass is called dark matter. Depending on how much dark matter there is, the universe may have different possible futures.



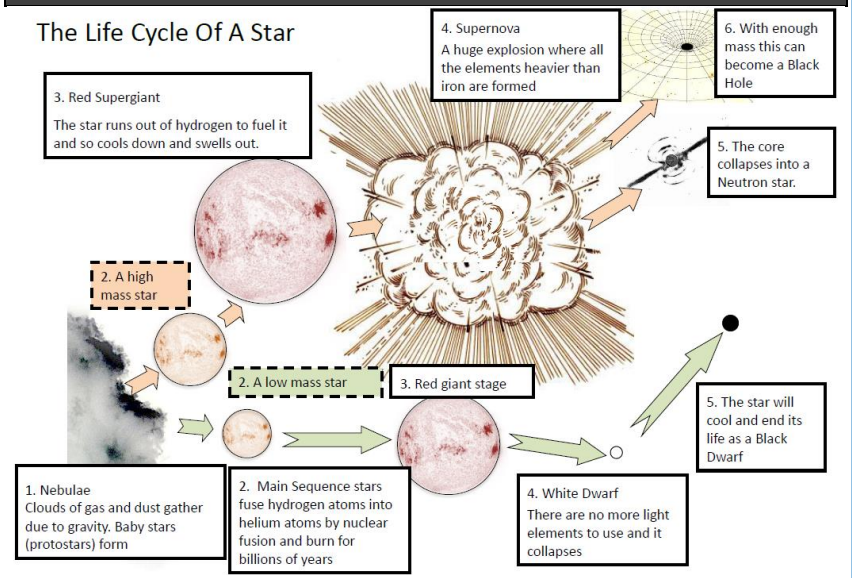
- If the density of the universe is less than a particular amount, it will expand forever and the stars will die out- the Big Yawn.
- If the density is more than a particular amount, it will stop expanding and go into reverse- the Big Crunch.
- Astronomers have observed that distant galaxies are accelerating away from each other – heading for a Big Yawn. They think that an unknown source of energy must be causing this accelerating motion- dark energy.
- In 2016, physicists detected gravitational waves for the first time. This will allow astronomers to observe the universe in a different way and make new discoveries.

Section 6: Formation of Heavy Elements

Nuclear Fusion occurs in all stars, this process takes the hydrogen present in all stars and fuses (joins) the nuclei together to form Helium. As the star begins to run out of Hydrogen, it gets hotter and will begin to fuse Helium together to make heavier elements and so on until Iron is formed. Elements heavier that Iron cannot be formed through Nuclear Fusion.

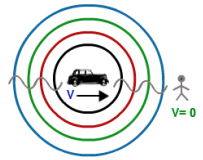
Instead, all elements heavier than Iron are formed during a Supernova, when a massive star explodes in a supernova, the energy released allows elements heavier that iron to be formed and spreads the remaining gas and dust of the star out into space. From the remains of these giant explosions, other stars, such as our sun may be formed, along with planets such as Earth that contain elements heavier than Iron.

Section 5: Lifecycle of a Star

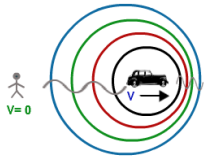


Section 7: Red-Shift and the Doppler Effect

When the source is not moving, each wave from the source is sent out from the same place. As the waves travel, they remain the same distance apart from each other and the wavelength remains constant.



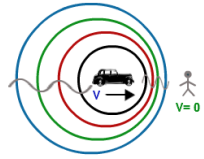
Source at rest



Source in motion

With the source travelling away from the observer, each wave has slightly further to travel to reach them. This has the effect of spreading the waves out and making the wavelength appear longer. The waves are red-shifted.

With the source travelling towards the observer, each wave has slightly less distance to travel to reach the observer, the waves bunch up. This increases the frequency (blue-shifts) the waves for the observer.



Source in motion