

A



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I declare this is my own work.

A-level

PHYSICS

Paper 3

Section B Astrophysics

7408/3BA

Thursday 15 June 2023

Morning

At the top of the page, write your surname and forename(s), your centre number, your candidate number and add your signature.

[Turn over]



J U N 2 3 7 4 0 8 3 B A 0 1

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Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

MATERIALS

For this paper you must have:

- **a pencil and a ruler**
- **a scientific calculator**
- **a Data and Formulae Booklet**
- **a protractor.**

[Turn over]



INSTRUCTIONS

- **Use black ink or black ball-point pen.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do not write on blank pages.**
- **If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).**
- **Do all rough work in this book. Cross through any work you do not want to be marked.**
- **Show all your working.**



INFORMATION

- **The marks for questions are shown in brackets.**
- **The maximum mark for this paper is 35.**
- **You are expected to use a scientific calculator where appropriate.**
- **A Data and Formulae Booklet is provided as a loose insert.**

DO NOT TURN OVER UNTIL TOLD TO DO SO



SECTION B

Answer ALL questions in this section.

0 1 . 1

Draw a labelled diagram to define the parsec (pc). [1 mark]



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[Turn over]



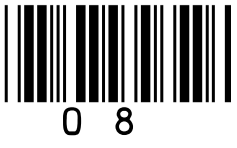
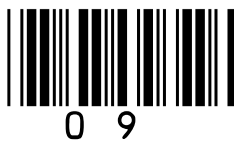


TABLE 1 shows data for two stars: Rigel and the Sun.

TABLE 1

STAR	SURFACE TEMPERATURE / K	ABSOLUTE MAGNITUDE	MASS / kg
Rigel	12 000	-7.84	3.6×10^{31}
Sun	5700	4.83	2.0×10^{30}



0 1 . 2

State the spectral class of Rigel. [1 mark]

[Turn over]

0	1	.	3
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The apparent magnitude of Rigel is 0.11

Calculate, in pc, the distance from Rigel to the Earth. [2 marks]

distance = _____ pc



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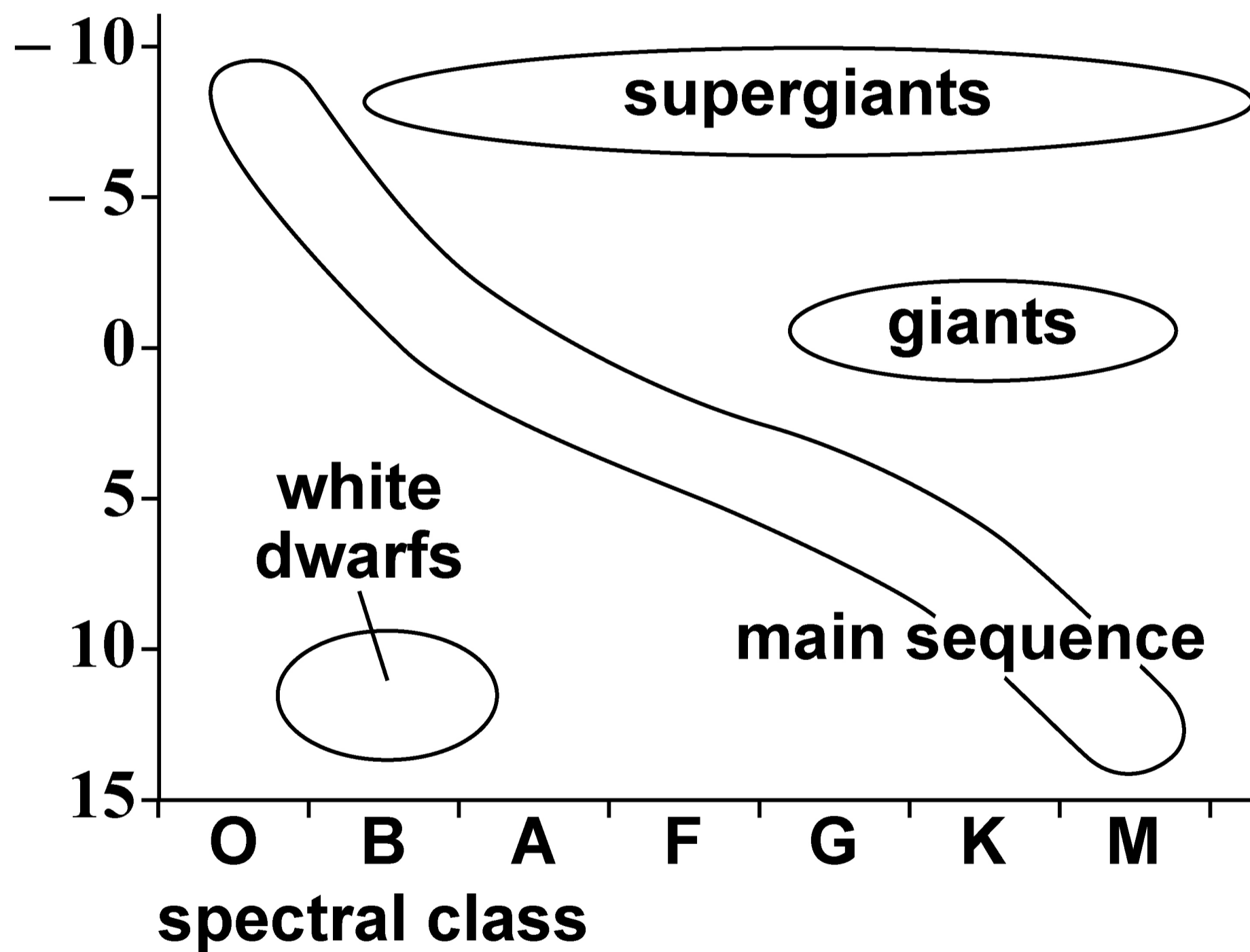


01.4

FIGURE 1 shows a Hertzsprung–Russell (HR) diagram.

FIGURE 1

absolute magnitude



Draw a line on FIGURE 1 to show the evolution of the Sun from formation to white dwarf. [1 mark]

0 1 . 5

One stage in the evolution of Rigel includes the emission of a gamma ray burst.

Outline the circumstances during which a gamma ray burst will be emitted by Rigel. [2 marks]

[Turn over]



7

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02.1

State what is meant by normal adjustment when applied to an astronomical refracting telescope.

[1 mark]

[Turn over]



0 2 . 2

Which combination of lenses gives the largest angular magnification when used as an astronomical telescope in normal adjustment?

Tick (✓) ONE box, on the opposite page. [1 mark]



OBJECTIVE LENS		EYEPIECE LENS	
Focal length / cm	Type	Focal length / cm	Type
<input type="checkbox"/> 5	diverging	100	converging
<input type="checkbox"/> 5	converging	100	converging
<input type="checkbox"/> 100	diverging	5	converging
<input type="checkbox"/> 100	converging	5	converging

[Turn over]

V1031 and WASP-82 are two stars in the constellation Orion.

V1031 appears 40 times brighter than WASP-82 when viewed from Earth.

The apparent magnitude of V1031 is 6.0

0 2 . 3

Calculate the apparent magnitude of WASP-82. [2 marks]



apparent magnitude = _____

[Turn over]



0 2 . 4

V1031 is just visible to the naked eye of an astronomer when her pupil diameter is 7 mm.

Suggest whether she can observe WASP-82 using a telescope with an objective diameter of 60 mm.

**Support your answer with a calculation.
[2 marks]**



[Turn over]



02.5

CCDs are often connected to telescopes.

Explain TWO reasons why this improves the ability of astronomers to observe dim stars. [3 marks]

1 _____

2 _____



03.1

State the defining property of a black hole. [1 mark]

[Turn over]



03.2

In 2019, astronomers linked several radio telescopes to produce a single telescope called the EHT. The resolution of the EHT is the same as the resolution that a telescope with an aperture equal to the diameter of the Earth could achieve.

TABLE 2 shows data about the EHT and the Hubble telescope.

TABLE 2

	APERTURE	OPERATING WAVELENGTH
EHT	1.3×10^7 m	1.3 mm
Hubble	2.4 m	410 nm



Galaxy M87 is 5.3×10^7 light years from Earth. The supermassive black hole at the centre of M87 has a mass 6.5×10^9 times the mass of the Sun.

The radius of the event horizon is R .

The astronomers propose to use either the EHT or the Hubble telescope to observe stars whose distance from the centre of the black hole is less than $1000R$.

[Turn over]



Discuss, with calculations, which telescope is more suitable for this observation. [4 marks]



03.3

A star is orbiting the black hole in M87. The star is observed in the plane of its orbit.

The wavelength of a spectral line observed in the light emitted from the star varies between a maximum and a minimum value.

maximum value observed = 374.96 nm

minimum value observed = 373.53 nm

**Calculate the orbital speed of the star.
[3 marks]**



orbital speed = _____ m s^{-1}

[Turn over]

8





0	4
---	---

M40 A and M40 B are two stars that appear very close to each other when viewed from Earth.

There are two possible reasons for this:

- they are an orbiting binary system**
- they are distant from each other and only appear in the same line of sight.**

30

In an orbiting binary system, the difference between the apparent magnitude and the absolute magnitude for each star is similar.



TABLE 3 shows data about these two stars.

TABLE 3

	TEMPERATURE/ K	RADIUS OF STAR / m	APPARENT MAGNITUDE
M40 A	6000	6.3×10^9	9.7
M40 B	4700	1.1×10^{10}	10.1

[Turn over]



Discuss the appearance of the two stars to an astronomer on the Earth.

In your answer you should:

- **compare the colour of the stars**
- **compare the brightness of the stars**
- **deduce, with a calculation, whether the stars form an orbiting binary system. [6 marks]**

[Turn over]



Vertical lines for writing.



[Turn over]

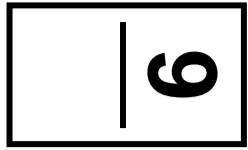


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3 7

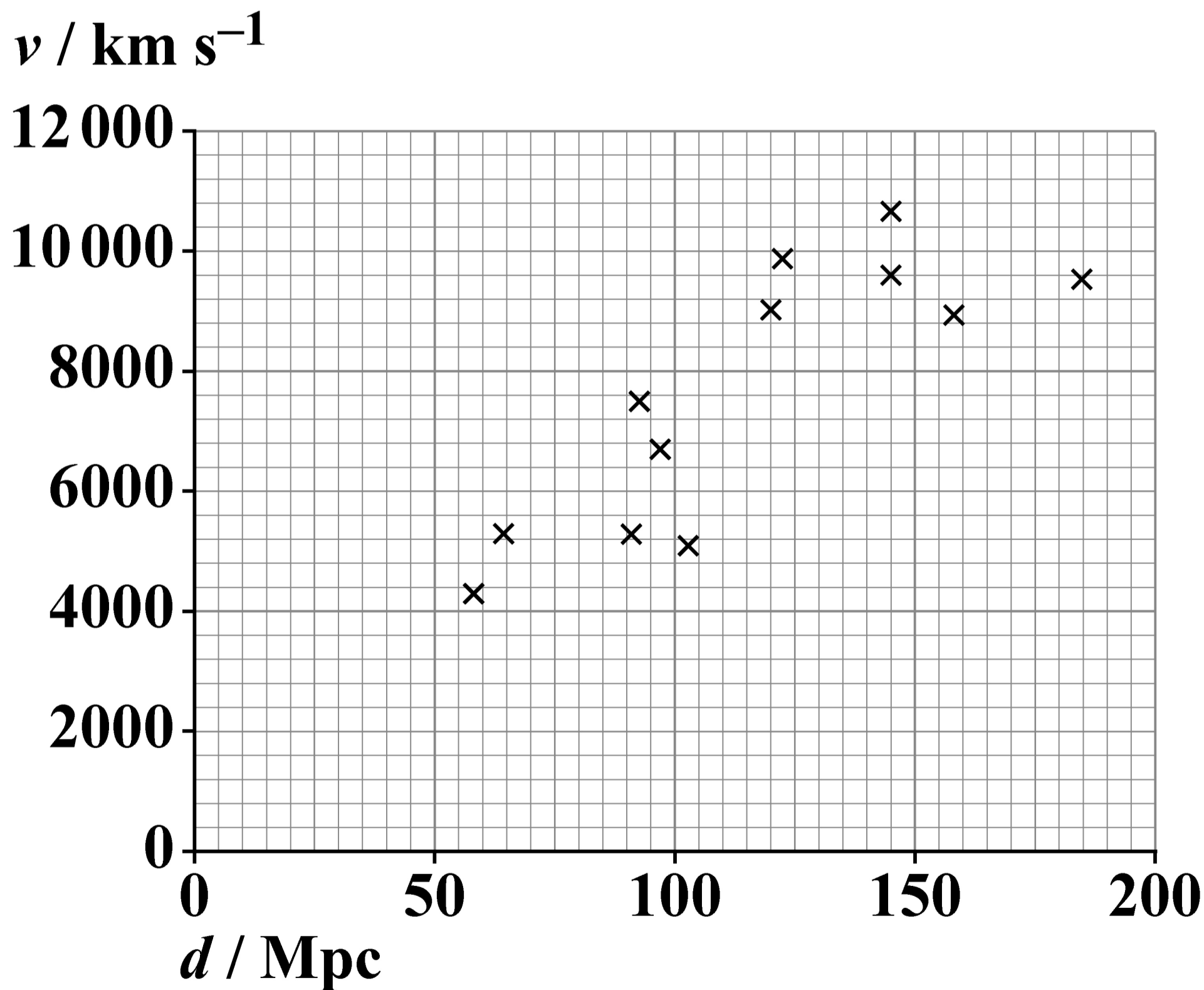


[Turn over]

05

FIGURE 2 shows, for some galaxies, how their recession speed v varies with distance d from the Earth.

FIGURE 2



0	5	.	1
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Estimate, using FIGURE 2, the age in seconds of the Universe. [3 marks]

age of Universe = _____ s

[Turn over]



05.2

The estimate in Question 05.1 assumes that the Universe has expanded at a constant rate. Measurements involving type 1a supernovae that are at large distances from Earth caused astronomers to make a modification to this assumption.

State:

- the modification**
- the explanation that was proposed to account for this modification.**

[2 marks]



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Question	Mark
1	
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4	
5	
TOTAL	

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