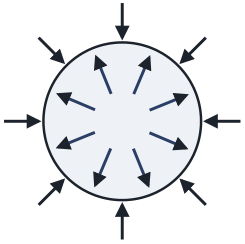
4.8 Space physics

OUR SOLAR SYSTEM

- One star (the Sun), eight planets, dwarf planets (e.g. Pluto) and natural satellites (moons) that orbit planets.
- Our solar system is a small part of the **Milky Way** galaxy.
- The Sun formed from a **nebula** (cloud of dust and gas) pulled together by gravity.

MAIN SEQUENCE STARS



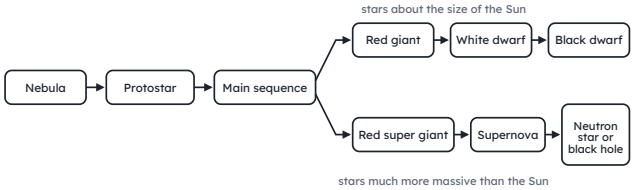
Main sequence star is stable: inward gravity balances the outward force from fusion energy (equilibrium)

- Gravity pulls the nebula together → protostar → hot enough for fusion of hydrogen → main sequence star.
- Stable for billions of years: forces in equilibrium.

WHERE THE ELEMENTS COME FROM

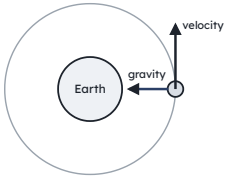
- Fusion in stars produces all the naturally occurring elements up to iron.
- Elements heavier than iron are produced in a **supernova**.
- The supernova explosion distributes the elements throughout the universe.

LIFE CYCLE OF STARS



The life cycle depends on the size (mass) of the star.

ORBITS

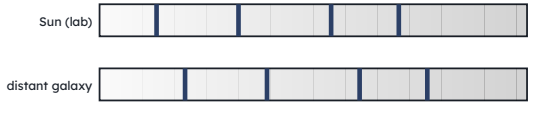


Gravity provides the force towards the centre, so speed stays the same but direction (velocity) changes: the satellite is accelerating (Higher)

Smaller orbit → must move faster to stay in orbit (stable orbit: if speed changes, radius changes)

- Gravity provides the force that keeps planets and satellites (natural and artificial) in orbit.
- (HT) In a circular orbit, gravity changes the velocity but not the speed: the object is accelerating.
- (HT) For a stable orbit, if the speed changes the radius must change: faster → smaller orbit.

RED-SHIFT



Red-shift: lines move to longer wavelengths → galaxy moving away. Further away = bigger red-shift → universe is expanding → evidence for the Big Bang

- **Red-shift:** an observed increase in the wavelength of light from most distant galaxies.
- The further away the galaxy, the faster it is moving away and the bigger the red-shift.

THE BIG BANG

- Red-shift shows the universe is expanding: evidence for the **Big Bang**.
- The universe began from a very small region that was extremely hot and dense.
- Since 1998, observations of supernovae suggest distant galaxies are receding ever faster.
- **Dark mass** and **dark energy** are proposed to explain observations, but are not understood: there is still much to learn.

EXAM TIPS

- The Sun will not become a black hole: it isn't massive enough.
- 'Red-shift' is about wavelength increasing, not the galaxy turning red.
- Use 'equilibrium' or 'balanced' for main sequence stars.

MODEL EXPLANATIONS (GRADE 7+ ANSWERS)

Explain how the elements found on Earth were made.
Fusion in stars joins light nuclei to make heavier elements, up to iron. Elements heavier than iron are made in supernovas, which distribute them through the universe, where they form new stars and planets.

Explain why a satellite in a lower orbit must travel faster. (Higher)
Closer to the Earth, the gravitational force is stronger, so the satellite must move faster to stay in orbit. For a stable orbit, if the speed changes the radius must change; a smaller orbit needs a higher speed.

Explain why scientists accept the Big Bang theory.
It explains why light from most distant galaxies is red-shifted, showing the universe is expanding. Theories are accepted when they explain the evidence; they can be changed if new evidence (e.g. dark energy) is found.

4.8 Space physics

AQA GCSE Physics 8463
Paper 2 · All Physics only · Higher (HT)
All equations are on the Physics Equations Sheet

SEQUENCES TO LEARN

- Sun-sized: nebula → protostar → main sequence → red giant → white dwarf → black dwarf
- Much more massive: nebula → protostar → main sequence → red super giant → supernova → neutron star or black hole
- Evidence chain: red-shift → galaxies receding → expanding universe → Big Bang

KEY WORDS

Nebula: a cloud of dust and gas where stars form.
Main sequence star: a stable star: inward gravity balances the outward force from fusion energy.
Supernova: the explosion of a massive star; produces elements heavier than iron and distributes them through the universe.
Satellite: an object that orbits a larger body; moons are natural, others artificial.
Red-shift: an observed increase in the wavelength of light from most distant galaxies.
Big Bang theory: the universe began from a very small region that was extremely hot and dense.
Dark mass and dark energy: proposed to explain observations; not yet understood.

DATA AND EVIDENCE SKILLS

- Plot speed of recession against distance: a straight line through the origin shows proportionality.
- Evidence → conclusion: red-shift → galaxies moving away → universe expanding → Big Bang.
- Theories change when new evidence appears (e.g. dark energy since 1998).

MISCONCEPTIONS

× **The Sun will become a black hole.**	✓ It isn't massive enough: it becomes a white dwarf, then a black dwarf.
× **Red-shift means the galaxy looks red.**	✓ It means the wavelength of its light has increased.
× **Satellites at constant speed aren't accelerating.**	✓ Their direction changes, so velocity changes: they accelerate (Higher).

AIM FOR GRADE 7+

- Explain the life cycle of a star as a sequence of linked steps.
- Link red-shift to distance and speed, then to an expanding universe.
- Explain why orbiting objects accelerate at constant speed (Higher).

COMMAND WORDS

State	a short answer, no explanation
Describe	say what happens, in order
Explain	say what and why: use "because" and "so"
Calculate	equation, substitution, answer, unit
Evaluate	both sides, then a justified conclusion

QUICK-FIRE QUIZ: COVER THE ANSWERS

Number of planets in our solar system?	**Eight**
Where do stars form?	**Nebula**
Elements made in normal stars?	**Up to iron**
What keeps planets in orbit?	**Gravity**
Evidence universe is expanding?	**Red-shift of distant galaxies**
Unknowns in cosmology?	**Dark mass and dark energy**

PRACTICAL LANGUAGE

Accurate: close to the true value. **Precise:** measurements close to each other. **Repeatable:** same person, same method, similar results. **Reproducible:** similar results by another person or method.
Resolution: smallest change an instrument can show.
Random error: unpredictable scatter; reduce by repeating and averaging. **Systematic error:** every reading out by the same amount, e.g. a **zero error**.

SIX-MARK ANSWERS

- Plan: jot 6 key points first.
- Write in a logical order, using AQA key words.
- Methods: equipment, what you change, what you measure, what you keep the same, repeats, safety.
- Explanations: link each step with "so" or "because".

MATHS SKILLS

- Standard form: $3.2 \times 10^4 = 32\,000$; $5 \times 10^{-3} = 0.005$.
- Give answers to the same number of significant figures as the data (usually 2 or 3).
- Rearrange before substituting; show every step.
- Mean = total ÷ number of readings (leave out anomalies).