

25.1 Standard candles

Name: _____ Class: _____ Date: _____ **Total: 25 marks**

KEY WORDS luminosity 光度 • standard candle 标准烛光 • radiant flux intensity 辐射通量密度
• power 功率 • inverse-square law 平方反比定律

Objective

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

You must be able to:

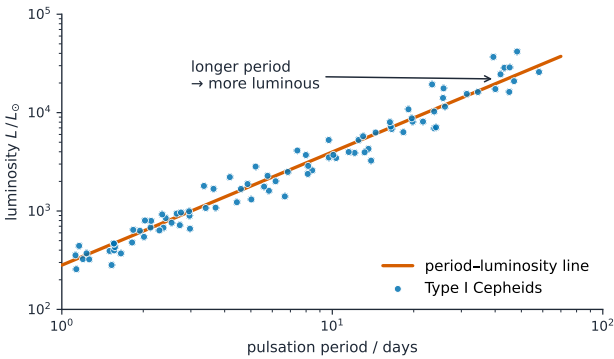
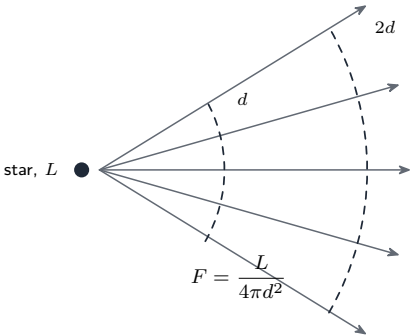
- use **luminosity** and the **inverse-square law** $F = \frac{L}{4\pi d^2}$
- explain how **standard candles** give distances

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:



Cepheid: longer period $\Rightarrow$ brighter • standard candles

Cepheids as standard candles

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

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: $F = \frac{3.8 \times 10^{26}}{4\pi(1.5 \times 10^{11})^2} = 1.4 \times 10^3$ 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 | B |
| C | D |
- 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 An astronomer wants the distance to a galaxy several million light-years away. Explain how a **standard candle** in that galaxy makes this possible, giving the quantity that must be measured, the quantity that must be known in advance, and the assumption the method depends on. [4]

3.4 A star has a luminosity of 6.5×10^{27} W. Its radiant flux intensity measured at the Earth is 2.9×10^{-9} W m⁻².

(a) **Define** the **luminosity** of a star and the **radiant flux intensity** received from it. [2]

(b) **Determine** the distance of the star from the Earth. [3]

(c) The star's surface temperature is 9600 K. Taking $\sigma = 5.67 \times 10^{-8}$ W m⁻² K⁻⁴, **determine** its radius. [3]

(d) A second star at the same distance has the same radius but **half** the surface temperature. **Determine** the flux intensity received from it, as a fraction of that from the first star. [2]

(e) **Suggest** why the flux intensity actually measured at the Earth may be **lower** than the calculation predicts. [2]