Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
Level 1/Level 2 GCSE (9–1)

Centre Number | | | | | |

Candidate Number | | | | |

Monday 8 June 2020

Afternoon (Time: 1 hour 45 minutes) | Paper Reference **1AS0/02**

Astronomy

Paper 2: Telescopic Astronomy

You must have:
Formulae and Data Sheet (enclosed)
Calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- Calculators may be used.
- Any diagrams may NOT be accurately drawn, unless otherwise indicated.
- You must show **all your working out** with **your answer clearly identified** at the **end of your solution**.

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

Formulae and Data Sheet

Formulae

Equation of Time = Apparent Solar Time (AST) – Mean Solar Time (MST)	
Kepler's 3rd law:	$\frac{T^2}{r^3}$ = a constant
Magnification of telescope:	magnification = $\frac{f_o}{f_e}$
Distance modulus formula:	$M = m + 5 - 5\log d$
Redshift formula:	$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$
Hubble's law:	$v = H_0 d$

Data

Mass of Earth	6.0×10^{24} kg
Mean diameter of Earth	13 000 km
Mean diameter of Moon	3500 km
Mean diameter of Sun	1.4×10^{6} km
One Astronomical Unit (AU)	1.5×10^{8} km
Mean Earth to Moon distance	380 000 km
One light year (l.y.)	9.5×10^{12} km
One parsec (pc)	3.1×10^{13} km = 3.26 l.y.
Sidereal day of Earth	23 h 56 min
Synodic day of Earth	24 h 00 min
Temperature of solar photosphere	5800 K
Hubble Constant	68 km/s/Mpc
Speed of light in vacuum	3.0×10^{8} m/s

Name	Type of body	Mean distance from Sun/AU	Sidereal period/Earth year	Mean temperature /°C	Diameter /1000 km	Mass/ Earth mass	Ring system	Moons
Mercury	planet	0.38	0.24	170	4.9	0.055	no	none
Venus	planet	0.72	0.62	470	12.1	0.82	no	none
Earth	planet	1.0	1.0	15	12.8	1.00	no	1: the Moon
Mars	planet	1.5	1.9	–50	6.9	0.11	no	2 small moons: Deimos and Phobos
Ceres	dwarf planet	2.8	4.6	–105	0.95	1.5×10^{-4}	no	none
Jupiter	planet	5.2	11.9	–150	143	318	yes	4 major moons: Ganymede, Callisto, Europa, Io >60 others
Saturn	planet	9.5	29.5	–180	121	95	yes	5 major moons: including Titan, Iapetus >55 others
Uranus	planet	19.1	84.0	–210	51	15	yes	5 major moons: including Titania, Oberon >20 others
Neptune	planet	30.0	165	–220	50	17	yes	1 major moon: Triton >12 others
Pluto	dwarf planet	39.5	248	–230	2.4	2.2×10^{-3}	no	1 major moon: Charon >4 other moons
Haumea	dwarf planet	43.1	283	–241	1.4	6.7×10^{-4}	no	2
Eris	dwarf planet	67.8	557	–230	2.3	2.8×10^{-3}	no	at least 1

Answer ALL questions. Write your answers in the spaces provided.

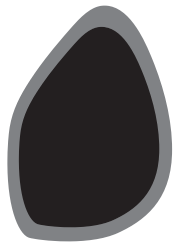
Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A student used a small telescope to make some sketches of astronomical objects.

(a) Identify each of the following objects from the student's sketches.

(i) A dark patch on the surface of the Sun, with a darker centre.

(1)



☒ **A** solar cycle

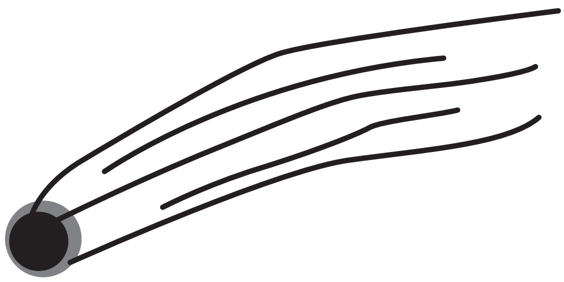
☒ **B** solar flare

☒ **C** solar wind

☒ **D** sunspot

(ii) A fuzzy patch of light with a tail, visible in the sky for several weeks.

(1)



☒ **A** asteroid

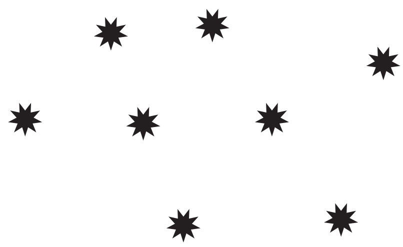
☒ **B** comet

☒ **C** meteor

☒ **D** planet

(iii) A small group of several bright stars.

(1)



☒ **A** binary star

☒ **B** constellation

☒ **C** globular cluster

☒ **D** open cluster

(b) A student writes a description of how some astronomical objects appear when viewed through a small telescope.

Identify each object from its description.

(i) 'A planet with bright rings around it.'

(1)

☒ **A** Mars

☒ **B** Mercury

☒ **C** Neptune

☒ **D** Saturn

(ii) 'A star with a fuzzy ring of material around it.'

(1)

☒ **A** black hole

☒ **B** double star

☒ **C** globular cluster

☒ **D** planetary nebula

(c) Sketch the appearance of a crater on the Moon, when viewed through a pair of binoculars.

(1)

(Total for Question 1 = 6 marks)

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2 (a) Identify each of the following planets from the description provided.

(i) The smallest planet in the Solar System.

(1)

☒ **A** Jupiter

☒ **B** Mercury

☒ **C** Uranus

☒ **D** Venus

(ii) The planet with the highest average surface temperature.

(1)

☒ **A** Jupiter

☒ **B** Mercury

☒ **C** Uranus

☒ **D** Venus

(iii) The first planet to be discovered with a telescope.

(1)

☒ **A** Jupiter

☒ **B** Mercury

☒ **C** Uranus

☒ **D** Venus

(iv) The first planet to have some of its satellites discovered with a telescope.

(1)

☒ **A** Jupiter

☒ **B** Mercury

☒ **C** Uranus

☒ **D** Venus

(b) The list below shows four series of stages in the life of a star.

(i) Which is the correct series for a star with a mass similar to the Sun's?

(1)

☒ **A** main sequence – neutron star – red giant

☒ **B** main sequence – red giant – supernova

☒ **C** main sequence – red giant – white dwarf

☒ **D** main sequence – white dwarf – black hole

(ii) Which is the correct series for a star with a mass twenty times that of the Sun?

(1)

☒ **A** main sequence – neutron star – red giant

☒ **B** main sequence – red giant – supernova

☒ **C** main sequence – red giant – white dwarf

☒ **D** main sequence – white dwarf – black hole

(Total for Question 2 = 6 marks)

3 Figure 1 shows a telescope.

Figure 1

(a) This telescope is a: **(1)**

☒ **A** Cassegrain reflector

☒ **B** Galilean refractor

☒ **C** Keplerian refractor

☒ **D** Newtonian reflector

(b) Identify each of the following parts of the telescope.

(i) The part labelled **X** in Figure 1 is the: **(1)**

☒ **A** eyepiece lens

☒ **B** finder scope

☒ **C** objective mirror

☒ **D** secondary mirror

(ii) The part labelled **Y** in Figure 1 is the: **(1)**

☒ **A** eyepiece lens

☒ **B** finder scope

☒ **C** objective mirror

☒ **D** secondary mirror

(c) Owen wishes to use this telescope to observe the planet Jupiter.

He wants to obtain a view similar to the one shown in Figure 2.

Figure 2

The telescope in Figure 1 has an aperture of 25 cm and a focal length of 200 cm.

Explain **why** Owen has chosen to use:

(i) a telescope with an aperture of 25 cm

(2)

(ii) a telescope with a focal length of 200 cm

(2)

(iii) Owen has a range of eyepieces available for the telescope in Figure 1.

Suggest a suitable focal length for the eyepiece in order to obtain the view in Figure 2 and give a reason for your answer.

(2)

Focal length = mm

(Total for Question 3 = 9 marks)

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4 In 1609 the astronomer Galileo Galilei made drawings of the planet Venus, using a small telescope. These drawings are shown in Figure 3.

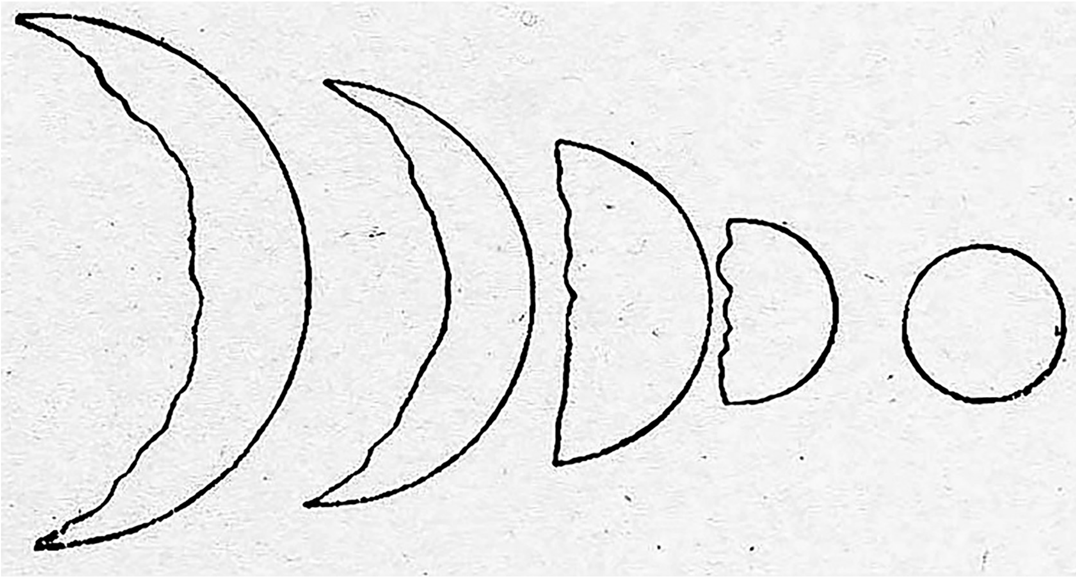

Figure 3

The drawings show how Venus appears to change its appearance, for an observer on the Earth.

(a) The drawings in Figure 3 help to prove that Venus cannot be orbiting the Earth. Explain how they do this.

You may include a carefully labelled diagram in your answer.

(2)

(b) Ancient Babylonian descriptions of Venus from around 4000 BCE sometimes refer to it as having ‘horns’.

It has been suggested that this may mean that some ancient Babylonian astronomers were able to see the changing shape of Venus.

Figure 4 contains some data about the visibility of the planet Venus.

Phase of Venus	Angular diameter (°)
Full	0.0026 – 0.0027
Crescent	0.016 – 0.018

Observing instrument	Angular resolution (°)
Average human eye	0.017
Early Galilean telescope	0.0006

Figure 4

Evaluate the suggestion that ancient astronomers were able to observe the changing shape of Venus.

Use the data in Figure 4.

(3)

(c) Figure 5 shows the transit of Venus that took place in June 2004.

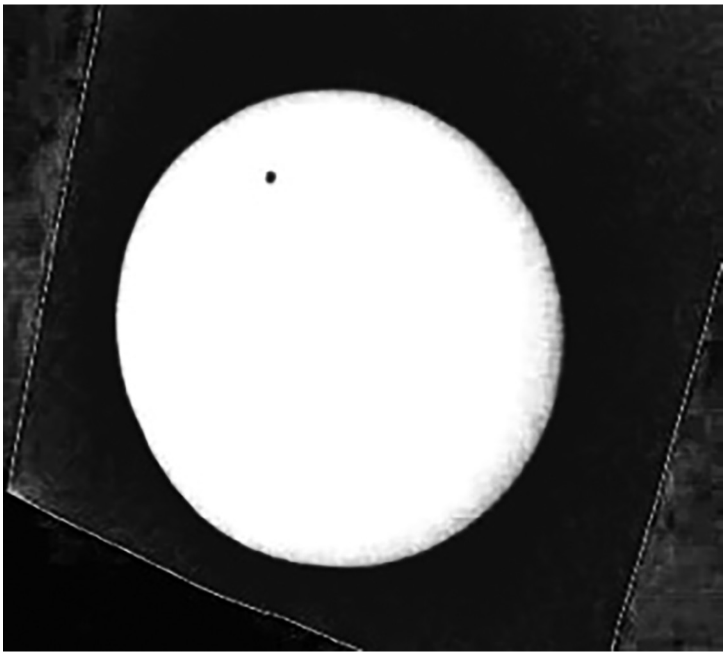

Image: Karen Fisher

Figure 5

Observing a transit of Venus involves looking at the Sun's disc.

Explain how the photograph in Figure 5 could have been taken **safely**.

You may include a clearly labelled diagram in your answer.

(2)

(d) Alice and Bob decide to observe a transit of Venus.

Alice (**A**) observes from the North Pole and Bob (**B**) observes from the South Pole, as shown in Figure 6.

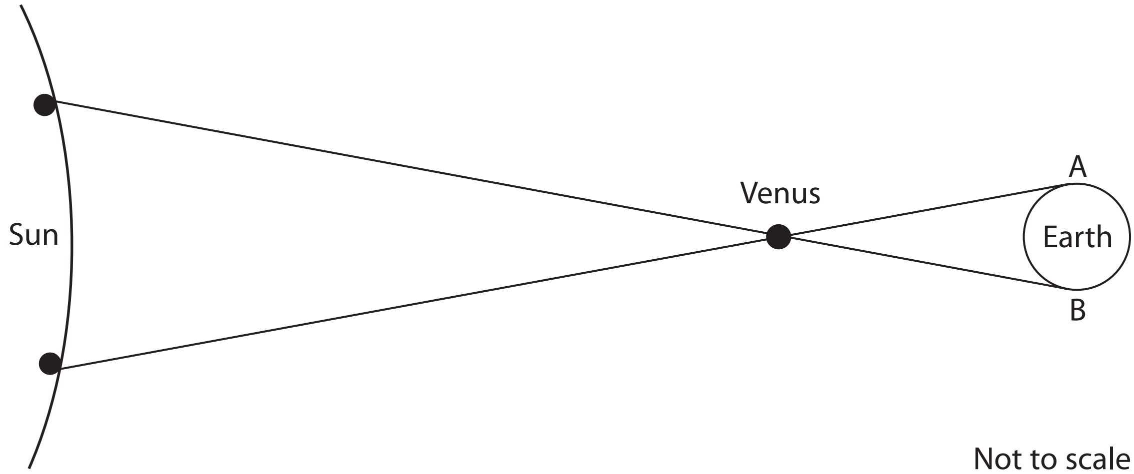

Figure 6

By comparing their measurements of the transit, they find that the distance between the Earth and the Sun is 12 000 times the diameter of the Earth.

(i) Calculate the distance between the Earth and the Sun.

Use the results of Alice and Bob's observations.

Use data from the Formulae and Data Sheet.

Give your answer in kilometres.

(2)

Distance = ... km

(ii) In 1761 observations of a transit of Venus were also used to measure the distance between the Earth and the Sun.

One observer was in Newfoundland (Latitude = 60° N) and the other was at the Cape of Good Hope (Latitude = 34° S).

Alice and Bob's observations give a more accurate value for the distance between the Earth and the Sun than the observations made in 1761.

Explain why Alice and Bob's observations give a more accurate result.

(2)

(Total for Question 4 = 11 marks)

5 In 1929 Edwin Hubble discovered that the light from many galaxies is red-shifted.

(a) (i) Light that has been red-shifted will appear to have a:

(1)

☒ **A** greater brightness

☒ **B** higher frequency

☒ **C** higher speed

☒ **D** longer wavelength

(ii) This red-shift was explained by the theory that the Universe:

(1)

☒ **A** began with a Big Bang

☒ **B** is contracting

☒ **C** is expanding

☒ **D** will end with a Big Crunch

(b) Figure 7 shows the Hooker '100-inch' telescope at the Mount Wilson Observatory in the United States, which Edwin Hubble used to make this discovery.

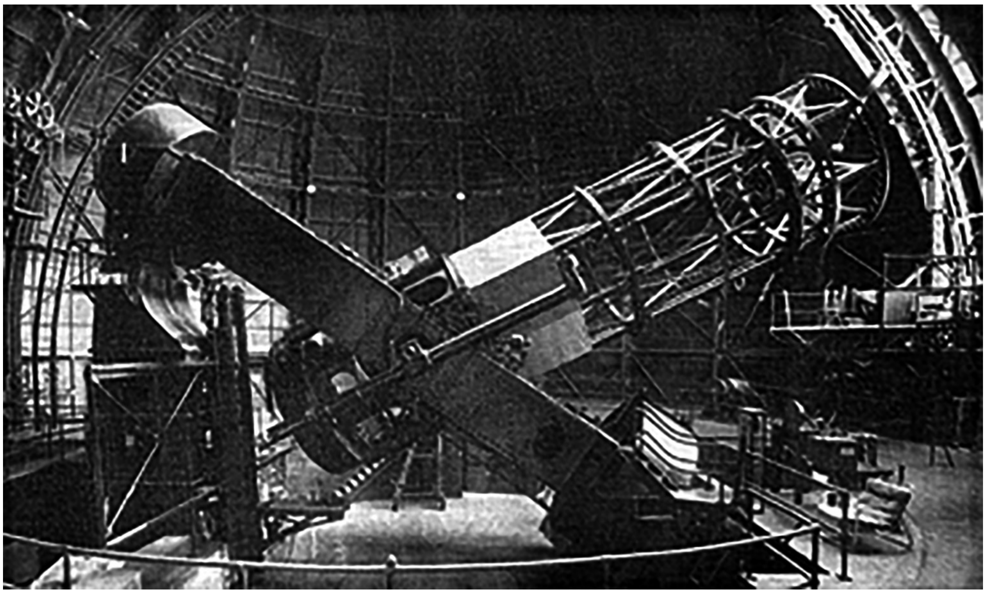

Image: Mount Wilson Observatory

Figure 7

Figure 8 shows some information about this telescope.

Aperture	2.5 m
Focal length	53 m
Magnification	2000 ×

Figure 8

Explain why astronomers using earlier telescopes were not able to discover the red-shift of light from other galaxies.

Use the data in Figure 8.

(3)

(c) Later observations found some galaxies whose light is blue-shifted.

These included the Andromeda and Triangulum galaxies.

Explain why the light from these galaxies is blue-shifted.

(2)

(d) As Figure 9 shows, the Mount Wilson Observatory was built near the top of an isolated mountain.

Since the observatory was built, the city of Los Angeles has expanded.

It is now quite close to the observatory.

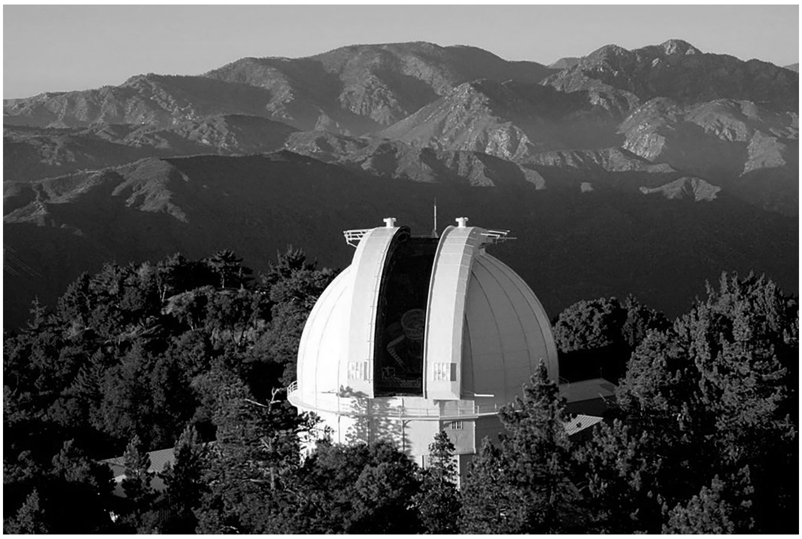

Image: Mount Wilson Observatory

Figure 9

State **two** ways in which light pollution from Los Angeles could affect the images from the optical telescopes at the Mount Wilson Observatory.

(2)

1

2

(Total for Question 5 = 9 marks)

6 Figure 10 shows the Lovell radio telescope at the Jodrell Bank Observatory.

It has a large metal dish with a diameter of 76 m.

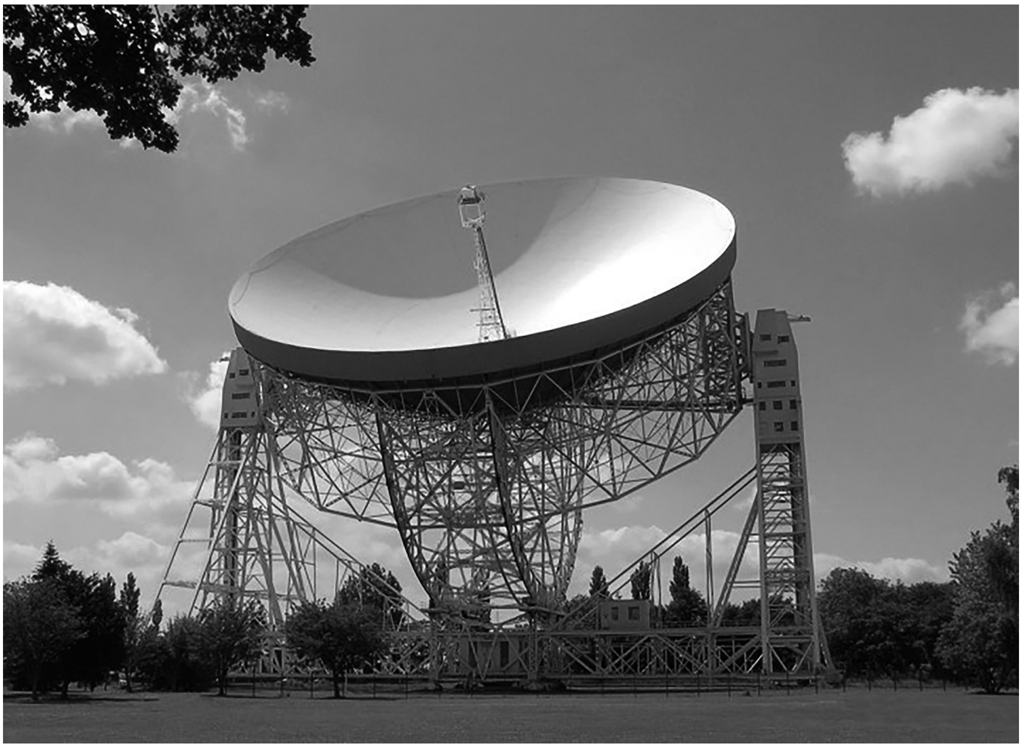

Image: University of Manchester

Figure 10

(a) State the reason why the dish in a radio telescope must be made from metal.

(1)

(b) Explain why the dish in this radio telescope needs to have a much larger diameter than the mirrors in the largest optical telescopes.

(3)

(c) Figure 11 shows two of the radio dishes at the Mullard Radio Astronomy Observatory near Cambridge.

Figure 11

This telescope has three dishes, spread out over 1600 m.

Each dish has a diameter of 18 m.

(i) Explain why this radio telescope is made up of several smaller dishes, rather than a single large dish.

(3)

(ii) State **two** ways that the resolution of this telescope could be increased.

(2)

1

2

(Total for Question 6 = 9 marks)

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7 (a) Identify each of the following stages in the life of a star from the description provided.

(i) Where the inward pull of gravity is balanced by outward radiation pressure. **(1)**

- ☒ **A** black hole
- ☒ **B** main sequence star
- ☒ **C** neutron star
- ☒ **D** white dwarf star

(ii) Where the inward pull of gravity is balanced by outward electron pressure. **(1)**

- ☒ **A** black hole
- ☒ **B** main sequence star
- ☒ **C** neutron star
- ☒ **D** white dwarf star

(iii) Where the inward pull of gravity is balanced by outward neutron pressure. **(1)**

- ☒ **A** black hole
- ☒ **B** main sequence star
- ☒ **C** neutron star
- ☒ **D** white dwarf star

(b) An astronomer wishes to identify a white dwarf star from a group of five stars.

Figure 12 gives some information about these five stars.

Star	Apparent magnitude	Absolute magnitude	Spectral class	Mass (Sun = 1)
A	6.2	–4.1	B1	10
B	2.4	9.2	K5	0.6
C	–4.7	4.8	G2	1.0
D	–1.9	7.4	K6	0.8
E	0.2	11	B2	0.5

Figure 12

Evaluate which of these five stars is most likely to be a white dwarf star.

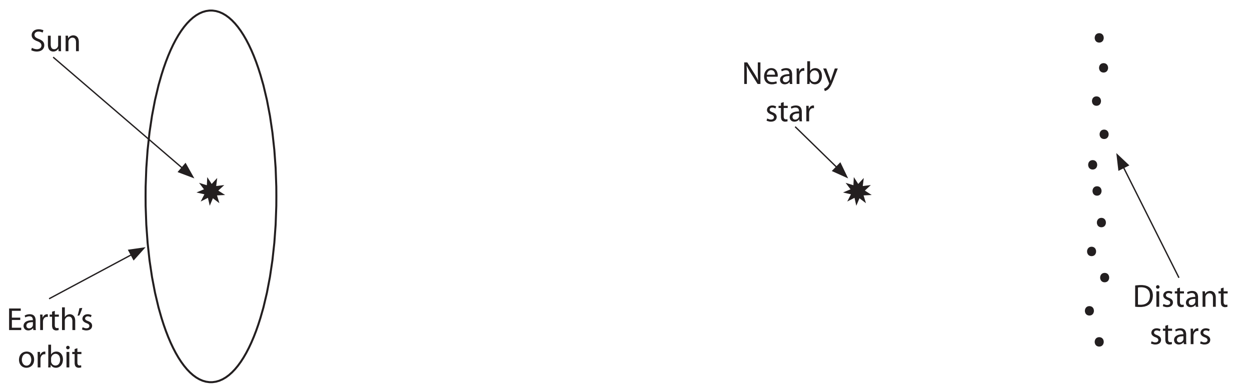
(6)

(c) An astronomer wishes to find the distance to the star Procyon B, a nearby white dwarf star.

One method for measuring the distance of nearby stars is called 'heliocentric parallax'.

This method involves observing a nearby star against the background of more distant stars.

Figure 13 shows the Sun and a nearby star.



Not to scale

Figure 13

(i) Complete Figure 13 to show the parallax angle of the nearby star, for an observer on the Earth.

Label the angle '**P**'.

(2)

(ii) The astronomer measures the parallax angle of the star Procyon B to be 0.25″.

Calculate the distance of Procyon B in light years.

(3)

Distance = ... l.y.

(Total for Question 7 = 14 marks)

8 A galaxy is a group of billions of stars, as shown in Figure 14.

Each star is orbiting the core of the galaxy.

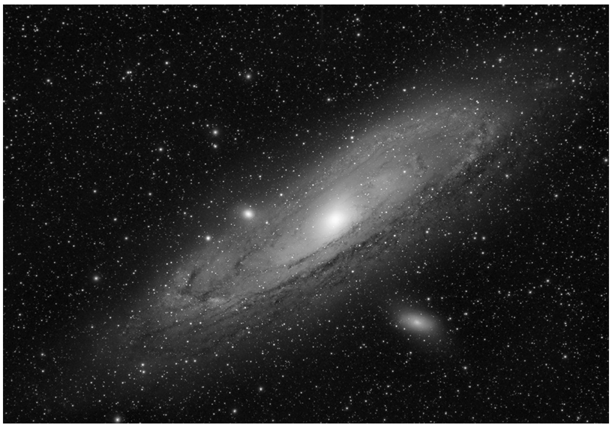


Image: PavelSmilyk/Getty Images

Figure 14

Two groups of astronomers investigate the connection between the speed of a star and its distance from the centre of the galaxy.

The first group suggests that stars near the edge of the galaxy should be travelling much more slowly than those near the core.

Their suggestion is shown by the curve labelled '**Theory**' in Figure 15.

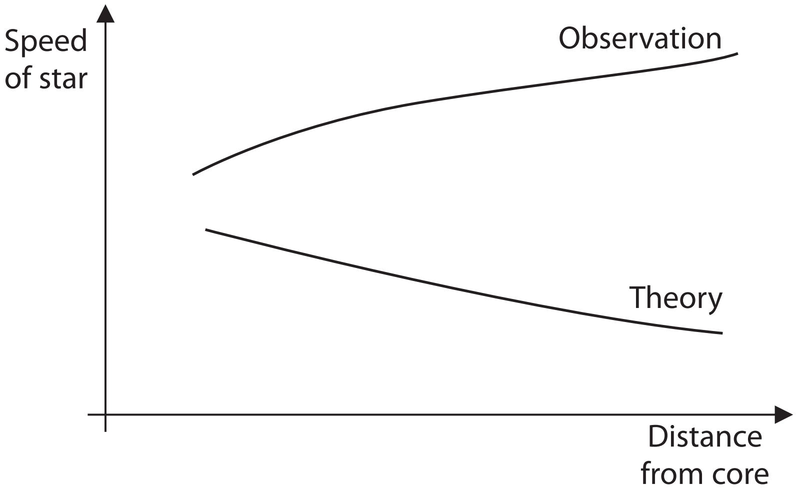


Figure 15

(a) Explain this suggestion, using the idea of gravity.

(2)

(b) A second group of astronomers measures the speed of some stars at different distances from the core of the galaxy.

They use 21 cm radio waves for these observations.

(i) Explain why they used 21 cm radio waves for these observations.

(2)

Their results are shown by the curve labelled '**Observation**' in Figure 15.

(ii) Describe the connection between **Speed of star** and **Distance from core** shown by the '**Observation**' curve in Figure 15.

(2)

(c) Analyse the data in Figure 15 to explain the difference between the '**Theory**' and '**Observation**' curves.

(4)

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(d) An astronomer is studying a spectral line with a wavelength of 400.0 nm.

He uses observations of the spectra from two galaxies, A and B.

His measurements are shown in Figure 16.

	Observed wavelength of spectral line (nm)
Galaxy A	480.0
Galaxy B	399.6

Figure 16

When viewed from Earth, galaxies A and B are directly opposite each other in the sky.

Calculate the wavelength that this spectral line will appear to have in the spectrum of galaxy B, when observed by an astronomer in galaxy A.

(3)

Wavelength = ... nm

(Total for Question 8 = 13 marks)

9 Wahida used a small pair of binoculars to estimate the magnitudes of some of the brightest stars in the constellation of Orion. The view from her observing location is shown in Figure 17.

Figure 17

Her observations are recorded in Figure 18.

	Star name	Estimated magnitude	Actual magnitude	Difference
α	Betelgeuse	0.8	0.42	+0.38
β	Rigel	0.5	0.18	+0.32
γ	Bellatrix	1.0	1.64	–0.64
δ	Mintaka	1.3	2.20	–0.90
ε	Alnilam	1.1	1.69	–0.59
ζ	Alnitak	1.1	1.88	–0.78
κ	Saiph	1.1	2.07	–0.97
λ	Meissa	1.6	3.47	–1.87
ι	Hatsya	1.5	2.77	–1.27

Figure 18

(a) Analyse the information in Figures 17 and 18 in order to comment on Wahida's observational method.

(3)

(b) Evaluate ways to improve Wahida's observations in order to obtain more accurate estimates of the stars' magnitudes.

(6)

(c) Wahida discovers that the constellation of Orion contains an emission nebula.

Describe what is meant by an emission nebula.

(2)

(Total for Question 9 = 11 marks)

10 (a) In the seventeenth century, the Dutch astronomer Christiaan Huygens made observations to compare the brightness of the star Sirius with the brightness of the Sun.

(i) State **two** practical difficulties in carrying out this comparison.

(2)

1

2

(ii) Huygens estimated that the Sun is approximately 400 million times brighter than the star Sirius.

He concluded that Sirius must therefore be 20 000 times further away from the Earth than the Sun.

Explain how he came to this conclusion.

(2)

(iii) State **one** assumption that Huygens made about the Sun and the star Sirius.

(1)

(iv) Calculate the distance from the Earth to the star Sirius.

Use Huygen's estimate that Sirius is 20 000 times further from the Earth than the Sun.

Use information from the Formulae and Data Sheet.

Give your answer in kilometres (km).

(2)

Distance = km

(b) The star Sirius has an absolute magnitude of 1.42.

(i) Explain the **difference** between absolute magnitude and apparent magnitude.

You may include a carefully labelled diagram in your answer.

(2)

(ii) The star Sirius is actually 2.64 pc from the Earth.

Calculate its apparent magnitude.

Use the equation:

$$M = m + 5 - 5 \log d$$

(3)

Apparent magnitude =

(Total for Question 10 = 12 marks)

TOTAL FOR PAPER = 100 MARKS

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