Paper Reference(s) 1AS0/02
Pearson Edexcel Level 1/Level 2 GCSE (9–1)

Total Marks

Astronomy
PAPER 2: Telescopic Astronomy

Wednesday 21 June 2023 – Morning

Time: 1 hour 45 minutes

In the boxes below, write your name, centre number and candidate number.

Surname					
Other names					
Centre Number					
Candidate Number					

Y71933RA

Pearson

YOU MUST HAVE

Calculator, ruler

YOU WILL BE GIVEN

Diagram Booklet
Formulae and Data Booklet

INSTRUCTIONS

Answer ALL questions.

Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – 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.

There may be spare copies of some diagrams.

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.

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 telescope to make sketches of some astronomical objects.

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

(i) Look at FIGURE 1 for Question 1(a)(i) in the Diagram Booklet. A small, bright disc with four fainter points of light in a line. (1 mark)

☐ A a comet

☐ B a galaxy

☐ C a globular cluster

☐ D Jupiter and its moons

(continued on the next page)

1(a) continued.

(ii) Look at FIGURE 2 for Question 1(a)(ii) in the Diagram Booklet. Many thousands of stars forming a tightly packed, spherical ball.
(1 mark)

☐ A a binary star system

☐ B a globular cluster

☐ C an open cluster

☐ D Jupiter and its moons

(continued on the next page)

1(a) continued.

(iii) Look at FIGURE 3 for Question 1(a)(iii) in the Diagram Booklet. Two stars that appear very close to each other.
(1 mark)

☐ A a binary star system

☐ B a galaxy

☐ C a globular cluster

☐ D an open cluster

(continued on the next page)

1 continued.

(b) A student views some astronomical objects through a small telescope. The student writes a description of each object.

Identify each object from its description and image.

(i) Look at FIGURE 4 for Question 1(b)(i) in the Diagram Booklet. A fuzzy object that has spiral arms.
(1 mark)

☐ A the aurora

☐ B a comet

☐ C a galaxy

☐ D an open cluster

(continued on the next page)

1(b) continued.

(ii) Look at FIGURE 5 for Question 1(b)(ii) in the Diagram Booklet. Hundreds of stars forming an irregularly-shaped group. (1 mark)

☐ A a binary star system

☐ B a globular cluster

☐ C a galaxy

☐ D an open cluster

(continued on the next page)

1(b) continued.

(iii) Look at FIGURE 6 for Question 1(b)(iii) in the Diagram Booklet. A fuzzy object that has two tails.
(1 mark)

☐ A the aurora

☐ B a comet

☐ C a galaxy

☐ D an open cluster

(Total for Question 1 = 6 marks)

2 (a) Which ONE of the following is NOT an internal division of the Moon? (1 mark)

☐ A coma

☐ B crust

☐ C mantle

☐ D outer core

(continued on the next page)

2 continued.

(b) There are different theories of the Moon's origin.

Identify each theory from the following short descriptions.

(i) The gravitational attraction of the Earth brought the passing Moon into the Earth's orbit.
(1 mark)

☐ A Capture Theory

☐ B Co-accretion Theory

☐ C Convergence Theory

☐ D Giant Impact Theory

(continued on the next page)

2(b) continued.

(ii) The Earth and the Moon formed at the same time due to the gravitational attraction of material orbiting the Sun.
(1 mark)

☐ A Capture Theory

☐ B Co-accretion Theory

☐ C Convergence Theory

☐ D Giant Impact Theory

(continued on the next page)

2 continued.

(c) The Moon's near side is the surface that can be observed from Earth.

State ONE physical feature that is more common on the Moon's near side than on its far side.
(1 mark)

(continued on the next page)

2 continued.

(d) Look at FIGURE 7 for Question 2(d) in the Diagram Booklet. An astronomer wanted to photograph the SHAPE of some constellations.

The astronomer took a photograph through a correctly focussed telescope.

FIGURE 7 shows this photograph.

Explain how the astronomer could obtain a better photograph of the shape of these constellations.
(2 marks)

Answer space continues on the next page.

2(d) continued.

(Total for Question 2 = 6 marks)

3 (a) Astronomers plan to send a space probe to the SURFACE of the planet Mars.

(i) State ONE way that the Martian atmosphere will be an advantage for their mission.
(1 mark)

(ii) State ONE way that the Martian atmosphere will be a disadvantage for their mission.
(1 mark)

(continued on the next page)

3 continued.

(b) The minimum distance from the Earth to Mars is 55 million km.

A space probe travelling from the Earth to Mars moves at a maximum speed of 11 000 km / h.

(i) Calculate the minimum time the space probe would take to travel from the Earth to Mars.

Use the equation:

$$\text{time} = \frac{\text{distance travelled}}{\text{average speed}}$$

Give your answer in days.
(3 marks)

Answer space continues on the next page.

3(b)(i) continued.

$$\text{time} = \frac{\text{distance travelled}}{\text{average speed}}$$

Minimum time = _____ days

(continued on the next page)

3(b) continued.

(ii) State ONE reason why the space probe will actually take longer to travel from the Earth to Mars than the value calculated in part 3(b)(i).
(1 mark)

(Total for Question 3 = 6 marks)

4 (a) Look at TABLE 1 for Question 4(a) in the Diagram Booklet. It shows four types of nebula.

(i) State which type of nebula is most likely to contain a white dwarf star.
Use information from TABLE 1.
(1 mark)

(ii) State TWO types of nebula where main sequence stars are forming.
Use information from TABLE 1.
(1 mark)

1 _____

2 _____

(continued on the next page)

4(a) continued.

(iii) State TWO types of nebula that are expanding.
Use information from TABLE 1.
(1 mark)

1 _____

_____

2 _____

_____

(continued on the next page)

4(a) continued.

(iv) Look at FIGURE 8 for Question 4(a)(iv) in the Diagram Booklet. It shows an image of a supernova remnant taken using visible light.

Give THREE reasons why a black hole cannot be seen at the centre of this image.
(3 marks)

Answer space continues on the next page.

1 _____

_____

_____

2 _____

_____

_____

4(a)(iv) continued.

3 _____

_____

_____

(continued on the next page)

4 continued.

(b) Look at FIGURE 9 for Question 4(b) in the Diagram Booklet. It shows a Hertzsprung–Russell diagram.

The positions of five stars (V, W, X, Y, Z) are shown on the diagram.

(i) Which star is a supergiant? (1 mark)

☐ A star V

☐ B star W

☐ C star Y

☐ D star Z

(continued on the next page)

4(b) continued.

(ii) Which star lies on the main sequence and has the highest surface temperature?
(1 mark)

☐ A star V

☐ B star W

☐ C star X

☐ D star Z

(iii) Which star outputs more power than the Sun and has molecular absorption lines in its spectrum?
(1 mark)

☐ A star V

☐ B star W

☐ C star X

☐ D star Y

(Total for Question 4 = 9 marks)

5 (a) (i) Which galaxy classification is NOT used in the Hubble classification system?
(1 mark)

☐ A barred spiral

☐ B elliptical

☐ C globular

☐ D irregular

(continued on the next page)

5(a) continued.

(ii) Explain why it is difficult for astronomers to determine the Hubble classification of the Milky Way galaxy.
(2 marks)

(continued on the next page)

5 continued.

(b) (i) Look at FIGURE 10 for Question 5(b)(i) in the Diagram Booklet. It shows a sketch of the Milky Way galaxy viewed from the side.

Label clearly on Figure 10 a possible position of the Sun.

Use the label S.
(1 mark)

(ii) Look at FIGURE 11 for Question 5(b)(ii) in the Diagram Booklet. It shows a sketch of the Milky Way galaxy viewed from above.

Draw on FIGURE 11 the AREA where dark matter is most likely to be located.
(1 mark)

(continued on the next page)

5(b) continued.

(iii) An astronomer needs to show the location of globular clusters.

Explain why the astronomer chose the view of the Milky Way in FIGURE 10 rather than the view in FIGURE 11 to show the location of globular clusters.

You may include a clearly labelled diagram in your answer.
(2 marks)

Answer space continues on the next page.

5(b)(iii) continued.

(continued on the next page)

5 continued.

(c) Astronomers are trying to predict the future evolution of the Universe.

Look at FIGURE 12 for Question 5(c) in the Diagram Booklet. It shows how the mean distance between galaxies changes as the Universe evolves.

Two possible predictions are shown.

Analyse FIGURE 12 in order to explain why astronomers have suggested the existence of dark energy.
(2 marks)

Answer space continues on the next page.

5(c) continued.

(Total for Question 5 = 9 marks)

6 (a) (i) Which of the Sun's internal divisions has the lowest temperature?
(1 mark)

☐ A convective zone

☐ B core

☐ C photosphere

☐ D radiative zone

(ii) In which of the Sun's internal divisions does the proton-proton cycle occur?
(1 mark)

☐ A convective zone

☐ B core

☐ C photosphere

☐ D radiative zone

(continued on the next page)

6 continued.

(b) Look at FIGURE 13 for Question 6(b) in the Diagram Booklet. It shows a graph of the temperature of the Sun's atmosphere at different heights above its surface.

TABLE 2 shows two data points that have NOT been plotted on the graph in FIGURE 13.

TABLE 2

Height above Sun's surface (km)	Temperature of the Sun's atmosphere (K)
1800	10^4
2300	10^5

(i) Plot the remaining data points on the graph in FIGURE 13.

Use the information in TABLE 2.

Draw a line of best fit.
(3 marks)

(continued on the next page)

6(b) continued.

(ii) State the height above the Sun's surface where the temperature CHANGE with height is greatest. (1 mark)

(iii) Estimate the temperature at a height of 6000 km above the Sun's surface. (1 mark)

(continued on the next page)

6(b) continued.

(iv) Explain with reference to FIGURE 13 why your estimate in 6(b)(iii) may not be accurate. (2 marks)

(Total for Question 6 = 9 marks)

7 (a) (i) State TWO differences between a refracting telescope and a reflecting telescope.
(2 marks)

1 _____

_____

_____

2 _____

_____

_____

(ii) State ONE difference between a Galilean refracting telescope and a Keplerian refracting telescope.
(1 mark)

_____

_____

_____

7 continued.

(b) In 1610, Galileo Galilei was the first astronomer to observe Saturn using a telescope. He was unable to resolve Saturn's ring system clearly.

Galileo saw a pair of objects on either side of the planet.

He wrongly thought that Saturn's ring system was a pair of moons.

Look at FIGURE 14 for Question 7(b) in the Diagram Booklet. It shows Galileo's sketch of Saturn made in 1610.

(continued on the next page)

7(b) continued.

(i) Using the same telescope, Galileo observed Saturn two years later and was surprised to see that the ‘two moons’ had disappeared.

After two more years, he observed that the ‘two moons’ had reappeared.

Suggest an explanation for these observations.

You may include a clearly labelled diagram in your answer.
(2 marks)

Answer space starts on the next page.

7(b)(i) continued.

(continued on the next page)

7(b) continued.

(ii) TABLE 3 shows details of one of Galileo's telescopes.

TABLE 3

focal length of eyepiece lens	50 mm
focal length of objective lens	98·0 cm

Calculate the magnification of this telescope.

Use information from the Formulae and Data Booklet.
(2 marks)

Answer space continues on the next page.

7(b)(ii) continued.

TABLE 3

focal length of eyepiece lens	50 mm
focal length of objective lens	98·0 cm

Magnification = _____

(continued on the next page)

7(b) continued.

(iii) Galileo's telescope had a very small field of view, making accurate observations difficult.

Explain why a very small field of view should NOT affect observations of Saturn's rings. (2 marks)

(continued on the next page)

7 continued.

(c) Modern telescopes can resolve Saturn's rings.

Look at the equation for Question 7(c) in the Diagram Booklet. It can be used to calculate the diameter of Saturn's rings.

Calculate the diameter of Saturn's rings.

Use the following data and information from the Formulae and Data Booklet.

wavelength of light = $5{\cdot}0 \times 10^{-7}$ m
diameter of telescope lens = 0·0037 m
minimum distance between Saturn and Earth = 8·5 AU.

Give your answer in km.
(2 marks)

Answer space continues on the next 2 pages.

7(c) continued.

wavelength of light = $5{\cdot}0 \times 10^{-7}$ m
diameter of telescope lens = 0·0037 m
minimum distance between Saturn and Earth = 8·5 AU.

7(c) continued.

wavelength of light = $5{\cdot}0 \times 10^{-7}$ m
diameter of telescope lens = 0·0037 m
minimum distance between Saturn and Earth = 8·5 AU.

Diameter of
Saturn's rings = _____ km

(continued on the next page)

7 continued.

(d) Look at FIGURE 15 for Question 7(d) in the Diagram Booklet. It shows photographs of Saturn taken by two different modern telescopes.

The telescopes were correctly focussed.

The photographs were taken with the same camera and had the same exposure time.

Analyse FIGURE 15 in order to comment on the differences between the telescopes that could explain the differences between the images produced.
(3 marks)

Answer space continues on the next page.

7(d) continued.

(Total for Question 7 = 14 marks)

8 Astronomers use different techniques to measure the distance to stars.

These techniques include:

- **heliocentric parallax**
- **the period of Cepheid variables**
- **use of the Hertzsprung–Russell diagram.**

(a) State ONE problem or limitation of each of these three techniques. (3 marks)

Answer space continues on the next page.

Heliocentric parallax

8(a) continued.

The period of Cepheid variables

Use of the Hertzsprung–Russell diagram

(continued on the next page)

8 continued.

(b) Look at FIGURE 16 for Question 8(b) in the Diagram Booklet. It shows the Period–Luminosity relationship for Cepheid variable stars.

A Cepheid variable star has a period of 30 days.

The star has a mean apparent magnitude of 5·0.

Calculate the distance to the Cepheid variable star.

Use FIGURE 16 and information from the Formulae and Data Booklet.

Use the equation:

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

Give your answer in light years (l.y.).
(4 marks)

Answer space continues on the next page.

8(b) continued.

Distance to
Cepheid Variable = _____ l.y.

(continued on the next page)

8 continued.

(c) An astronomy student decides to measure the period of the Cepheid variable star, delta Cephei.

He takes a photograph of this star and the surrounding night sky.

He then selects two reference stars that he can use to measure the brightness of delta Cephei.

Look at FIGURE 17 for Question 8(c) in the Diagram Booklet. It shows the student's photograph and the labels that he added.

To determine the period of delta Cephei, the student then took similar photographs once a week for two months.

(continued on the next page)

8(c) continued.

Evaluate ways to improve the student's observations in order to obtain a more accurate measurement for the period of delta Cephei.
(6 marks)

Answer space continues on the next 2 pages.

8(c) continued.

8(c) continued.

(Total for Question 8 = 13 marks)

9 (a) The Drake Equation can be used to estimate the number of technological civilisations in our galaxy.

Which variable is NOT used in the Drake Equation?
(1 mark)

☐ A average length of time for which civilisations can communicate

☐ B average rate of star formation

☐ C fraction of life-supporting planets that develop life

☐ D fraction of stars that are visible from Earth

(continued on the next page)

9 continued.

(b) Look at FIGURE 18 for Question 9(b) in the Diagram Booklet. It shows the first image of an exoplanet orbiting a brown dwarf.

Brown dwarfs have a mass that is too small to start nuclear fusion and are called ‘failed stars’.

Give THREE reasons why this exoplanet is unlikely to support life. (3 marks)

Answer space continues on the next page.

1 _____

_____

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2 _____

_____

_____

9(b) continued.

3 _____

_____

_____

(continued on the next page)

9 continued.

(c) Astronomers have estimated that the Goldilocks (Habitable) Zone around the Sun lies between the orbits of Venus and Mars.

However, there are proposed missions to search for life on Enceladus, a moon of Saturn.

(i) Enceladus does not lie within the Sun's estimated Goldilocks Zone.

Explain why astronomers think that Enceladus may support life. (2 marks)

Answer space continues on the next page.

9(c)(i) continued.

(ii) Explain how the location of the Goldilocks Zone around a brown dwarf would be different from the Goldilocks Zone around the Sun. (2 marks)

(continued on the next page)

9 continued.

(d) Look at TABLE 4 for Question 9(d) in the Diagram Booklet. It shows some information about four stars, A, B, C and D.

A planet orbits each of these stars.

Evaluate the data in TABLE 4 in order to identify which of the four stars is likely to have a planet that is located within the Goldilocks (Habitable) Zone.

Explain your reasoning.
(6 marks)

Answer space continues on the next 3 pages.

9(d) continued.

9(d) continued.

9(d) continued.

(Total for Question 9 = 14 marks)

10 (a) Edwin Hubble concluded that the Universe is expanding.

Explain how the expansion of the Universe can support both the Big Bang theory and the Steady State theory.
(4 marks)

Answer space continues on the next page.

Support for the Big Bang theory

10(a) continued.

Support for the Steady State theory

(continued on the next page)

10 continued.

(b) Look at TABLE 5 for Question 10(b) in the Diagram Booklet. It shows the redshift of different objects in the Universe and how the redshift changes with distance from the Earth.

Analyse the data in TABLE 5 in order to explain why observations of quasars do NOT support the Steady State theory.
(3 marks)

Answer space continues on the next page.

10(b) continued.

(continued on the next page)

10 continued.

(c) An absorption line in the spectrum of two quasars, A and B, is measured.

The observed wavelength of the absorption line in the spectrum of quasar A is measured as 532·5 nm.

The observed wavelength of the same absorption line in the spectrum of quasar B is measured as 543·8 nm.

The absorption line has an emitted wavelength of 520·5 nm.

Calculate the difference in the radial velocity of the two quasars.

Use the equation:

$$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$$

The speed of light is $3{\cdot}0 \times 10^5$ km/s.

Give your answer in km/s.
(4 marks)

Answer space continues on the next 2 pages.

10(c) continued.

$$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$$

10(c) continued.

$$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$$

Difference in
radial velocity = _____ km/s

(continued on the next page)

10 continued.

(d) Read the extract for Question 10(d) in the Diagram Booklet. The extract is from an article on the history of astronomical discovery.

Explain how astronomers used radio telescopes and optical telescopes to determine the precise location of the first quasar.

You may include a clearly labelled diagram in your answer.
(3 marks)

Answer space continues on the next 2 pages.

10(d) continued.

10(d) continued.

(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 100 MARKS
END OF PAPER