25. Astronomy and Cosmology

25.1 Standard candles

Paper 4

Question Paper

1 **(a)** **(i)** State what is meant by the luminosity of a star.

.....

.....

..... [2]

(ii) Explain how a standard candle in a distant galaxy can be used to determine the distance of the galaxy from an observer.

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.....

..... [3]

2 **(b)** Stars in a distant galaxy emit radiation. The total luminosity of the stars in the galaxy is 1.90×10^{36} W.
The emission spectrum of the radiation contains a line X at a wavelength of 658 nm.

Radiation from the galaxy is observed on the Earth. The observed radiation has a radiant flux intensity of 8.42×10^{-16} W m^{-2}. In the observed emission spectrum, line X is at a wavelength of 726 nm.

Determine:

(i) the distance d of the galaxy from the Earth

d = ... m [2]

3 The Sun may be considered as a uniform sphere with a mass of 1.99×10^{30} kg and a surface temperature of 5780 K.

A probe with a mass of 2.63 kg moves in a straight line towards the Sun.
When it is at a distance x from the centre of the Sun, the probe measures the gravitational field strength g due to the Sun and the radiant flux intensity F of radiation from the Sun.

(c) (i) Show that, for any particular value of x, the numerical values of g and F are related by

$$g = \frac{4\pi GM}{L} F$$

where M is the mass of the Sun, L is the luminosity of the Sun and G is the gravitational constant.

[3]

(ii) Fig. 2.1 shows the variation of g with F.

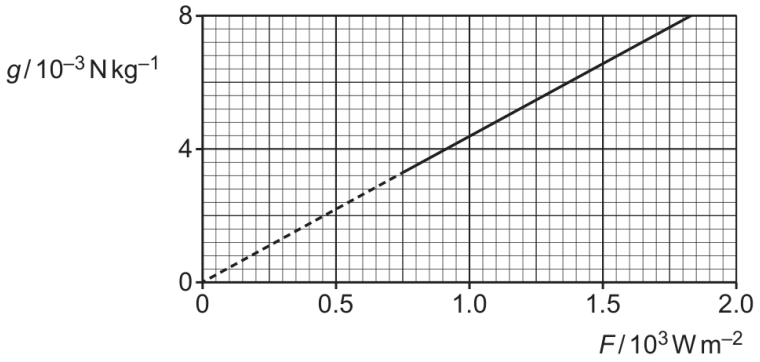


Fig. 2.1

Determine a value for the luminosity L of the Sun. Give a unit with your answer.

L = ... unit ..... [2]

4 **(b)** A star of luminosity 3.8×10^{31} W is a distance of 1.8×10^{24} m from the Earth.

Calculate the radiant flux intensity at the Earth of the radiation emitted by the star.

radiant flux intensity = ... $W\,m^{-2}$ [2]

5 **(c)** The radiant flux intensity of the radiation from the star in **(b)** is $2.52 \times 10^{-8}\,\text{W m}^{-2}$ when observed at a distance of $4.16 \times 10^{16}\,\text{m}$ from the star.

(i) Calculate the luminosity of the star. Give a unit with your answer.

luminosity = ... unit ..... [2]

6 **(b)** A cosmology student observes the electromagnetic radiation received from a star in a galaxy. The student uses Wien's law to estimate the surface temperature of the star, a standard candle to estimate the distance to the galaxy, and the Stefan–Boltzmann law to estimate the radius of the star.

The student observes that the radiation from the star is redshifted.

(i) State what is meant by a standard candle.

..... [1]

7 **(a)** State what is meant by the luminosity of a star.

..... [1]

(b) A star in the constellation Canis Major is a distance of 8.14×10^{16} m from the Earth and has a luminosity of 9.86×10^{27} W. The surface temperature of the star is 9830 K.

(i) Calculate the radiant flux intensity of the radiation from the star observed from the Earth. Give a unit with your answer.

radiant flux intensity = ... unit ..... [2]