

Questions

Q1.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Which of the following is a valid unit for luminosity?

- ☐ **A** W m^{-2}
- ☐ **B** N m s^{-2}
- ☐ **C** J s^{-1}
- ☐ **D** J m^{-2}

(Total for question = 1 mark)

Q2.

A correct unit for radiant energy flux is

- ☐ **A** $\text{N m}^{-1} \text{s}^{-1}$
- ☐ **B** Nm^{-1}
- ☐ **C** W
- ☐ **D** W m^2

(Total for question = 1 mark)

Q3.

Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

X and Y are identical stars. When viewed from Earth the intensity of star X is four times the intensity of star Y.

Which of the following explanations is possible?

- ☐ **A** X is twice as far away as Y.
- ☐ **B** X is four times as far away as Y.
- ☐ **C** Y is twice as far away as X.
- ☐ **D** Y is four times as far away as X.

(Total for question = 1 mark)

Q4.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

There are several different methods that can be used to determine the distance from our solar system to astronomical objects. These include the measurement of red shift, trigonometrical parallax and the use of standard candles.

Which row of the table shows a suitable method for each of the objects named?

	Nearby star	Nearby galaxy	Very distant galaxy
☐ A	parallax	red shift	standard candle
☐ B	red shift	standard candle	parallax
☐ C	parallax	standard candle	red shift
☐ D	red shift	parallax	standard candle

(Total for question = 1 mark)

Q5.

Standard candles are used by astronomers to determine the distances to distant star clusters.

A standard candle has a

- ☐ **A** constant brightness.
- ☐ **B** constant luminosity.
- ☐ **C** known brightness.
- ☐ **D** known luminosity.

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Two stars, P and Q, are observed from Earth. The intensity of radiation from P is less than that from Q. The parallax angle for P is greater than that for Q.

Which row of the table is correct?

	Distance from Earth	Comparison of luminosities
☐ A	P is closer than Q	luminosity of P is greater than Q
☐ B	P is closer than Q	luminosity of P is less than Q
☐ C	P is further away than Q	luminosity of P is greater than Q
☐ D	P is further away than Q	luminosity of P is less than Q

(Total for question = 1 mark)

Q7.

A converging lens can be used to produce a real image on a screen.

A magazine article includes the statement:

If the distance from the lens to the screen is doubled, the brightness of the image is halved.

Assess the validity of this statement.

(2)

(Total for question = 2 marks)

Q8.

Astronomers observing stars at the centre of our galaxy have suggested that many of them are orbiting a supermassive black hole. The mass of this black hole is 9.2×10^{36} kg.

Trigonometric parallax and Hubble's law are two methods used to determine astronomical distances.

Explain whether either of these methods is suitable to determine the distance to S0-2.

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(Total for question = 3 marks)

Q9.

In 2016 the Breakthrough Starshot initiative was announced. This project intends to send a fleet of small probes to Proxima Centauri, the nearest star to the Sun. This journey would take about twenty years.

Describe how the distance to nearby stars like Proxima Centauri is determined.

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(Total for question = 3 marks)

Q10.

Solar panels consisting of combinations of photovoltaic cells use energy in the radiation received from the Sun to generate electricity.

An advertisement for solar panels claims that the intensity of radiation from the Sun incident at the top of the Earth's atmosphere is more than 2 kW m^{-2} .

Assess the validity of this claim.

radius of Sun = 6.96×10^8 m

surface temperature of Sun = 5790 K

distance from Sun to Earth = 1.50×10^{11} m

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(Total for question = 4 marks)

Q11.

* Cepheid variable stars have long been seen as examples of standard candles. Recent measurements have indicated that the movement of the star through the interstellar material might result in the formation of a layer of dust around the star. This affects how bright the star appears.

Explain how standard candles are used in astronomy, and suggest how the existence of a layer of dust around a Cepheid variable star might affect the conclusions drawn by astronomers.

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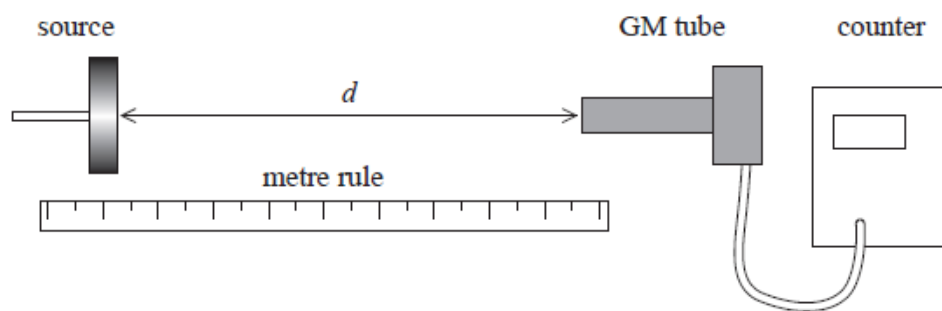
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(Total for question = 6 marks)

Q12.

A student investigated the way in which gamma radiation spreads out from a source. He placed a cobalt-60 source in a source holder and set up a Geiger-Müller (GM) tube a short distance d away. He connected the GM tube to a counter as shown.



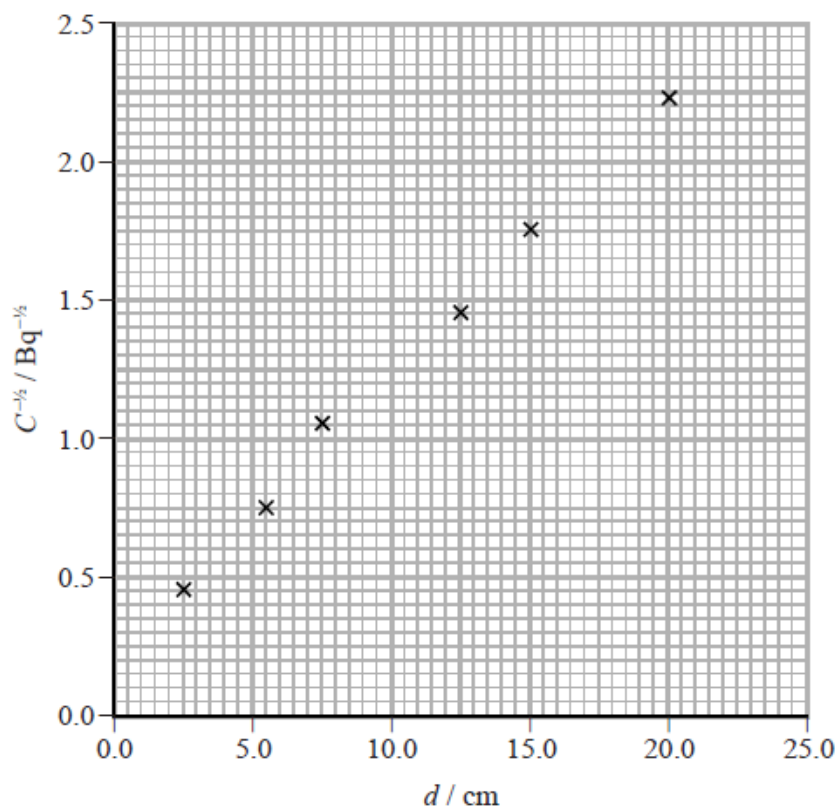
The student recorded the count for 2 minutes.

The variation in the intensity of gamma radiation with distance from a point source should obey an inverse square law. If this is the case, then the count rate C should vary with d according to the equation

$$C = \frac{K}{4\pi d^2}$$

where K is a constant.

The student plotted $\frac{1}{\sqrt{C}}$ against d and obtained the following graph.



(i) Draw a line of best fit on the graph.

(1)

(ii) The student concluded that the graph was consistent with the gamma radiation intensity obeying an inverse square law.

Discuss the extent to which the data obtained supports the student's conclusion.

(4)

[illegible]

(Total for question = 5 marks)

Q13.

Rigel A in the constellation of Orion is one of the brightest stars in the sky. It is a massive blue variable star with an intensity peak at a wavelength λ_{max} of $0.25 \mu\text{m}$.

RR Lyrae stars are also variable stars. They are used by astronomers as standard candles, although none of them are close enough for trigonometric parallax to be useful.

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

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*(ii) Describe how astronomers use standard candles.

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(iii) Explain why stars have to be within a certain distance from the Earth for trigonometric parallax to be useful.

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(Total for question = 12 marks)

Q14.

In 2016 the Breakthrough Starshot initiative was announced. This project intends to send a fleet of small probes to Proxima Centauri, the nearest star to the Sun. This journey would take about twenty years.

The radiation intensity at Earth from Proxima Centauri is $3.25 \times 10^{-11} \text{ W m}^{-2}$. The luminosity of the Sun is $L_{\odot}$.

(i) Show that the luminosity of Proxima Centauri is about $0.002 L_{\odot}$.

(3)

distance to Proxima Centauri = $4.00 \times 10^{16} \text{ m}$
 $L_{\odot} = 3.85 \times 10^{26} \text{ W}$

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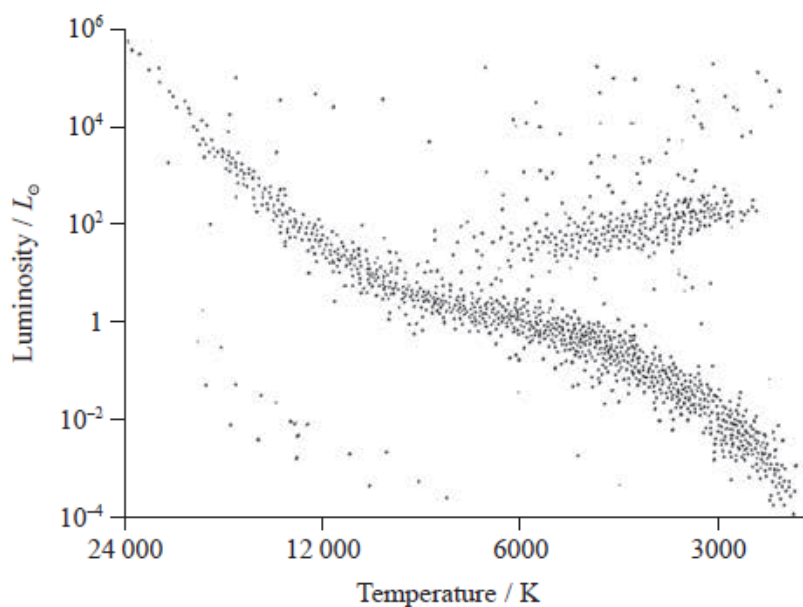
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(ii) Proxima Centauri is described on a website as a main sequence star.

Determine whether the surface temperature of Proxima Centauri is consistent with a position on the main sequence of the Hertzsprung-Russell diagram.

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radius of Proxima Centauri = $9.81 \times 10^7 \text{ m}$



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(Total for question = 3 marks)

Q15. * Parallax measurements are used to determine the distance to nearby stars, but this method is unsuitable for more distant objects.

Outline how parallax measurements are used to determine the distance to nearby stars and explain how the use of a standard candle enables the distance to more distant objects to be determined.

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(Total for Question = 6 marks)

Q16.

The distance to astronomical objects relatively close to the Sun is determined using trigonometric parallax. For objects beyond a certain distance standard candles are used.

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

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(b) Explain why trigonometric parallax is not used beyond a certain distance.

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(c) Describe how distances too large for the use of standard candles can be determined.

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(Total for question = 6 marks)

Q17.

According to astronomers in Denmark and Australia a common type of active galactic nucleus (AGN) could be used as an accurate "standard candle" for measuring cosmic distances. The technique has been used to measure distances corresponding to redshifts significantly larger than was previously possible.

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

(1)

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(ii) Explain how a standard candle is used to measure cosmic distances.

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(b) (i) State what is meant by redshift.

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(ii) Calculate the distance to a galaxy with a redshift $z = 0.12$

$H_0 = 2.1 \times 10^{-18} \text{ s}^{-1}$

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Distance to galaxy =

*(c) Discuss how astronomers were led to propose the existence of dark matter and the consequences of its existence for the ultimate fate of the universe.

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(d) Explain why the observable universe has a finite size.

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(Total for Question = 11 marks)

Q18.

Almost a century ago Edwin Hubble was investigating the light spectra emitted from a large number of galaxies. He used redshift values obtained from these spectra to determine the velocity of the galaxies relative to the Earth. He also measured the distances to each galaxy using Cepheid variable stars, which are a type of standard candle. From these measurements Hubble was able to formulate a law linking the velocity of distant galaxies to their distance from the Earth.

(a) (i) Explain what is meant by redshift.

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*(ii) Explain how redshift can be used to determine the velocity of a galaxy relative to the Earth.

(3)

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

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(c) Explain how Hubble's law can be used to find a value for the age of the universe.

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(d) Hubble's law is seen as one piece of evidence supporting the Big Bang theory of the origin of the universe. In this theory the universe has been expanding ever since it was created 14 billion years ago.

(i) Describe how you would expect the average density of matter in the universe to affect its ultimate fate.

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(ii) It is difficult for scientists to estimate the average density of the universe reliably. Explain why.

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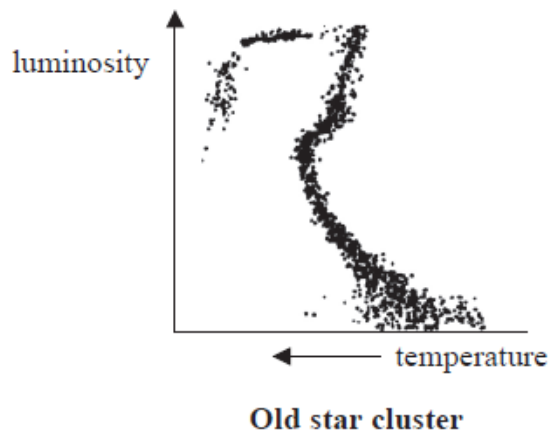
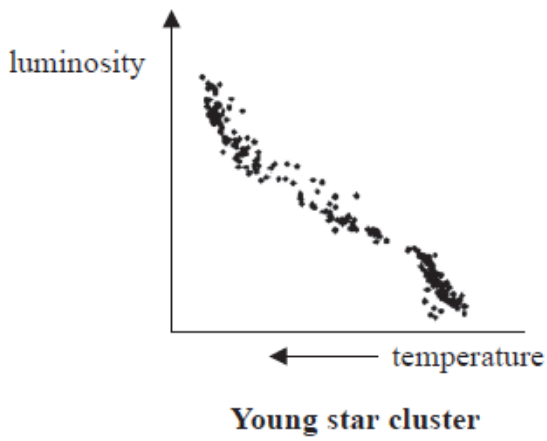
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(Total for question = 13 marks)

Q19.

(a) The Herzsprung-Russell (H-R) diagram is one of the most important tools in the study of stellar evolution.

The H-R diagrams below are for a young star cluster and an old star cluster.



Use the diagrams to describe and explain how the old star cluster is different from the young star cluster.

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(b) Trigonometric parallax is one way in which stellar distances can be measured.

Astronomers measure the parallax angle for two nearby stars. The parallax angle for star A is 3.74×10^{-6} rad and that for star B is 1.84×10^{-7} rad.

(i) Without calculation, state what can be deduced from this data about the relative distances of the two stars.

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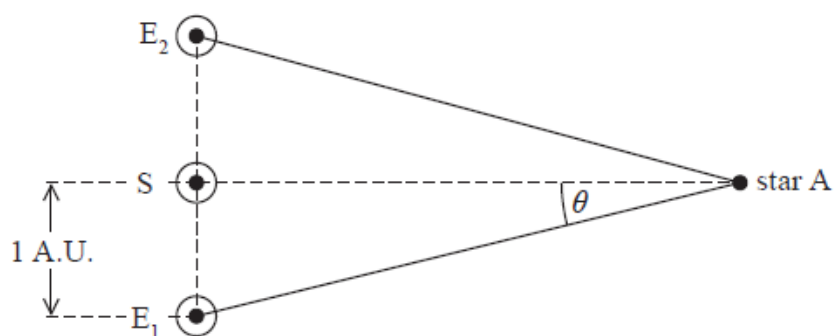
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(ii) The diagram shows the parallax angle for star A.

Calculate the distance of star A from the Earth.

1 A.U. is 1.50×10^{11} m

(2)

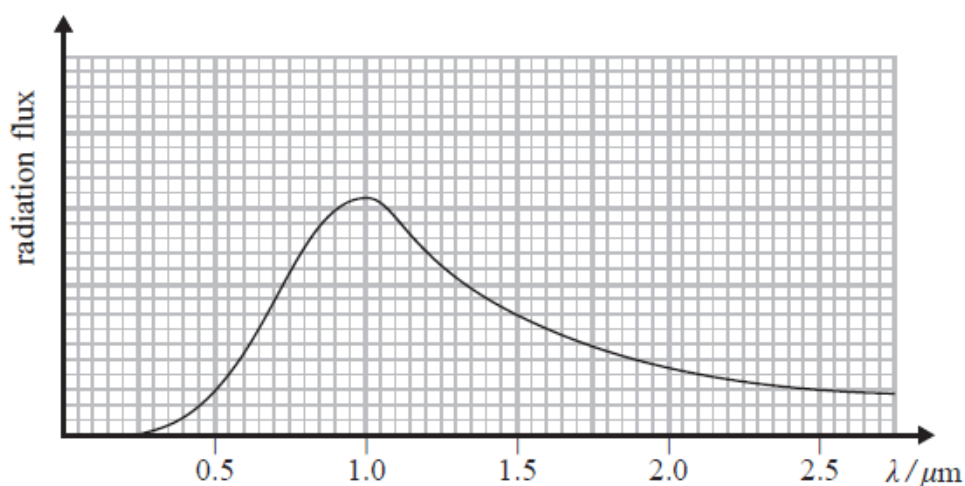


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Distance =

(c) In addition to finding the distances to stars astronomers are interested in determining the temperatures of stars.

The spectrum of star A is shown below.



Use data from the graph to determine the surface temperature of star A.

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Temperature =

(Total for question = 12 marks)