A-LEVEL PHYSICS • EXERCISE SHEET

25.1 Standard candles

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

Objective

Build the skills to answer exam questions on **luminosity** and **standard candles**.

You must be able to:

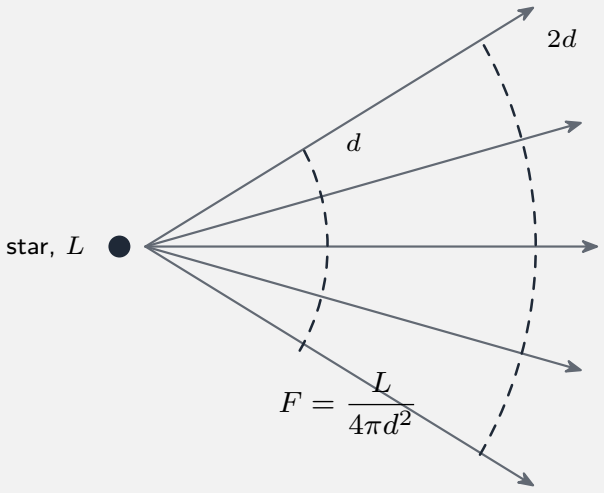
- use **luminosity** and the **inverse-square law** $F = \dfrac{L}{4\pi d^2}$
- explain how **standard candles** give distances

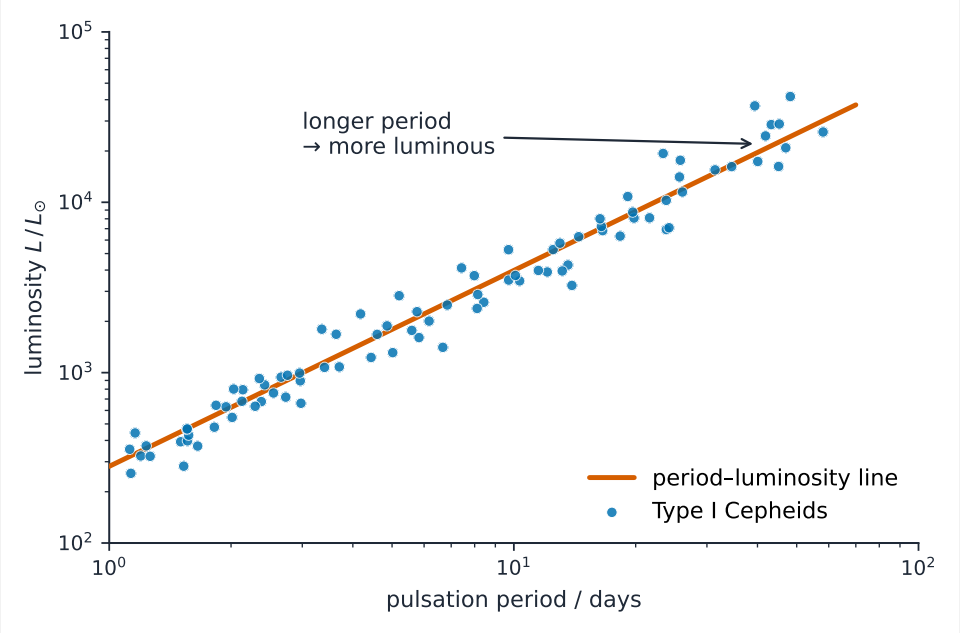
1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Luminosity and flux

The **luminosity** L is the total power a star radiates. At distance d this power is spread over a sphere of area $4\pi d^2$, so the **radiant flux intensity** is:





Cepheids as standard candles

$$F = \frac{L}{4\pi d^2}, \qquad d = \sqrt{\frac{L}{4\pi F}}.$$

A **standard candle** is an object of **known luminosity**; measuring its flux F gives its distance.

Worked example. Sun $L = 3.8 \times 10^{26}$ W, $d = 1.5 \times 10^{11}$ m: $F = \dfrac{3.8 \times 10^{26}}{4\pi(1.5 \times 10^{11})^2} = 1.4 \times 10^{3}$ W m^{-2}.

2 Practice

Now apply the methods above.

2.1 Define the **luminosity** of a star. [1]

2.2 Write the **inverse-square law** for radiant flux intensity. [1]

2.3 The Sun's luminosity is 3.8×10^{26} W. Find the flux at Earth ($d = 1.5 \times 10^{11}$ m). [2]

2.4 State what a **standard candle** is. [1]

3 Exam-style questions

3.1 If the distance to a star **doubles**, the radiant flux intensity becomes: [1]

- **A** twice as large
- **B** half as large
- **C** one quarter as large
- **D** four times as large

3.2 A standard candle has luminosity 4.0×10^{28} W. Its measured flux is 2.0×10^{-9} W m^{-2}. Calculate its **distance**. [3]

3.3 Explain how **standard candles** are used to determine the distance to a galaxy. [3]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **25.1 Standard candles** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/42 M25 —Q10 (luminosity, flux and standard candles)
- 9702/54 J25 —Q2 (planning a standard-candle distance measurement)

Solutions

2.1 The **total power** of radiation emitted by the star (in all directions).

2.2 $F = \dfrac{L}{4\pi d^2}$.

2.3 $F = \dfrac{3.8 \times 10^{26}}{4\pi(1.5 \times 10^{11})^2} = 1.4 \times 10^{3}$ W m^{-2}.

2.4 An object of **known luminosity**.

3.1 **C** —one quarter.

3.2 $d = \sqrt{\dfrac{L}{4\pi F}} = \sqrt{\dfrac{4.0 \times 10^{28}}{4\pi(2.0 \times 10^{-9})}} = 1.3 \times 10^{18}$ m.

3.3 Identify a standard candle (known L) in the galaxy; measure its **flux** F with a telescope; calculate the distance from $d = \sqrt{L/(4\pi F)}$.