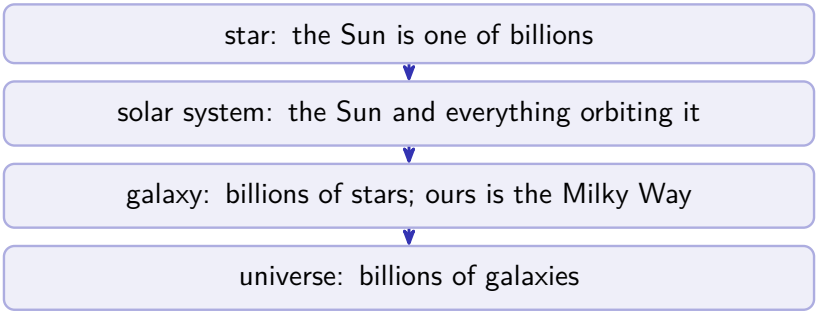
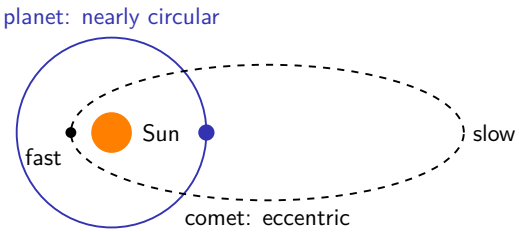
Topic 8: Astrophysics

Edexcel International GCSE Physics 4PH1 · Section 8 · statements 8.1–8.18P · sheets 8.1–8.2

From a star to the universe



Orbits and gravitational field strength



A comet moves fastest near the Sun and slowest far away. g depends on a body's mass and size.

- Planets move in nearly circular orbits.
- Comets move in highly eccentric orbits.

Orbital speed

$$v = \frac{2 \times \pi \times r}{T}$$

r from the centre of the body, in m; T in s

1. **Known** Moon: $r = 3.84 \times 10^8$ m, $T = 27.3$ days.
2. **Seconds** $T = 27.3 \times 24 \times 3600 = 2.36 \times 10^6$ s.
3. **Substitute** $v = 2\pi \times 3.84 \times 10^8 \text{ m}/2.36 \times 10^6 \text{ s} \approx 1.0 \times 10^3$ m/s.
4. **Compare** A satellite at 7000 km, $T = 5800$ s: about 7.6 km/s, much faster.

Your turn: weight on the Moon

Your turn

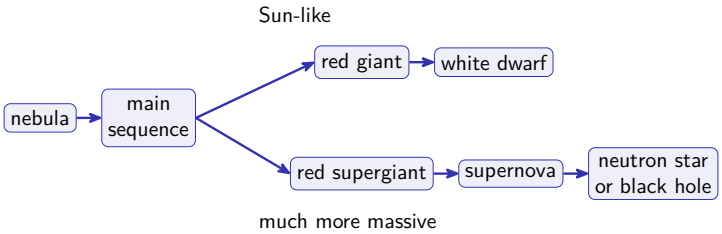
A 70 kg astronaut travels from the Earth ($g = 10$ N/kg) to the Moon ($g = 1.6$ N/kg).

A. Calculate the weight on Earth and on the Moon.

B. What is the astronaut's mass on the Moon?

C. Why is g smaller on the Moon?

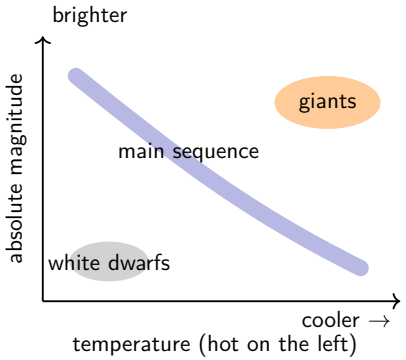
Two life cycles of stars



Sun-like: white dwarf. About 8 or more solar masses: supernova, then neutron star or black hole.

- Mass decides how a star ends.
- Colour shows surface temperature.

(P) The Hertzsprung–Russell diagram



HR diagram: absolute magnitude against temperature; hot stars on the left.

- Absolute magnitude compares stars at a standard distance.
- Main sequence, giants and white dwarfs form bands.

(P) Red-shift



Further galaxies show larger red-shifts, so they are receding faster.

- A receding source stretches the waves.
- Every spectral line moves to a longer wavelength.

(P) Calculating with red-shift

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$$

λ_0 laboratory wavelength; v and c in the same unit

1. **Speed** 500 nm seen at 505 nm: $\Delta\lambda/\lambda_0 = 5/500 = 0.01$, so $v = 0.01c = 3000$ km/s.
2. **Known** Galaxy recedes at 6000 km/s; hydrogen line $\lambda_0 = 656$ nm.
3. **Rearrange** $\Delta\lambda = \lambda_0 \times v/c = 656 \times 6000/300\,000 = 13$ nm.
4. **Observed** $656 + 13 \approx 669$ nm.

(P) Evidence for the Big Bang

Galaxy red-shift

The further the galaxy, the faster it recedes.

The universe is expanding, so it was once hot and dense.

Cosmic microwave background

Faint microwaves arrive from every direction.

They are the cooled remnant of the early universe's radiation.

Six mistakes that cost marks

Mistake	**Correct idea**
r from the surface	Add the planet's radius to the height
T in hours or days	Change to seconds for m/s
Less mass on the Moon	Same mass, smaller weight
(P) Red-shifted galaxies look red	Every line moves; colour hardly changes
(P) Divide by observed λ	Divide by the laboratory λ_0
Every star ends as a black hole	Sun-like stars end as white dwarfs

Check yourself

Your turn

Answer without notes, then check.

A. Satellite at $r = 42\,000$ km with $T = 24$ hours. Orbital speed?

B. Two stages after the main sequence for a Sun-like star?

C. What does a star's colour tell you?

D. (P) A line at 400 nm shifts to 404 nm. Calculate v/c.

E. (P) State the two pieces of evidence for the Big Bang.