Examiners' Report
Principal Examiner Feedback

Summer 2023

Pearson Edexcel

GCSE Astronomy (1AS0)

Paper 1: Naked-eye Astronomy

Summer 2023
Publications Code 1AS0_01_2306_ER

Introduction

The GCSE Astronomy examination continues to be centred around non-tiered examination papers with the 3½ hours of examination time split between two papers:

- Paper 1 – Naked-eye Astronomy
- Paper 2 – Telescopic Astronomy

The subject content of each paper mirroring a similar division of material within the Specification.

The central focus on observational astronomy is very evident in these examination papers where many questions are designed around presenting candidates with the results of an astronomical observation and asking them to process the information and arrive at scientific conclusions. Others ask them to comment on the conclusions which others, such as archaeoastronomers, have placed on astronomical data.

Guidance for centres

It is clear from this year's examination that centres and their candidates have worked extremely hard on their astronomical studies, despite the inevitable disruption from the unprecedented events of recent years.

The enthusiasm and commitment which have always characterised those involved with the teaching and learning of GCSE Astronomy continue to be evident. Centres and their candidates are to be commended for the conspicuous hard work and dedication (often as part of an extra-curricular provision) which clearly went into the preparation of this year's cohort.

Across both examination papers, this year's candidates demonstrated a number of impressive qualities, reflecting high quality teaching and learning throughout their courses:

- Candidates continue to show good flexibility when dealing with the wide range of data that the subject generates.
- Many candidates were able to apply their knowledge and understanding to the new or unfamiliar situations presented in many examination questions.
- Many candidates coped very well with the often very demanding mathematical skills required by the questions in this year's papers, including skills such as squaring, cubing and logarithmic scales.
- Strong graphical skills were demonstrated in both the creation and use of graphs.
- Many candidates showed excellent background knowledge in the subject, allowing them to enhance the depth and detail of their answers.

In addition, the following points have been identified as areas where future candidates could strengthen their performance in this qualification:

Question requirements

Although it may seem an obvious point, it is clear that a significant number of candidates are losing marks because they have not fully understood the requirements of the question, In particular candidates must pay close attention to the Command word used at the start of each question as these invariably determine the structure of the mark scheme

- Questions which ask candidates to Explain will not award any marks for a description. When answering these questions candidates must be clear that they are explaining **why** something happens and not simply describing **what** happens. Candidates should ensure that their answer gives material additional to that in the question and that they are not just repeating the question.
- Questions which ask candidates to 'Evaluate…' will require them to come to some kind of judgement or conclusion after having looked at both sides of the information presented.

- Questions that ask candidates to 'Show…' will award marks for each step of astronomical reasoning in the working. Marks will not be awarded for unexplained numbers or calculations.

A full list of the Command words used in the GCSE Astronomy examination and guidance on their requirements can be found in the Specification.

Diagrams

By the nature of the subject, almost every GCSE Astronomy examination question involves the use of a diagram either in the question, the answer or in the mind of the candidate answering it.

- Most concepts in astronomy are more clearly expressed using a diagram and so candidates are advised to use a fully labelled diagram whenever it will make their answer clearer. Obviously, a diagram is required by the mark scheme in questions which state 'Use a diagram…'. Although it is optional in questions stating 'You may use a diagram…' it is still strongly recommended. The use of diagrams to clarify answers was definitely a hallmark of the higher-scoring candidates in this year's examination.
- It is essential that all the key parts of a diagram are clearly labelled. A number of 'diagrams' seen by this year's Examiners contained lines and curves representing important items, but which had no label, often rendering the diagram insufficient for the award of marks.
- Candidates are advised to use a ruler whenever possible in their diagrams. Diagrams drawn without the use of a ruler can easily descend into becoming rough sketches.
- Diagrams in GCSE Astronomy often involve drawing an area of the night sky. Given its apparently 'domed' appearance this is something which candidates should practise beforehand as it can present something of a drawing challenge. Nevertheless, regarding each small section of the sky as a piece of flat graph paper, with lines drawn with a ruler and clearly labelled can make this a more straightforward task.

Calculations

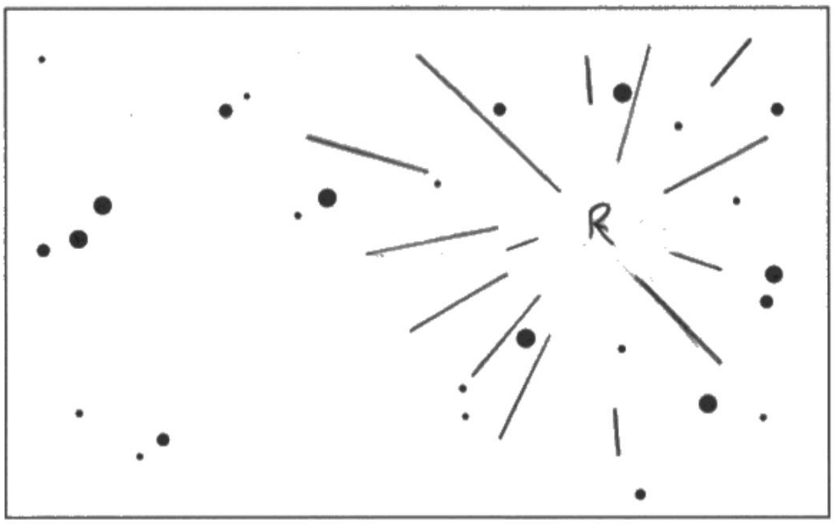
In both examination papers, calculations often represent a significant number of marks, and it is important that each candidate shows the full extent of their ability in these questions.

- It is important that candidates bring an adequate calculator to both examination papers so that they can meet all its mathematical demands. As well as basic arithmetical functions, astronomical calculations can often involve more complex operations such as squaring, cubing, taking logarithms etc.
- Candidates should ensure that they are familiar with the operation of their chosen calculator.
- Given that some calculations are now worth three or even four marks, the provision of clear structured working is now more important than ever.
- The provision of clear working is essential in questions which require candidates to 'Show…' rather than 'Calculate…'. In these questions there are obviously no marks for the final answer (given on the paper) and all marks are for the steps in the working and their astronomical justification.
- It is recommended that candidates give their final answers to a sensible number of significant figures, taking their cue from the data given in the question, in addition to the precise answer resulting from their calculation.
- Questions asking candidates to 'Analyse…' will require them to use the numerical data provided within the question as part of their answer. These data can be provided in a table, graph or other form but must be used in the candidates' calculations if full marks are to be obtained.

Comments on Individual Questions:

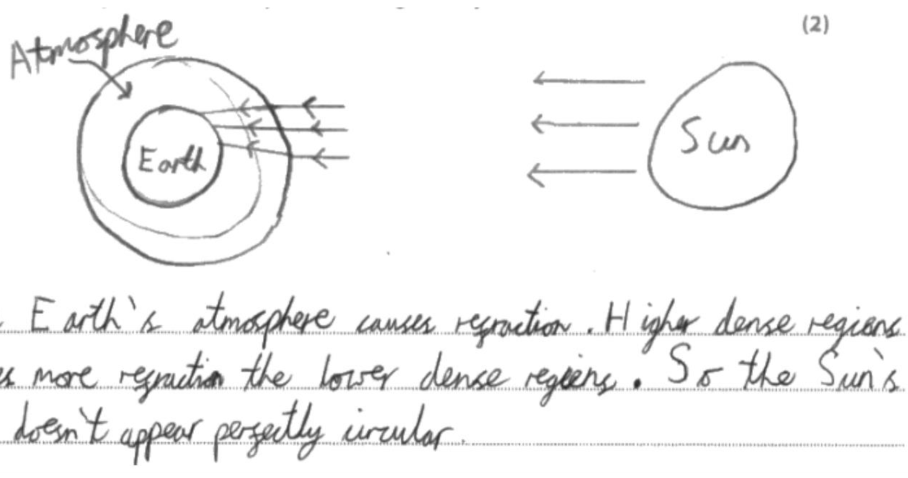
Q01bi & ii

The majority of candidates were able to provide a sketch of a meteor shower with its radiant found by projecting back the trails. The higher quality sketches, such as the one below, were drawn with a ruler and had their radiant marked with the letter 'R', as requested in the question.



Q03ai

Most candidates were aware that this effect was produced by atmospheric distortion of light rays from the Sun, although not all were able to use the specific term 'refraction' or to show that it resulted from rays changing direction as they entered the atmosphere. This second point was most effectively shown by the use of a clearly labelled diagram, as in the example below.



Q03aii

Many candidates were aware that the orangey-red colour was the result of a reduction in the shorter wavelength blue light rays with the higher-scoring candidates providing the specific term 'scattering' as well.

Q03bi

Candidates provided a wide range of possible sources for dust in the Earth's atmosphere both astronomical and terrestrial in origin.

Q03bii

Despite the novel setting for the assessment of this part of the Specification, most candidates recognised the prompts in the question to the fact that the Sun does not set for locations north of the Arctic Circle during the summer months and many went on to explain this as a result of the Earth's axial tilt.

Q04ai

This question uncovered a significant minority of candidates who were unclear regarding the origin of the Earth's tides. The remainder made good use of diagrams to show the symmetrical 'bulges' in water levels on either side of the Earth. Once again, the higher quality answers included full labelling of all parts of their diagrams. As the question required an explanation for the two high tides each day, full marks could only be gained by responses that included mention of the Earth's daily rotation.

Places near the sea have two high tides every 24 hours due to tidal locking. Tidal locking is the effect of the moons gravity on the oceans, gravity being the universal force which attracts masses to one another.

The response above establishes the presence of a pair of symmetrical tidal bulges by means of a labelled diagram, despite the representation of the Moon twice on the diagram, and thus gains two marks. However, it does not explain why the Earth's daily rotation causes each place on the Earth to experience two high tides each day and thus does not gain the third mark.

Q04aii

Although a fairly straightforward calculation to find the low tide time half way between the two high tide times given in the question, the sexagesimal format of the times made subtraction and addition more demanding. As a result, several candidates carried out the correct calculation but did not arrive at the correct time, thus scoring only one mark.

Q04bii & iii

These two questions examined candidate's' understanding of the link between spring tides and the phase of the Moon. Although many candidates clearly appreciated that a spring tide can only occur at the Moon's full or new phase, a number did not appreciate that seven days before the spring tide would thus align with either a first or last quarter Moon.

Candidates who gave an incorrect answer to Q04bii were still able to gain full marks for Q04biii by describing a consistent sequence of lunar phases for the following seven days.

Q05ai

The references to archeoastronomy in the current Specification are clearly featuring in the courses taught in many centres as almost all candidates were able to provide a possible role for ancient stone circles, aligned with astronomical objects such as the Sun, Moon or stars.

Q05aiii

Many candidates identified the effect described in the question as the result of the precession of the Earth's axial tilt and thus gained the first of the two marks available. However, the second mark proved much more demanding for the majority of candidates. It required them to establish that precession causes a gradual shift between the celestial sphere and the stars. Simply stating that the 'stars move' was insufficient as this very general statement is essentially provided by the question.

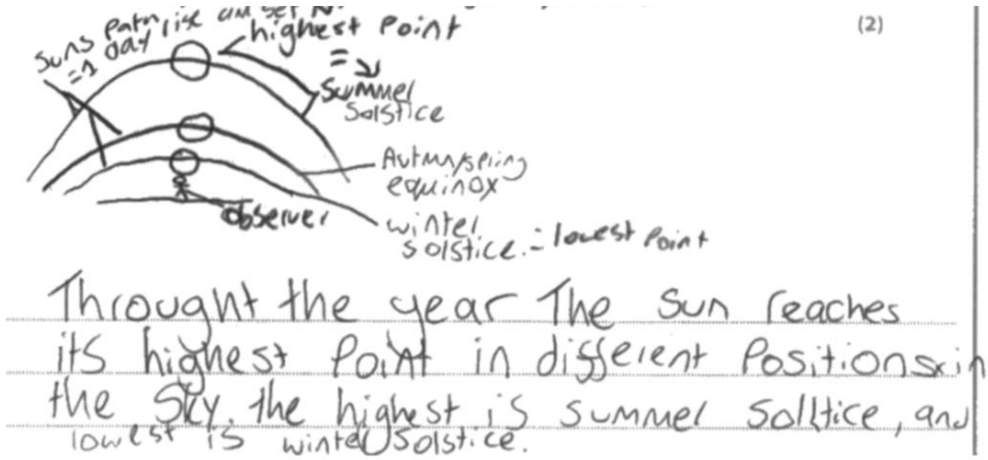
A wide range of attempted spellings for the word 'precession' were seen and credited as long as they were sufficiently close to the correct version. However, some candidates' spellings were very close to the word 'precision' which has an entirely different meaning and could not be credited.

Q05bi

Although the exact shape of the analemma is quite complex, almost all candidate's concluded that the solar images towards the top of the pattern would be recorded during the northern summer. They therefore correctly gave a date on or around the summer solstice.

Q05bii

Only a small number of more able candidates were able to give a full explanation for the shape of the analemma pattern shown in Figure 7. However, a pleasing proportion of candidates recognised that the solar images towards the top of the pattern were recorded during the summer and those towards the bottom during the winter. Linking this to the Earth's axial tilt and the consequent seasonal variation of the Sun's celestial position gained the first mark.



The response above makes a very clear link between the seasonal variation of the Sun's declination and the altitude of the midday solar image by the very effective use of a clearly labelled diagram and thus comfortably gains the first mark on this question.

The second, much more demanding mark, required candidates to explain that the annual variation of the Equation of Time would effectively move the midday solar image to the right or the left of the centre of the pattern.

Particularly for the second mark, candidates needed to link their astronomical cause to a feature of the pattern to gain the mark. A number provided an explanation of the Equation of Time but did not link it to the horizontal dimension of the analemma and thus did not gain the second mark.

Q05biii

Although the fact that the altitude of the north celestial pole is equal to the observer's latitude is well known amongst GCSE Astronomy candidates, this question provided a variation on this theme. Instead of referring to the altitude of the Pole Star in the sky, it gives the altitude of Point 'X' which has an approximate declination of 23½°. Q.9a(ii) is based around a similar idea, relating to the altitude of a celestial object with a declination of 0°.

As often happens with demanding calculation questions, candidates often forget to include full signposting with their working, making it very difficult for partial credit to be given in the event of an incorrect final answer.

Q06a

This question provided candidates with three relatively straightforward marks for plotting the data in Table 1 and drawing a line of best fit. With the quantity on the vertical axis already labelled, candidates simply had to add an appropriate scale of numbers to ensure effective use of the space provided.

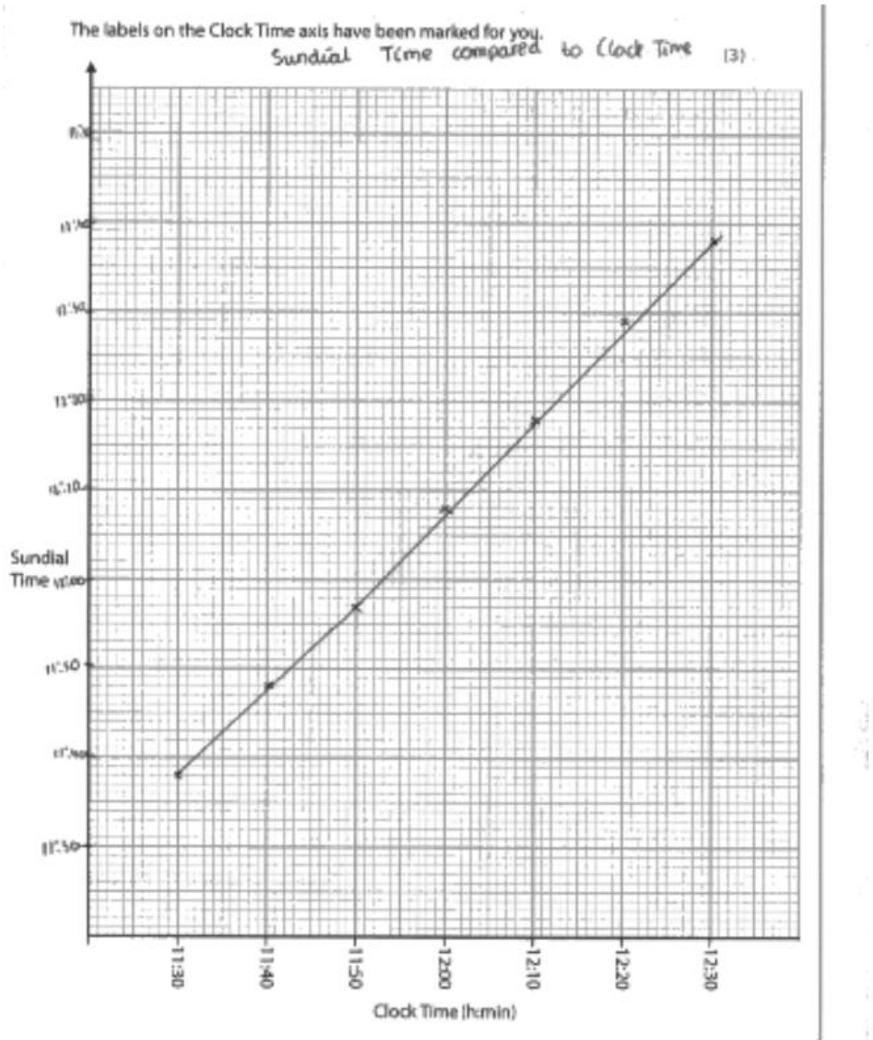


Figure 9

The response shown above thus gains full marks and even contains a title for the graph as well.

Q06b

This question allowed candidates to demonstrate their ability to evaluate the accuracy of data obtained from a series of astronomical observations. The quality of their evaluative comments determined the level of their mark, adjusted by the accuracy of their indicative content, as set out in the Mark Scheme.

The context provided was of a series of sundial measurements used to measure the mean difference between the time displayed on a sundial and on a clock. The data were then used to estimate the observer's longitude. The method described and results presented contained both positive and negative features on which candidates could comment.

The response shown below is firmly in the Level 2 tier with regard to its evaluative comments and includes the majority of points from the Indicative Content. It therefore achieves the higher of the two marks within Level 2, i.e. 4 marks.

- Annabel's sundial was placed on grass which may have been a source of error as the sundial may not have been perfectly level.
- She used the Clock Time (MST) as the independent variable which is successful as it provides more ease for her investigation
- Most of her results show an 8 minute difference between MST & AST, meaning her experiment is precise. She only had 2 anomalies with a 7 and 9 minute difference between AST and MST. This shows her method is accurate.

EOT = AST − MST

2 ¾° E = 11 mins + GMT (clock time) so at 11:30 clock time, her MST should've been 11:41.

MST = AST − EOT. 11:41 = AST − −3

11:41 = AST +3

11:41 − 3 = AST and her AST was 11:38 at this time (11:30 GMT.) Therefore, her calculations of her longitude

(Total for Question 6 = 9 marks)

are accurate and so is the method she used as she got an accurate answer.

Q07a

The majority of candidates were able to recall the definition of an inferior planet, with only a small number confusing it with the size or structure of the planet.

Q07biii

Almost all candidates could recall that Venus is the other inferior planet, along with Mercury, for observers on the Earth.

Q07c

This question allowed candidates to demonstrate their ability to design a programme of astronomical observations. The quality of their design determined the level of their mark, adjusted by the accuracy of their indicative content, as set out in the Mark Scheme.

The context provided was the design of an effective naked-eye observing programme for the planet Mercury. Although identified many thousands of years before the invention of the telescope, Mercury's proximity to the Sun in the sky made this a less than straightforward design brief.

Although many candidates listed some sound practice for the observation of planets, a surprising proportion made no reference to the difficulties of observing Mercury which is always close to the Sun in the sky.

Centres are reminded of the importance of including the Observational Tasks as part of their programme when preparing candidates for this examination. Particularly in this question, it was clear that some candidates had not always backed up their knowledge of the Subject Content with actual practical experience.

Q07d

This question illustrated a general confusion between the processes of eclipsing and occultation with a number of candidates scoring no marks. A number of candidates also thought that a body could be visible at the same time as either being eclipsed or occulted – presenting an area where revision may be needed.

Q08ai

Based on candidate responses, it appeared to be a relatively straightforward task to identify from Figure 12 that an object had hit the Moon and left a large impact crater with rays of ejecta clearly visible.

Q08aii

(ii) State **one** reason why it is still possible to see the effects of this event, hundreds of years after it happened.

(1)

No atmosphere to cause erosion or to hide the crater over time.

Unlike the sample shown above, a surprisingly large number of candidates did not appear to appreciate that lunar features such as the crater in Figure 12 have not changed their appearance due to the lack of atmosphere, water or tectonic activity on the Moon.

Q08aiii

Combining the position of the Sea of Tranquillity on the lunar disc with the information in the question that the crater was located to its north-west allowed many candidates to mark a possible location with an 'X', as in the example below.

Locations that were broadly in the north-west quadrant of the sea itself or in the area to its north-west were credited. Candidates who placed their X to the north-west of another sea were allowed one mark.

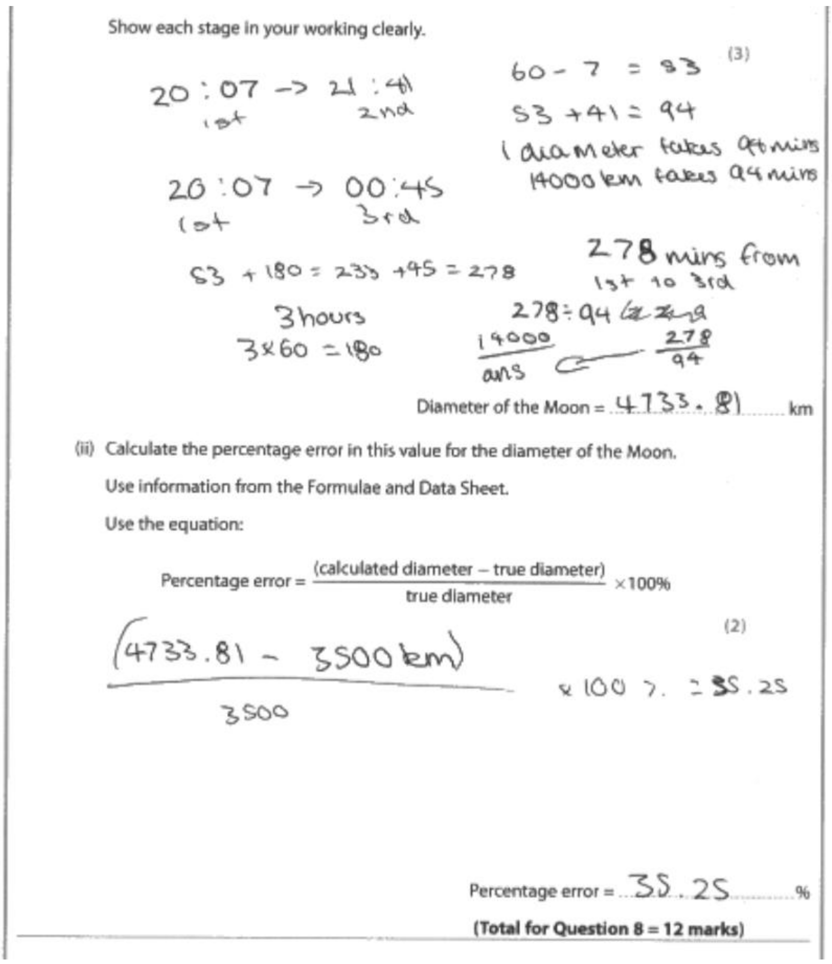
In questions such as these, candidates are reminded of the importance of ensuring that their 'X' is marked very clearly, so as to be sure of it standing out from the greyscale image behind it.

Q08b

Although this question simply asked for two features of the Earth-Moon system that supported the Giant Impact Hypothesis, a significant number of candidates found ways to avoid the award of both marks. Many candidates simply gave very general features without any specific detail. Others gave two points that were essentially the same thing – the most common being the similar chemicals found on the Earth and the Moon.

Q08ci & ii

These two questions asked candidates to follow Eratosthenes and use the relative lengths of time periods within a lunar eclipse to calculate the relative size of the Moon compared to the Earth. With a previous value for the diameter of the Earth given, part (i) asked for an estimate of the size of the Moon and part (ii) asked for a calculation of the percentage error in this figure.


Show each stage in your working clearly.

(3)

20:07 -> 21:41
1st 2nd

60 - 7 = 53
53 + 41 = 94
1 diameter takes 94 mins
14000 km takes 94 mins

20:07 -> 00:45
1st 3rd

53 + 180 = 233 + 45 = 278

278 mins from 1st to 3rd

3 hours
3×60 = 180

278÷94
14000/ans = 278/94

Diameter of the Moon = 4733.81 km

(ii) Calculate the percentage error in this value for the diameter of the Moon.

Use information from the Formulae and Data Sheet.

Use the equation:

$$\text{Percentage error} = \frac{(\text{calculated diameter} - \text{true diameter})}{\text{true diameter}} \times 100\%$$

(2)

(4733.81 - 3500 km) / 3500 × 100 % = 35.25

Percentage error = 35.25 %

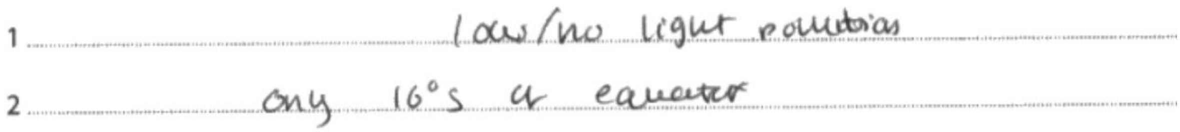
(Total for Question 8 = 12 marks)

Given that there were two marks available for the stages in the calculation, part (i) illustrated the importance of showing clearly all stages within a calculation. The response above has made the determination of the two time periods clear and shows clearly how these periods are used to arrive at the ratio between the sizes of the Earth and Moon.

All parts of these calculations are shown, although the answer could have been improved by further labelling. These help to make it clear what is being calculated, rather than having numbers simply appearing out of nowhere. A slight criticism is the large number of significant figures in the answer, given the precision of the data in the question.

Candidates' working in part ii was generally much more clearly expressed as the question paper had completed the first stage in clear working – stating the equation being used.

Q09ai


1 low/no light pollution
2 only 16°S of equator

Most candidates appreciated the low light pollution levels on a remote island such as St. Helena but only a small proportion commented on its closeness to the equator, meaning that only a small part of the celestial sphere remains invisible all year round.

Q09aii

The most popular incorrect answer for this question was '16°', suggesting that many candidates were familiar with the idea of the altitude of the celestial pole being equal to the observer's latitude. However, the object being observed here was on the Celestial Equator with a declination of 0°. Consequently, it would lie 90° further north in the sky, i.e. at an altitude of 74°.

Q09aiii

Although space was available for a diagram, the invisibility of Ahfa al Farkadain can be demonstrated quite simply using the inequality for checking if a star is invisible from a given location:

$$\text{Declination} - \text{Latitude} > 90^\circ$$

Which in this case gives us: $77^\circ\, 48' - -16^\circ = 93^\circ\, 48'$

Since 93° 48' is greater than 90°, the star will be invisible.

A large number of candidates attempted to use diagrams to prove the star's invisibility. However, these complex diagrams often suffered from incomplete or inaccurate labelling, leaving many curves and lines that communicated nothing to the marker.

Q09aiv

A wide range of factors were offered to explain the difficulty of celestial latitude measurements in the southern hemisphere, including climate, air quality and seeing conditions. The mark for this question could be obtained by pointing out that the bright star Polaris that marks the north celestial pole is not visible from southerly latitudes or by pointing out that there is no bright star near the south celestial pole.

Q09b

This question required a longitude calculation based on the difference between local time and the time at Greenwich. The candidate below has completed the calculation correctly, including a determination of whether the island is east or west of the Prime Meridian. Although all parts of the working are shown, this aspect of the answer could be improved with a little more labelling such as indicating the reason for the division by four. If the candidate's final answer had been wrong, it would be important that the marker understood the astronomical reason for each step in the calculation.

(b) A ship arrives at St. Helena exactly at local noon. → 12pm

The chronometer carried on the ship was set to local time at Greenwich at the start of its voyage and now reads 12:22:45.

Calculate the longitude of St. Helena. → 22:45 mins ahead

(3)

$\frac{22.75}{4} = 5.6875$

$= 5.6875^\circ$ West

$= 5.7^\circ W$ (2sf)

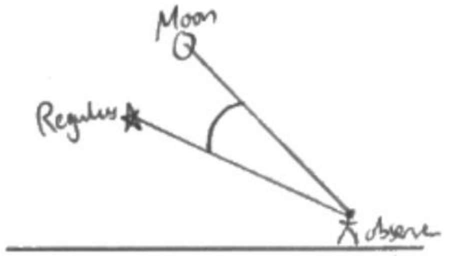
Longitude of St. Helena = 5.7° W

Q09c

This question generated a very wide range of responses. The method's title produced a group of candidates who thought it was based around a measurement of the distance between the Earth and the Moon. Others correctly used its title to help them gain the first mark by concluding that it involved a measurement of the angular distance between the Moon and another celestial body such as a bright star.

The other two aspects of the method – the use of tables to compare measurements with another location and thus the calculation of time difference and hence longitude – were only provided by a relatively small group of candidates, such as the one below.

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

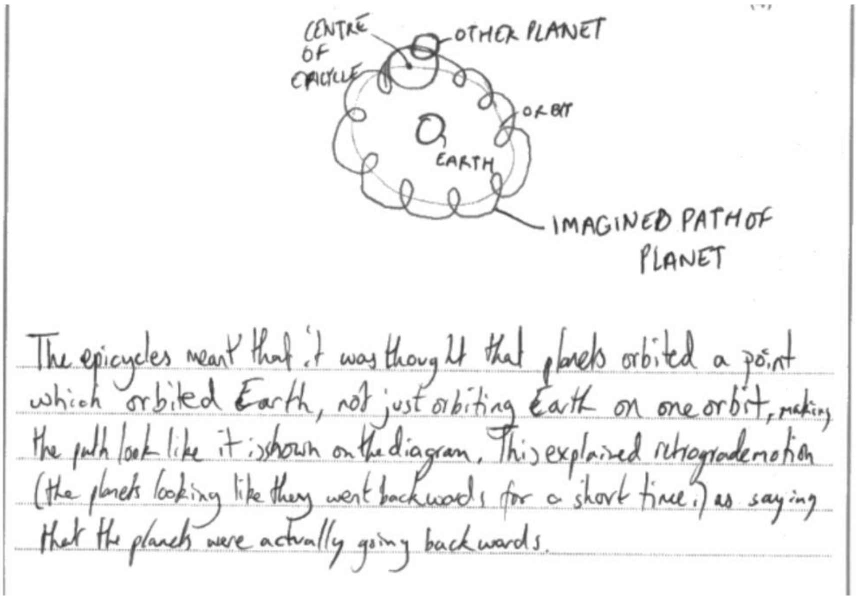


Measure angle subtended by Moon and fixed star (usually Regulus) – can be measured with a sextant. This can be corrected with books of measurements e.g. correct for parallax and adjust measurement to centre of moon. Anywhere on Earth this angular distance will be the same at the same moment of time so you can find the corresponding GMT to this distance. Compare this to MST and ÷4 to find degrees away from Prime Meridian.

(Total for Question 9 = 13 marks)

Q10b

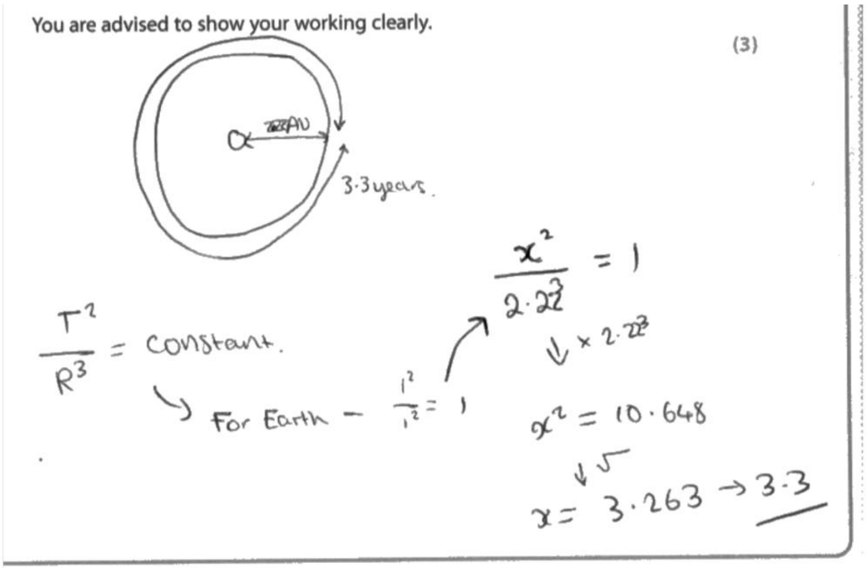
As with Q09c, this question required candidates to explain a complicated astronomical idea and thus illustrates again the value of carefully drawn and fully labelled diagrams. In the example below, the candidate has almost gained all four marks simply as a result of their diagram. The diagram shows an Earth-centred model, shows a planet orbiting on an epicycle and indicates how this model produces retrograde loops for an observer on the Earth.



Q10ci

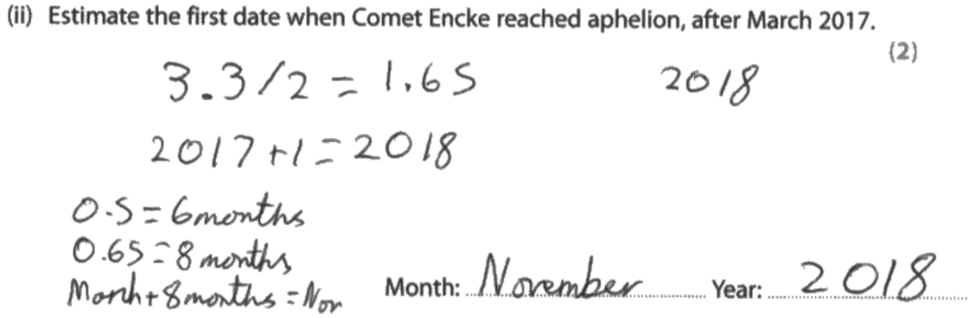
Although this question was clearly a 'Show…' rather than a 'Calculate…' question and prompted candidates to include the stages in their working clearly, many answers were simply a collection of numbers spread around the answer area with no clear path ending in the value of 3.3 years.

The response below has many features which help to make it a successful answer. Firstly, there is a clear path from Kepler's Third Law to the final answer, with the use of arrows to ensure that the route is always clear. Secondly, the three stages necessary in calculations (Equation, Number and Answer) are clearly present in the correct order – many answers started with numbers being squared or cubed for no stated reason.



Q10cii

In a similar way to Q04aii, this question simply required candidates to find the date that was halfway between two perihelion dates. This could be found by halving the comet's period (1.65 years) and then adding it to the first perihelion date of March 2017. The fact that the question was presented in years and months meant that some candidates lost their way when converting fractions of years to and from months.



(ii) Estimate the first date when Comet Encke reached aphelion, after March 2017.

(2)

3.3/2 = 1.65 2018

2017 + 1 = 2018

0.5 = 6 months

0.65 = 8 months

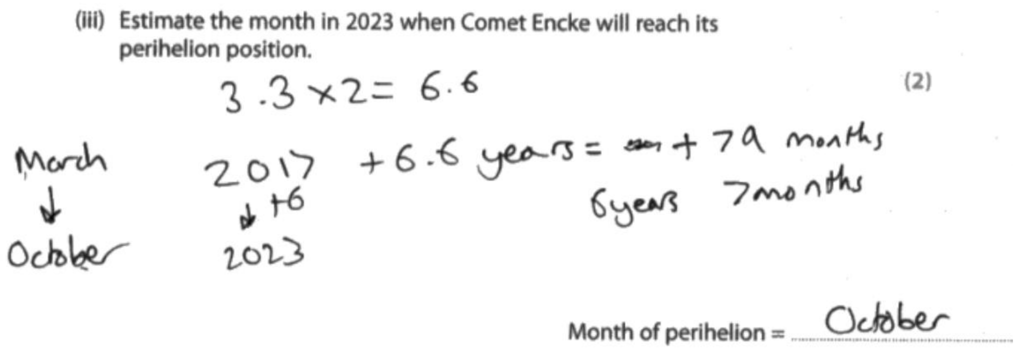
March + 8 months = Nov

Month: November Year: 2018

As well as arriving at the correct final answer, the candidate above has set their work out very clearly. Had their final answer been incorrect, the clear halving of the comet's period would have gained them one mark. Separating years and months was a very effective way of ensuring that these time periods were added correctly.

10ciii

In this question candidates needed to work out that it would take Comet Encke two complete orbits to arrive in the year 2023, i.e. 6.6 years after the March 2017 perihelion. There was therefore a mark available for candidates who had clearly realised this but had not gone on to find the correct answer to the question.



(iii) Estimate the month in 2023 when Comet Encke will reach its perihelion position.

(2)

3.3 × 2 = 6.6

March ↓ October

2017 ↓ +6 2023

+ 6.6 years = + 79 months

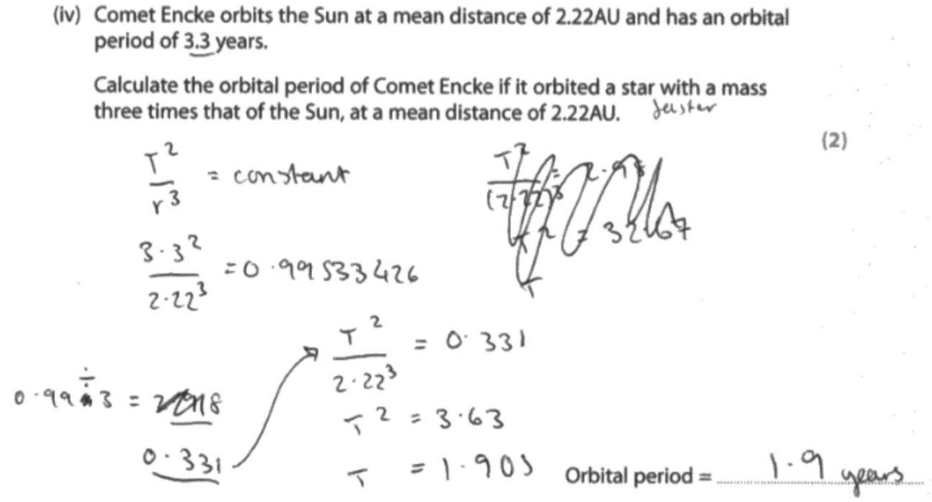
6 years 7 months

Month of perihelion = October

Although this candidate's response provides the correct answer, it would still have gained one mark without it as the two orbits of 3.3 years (= 6.6 years) are clearly shown at the start of the working.

10civ

This demanding question tested candidates' awareness that the constant of proportionality in Kepler's Third Law was inversely proportional to the mass of the central body. A mark was available for attempting to reduce this constant by a factor of three. However, many candidates presented such confused working that it was not possible to award this mark.



(iv) Comet Encke orbits the Sun at a mean distance of 2.22AU and has an orbital period of 3.3 years.

Calculate the orbital period of Comet Encke if it orbited a star with a mass three times that of the Sun, at a mean distance of 2.22AU.

(2)

$\frac{T^2}{r^3}$ = constant

$\frac{3.3^2}{2.22^3} = 0.99533426$

$0.99 \div 3 = 0.331$

$\frac{T^2}{2.22^3} = 0.331$

$T^2 = 3.63$

$T = 1.905$

Orbital period = 1.9 years

As well as finding the correct answer of 1.9 years, this candidate has also provided an excellent example of how to set out the working of this complex question. The sequence of operations is clear and unambiguous, with effective use of an arrow. It is clear that the constant relating T^2 and r^3 has been reduced to a third and so this candidate would have received one mark, even if their final answer had been incorrect.