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Examiners Report  
Principal Examiner Feedback

Summer 2024

Pearson Edexcel  
GCE Astronomy 1AS0 02  
Paper 2: Telescopic Astronomy

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June 2024

Publications Code 1AS0\_02

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## General Comments

### Summary

The enthusiasm and commitment which has always characterised those involved with the teaching and learning of GCSE Astronomy continues to be evident in candidates' responses to the examination papers. 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 coped very well with the often very demanding mathematical skills required by the questions in this year's papers.
- Strong graphical skills were demonstrated in both the creation and use of graphs.

It was also evident that, for some candidates, questions on some topic areas were rather unexpected and centres are reminded of the need for candidates to have been exposed to all parts of the Specification before the examination.

Comprehensive Topic Support Guides have been produced to support teaching and learning in several topic areas and these can be downloaded from the GCSE Astronomy pages of the Pearson website. As well as providing detailed subject background they contain worked examples and practice examination questions.

### 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. 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 'Compare...' will require both sides of the particular argument to be stated for full marks.
- 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, rather than unexplained numbers or calculations.

## 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 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 shapes 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.

## 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 worth three or even four marks, the provision of clear structured working is 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**

### **Q1a**

Almost all candidates were able to identify these two familiar astronomical objects from the images provided.

### **Q1b**

Almost all candidates were able to identify these familiar astronomical objects from the descriptions provided.

### **Q1c**

Although almost all candidates scored at least one mark on this question, only those who fully appreciated that the sketch was of the view through a very small aperture telescope scored full marks.

The addition of detail to Jupiter's disc, such as the horizontal bands or Great Red Spot lost a mark, as these features are only visible through telescopes with a much larger aperture.

### **Q2a**

Most candidates were clearly well aware of the relative masses of the terrestrial planets but far fewer appreciated that Uranus, although physically larger, has a smaller mass than Neptune, even though this information is on the formulae and data sheet.

### **Q2b**

The Apollo and New Horizons missions, as mentioned in the specification, were well known by most candidates, although a small minority thought that the Voyager probes had visited Pluto during their mission to the outer planets.

### **Q2c**

These questions showed that most candidates had a good understanding of the location and contents of these divisions within the solar system.

### **Q2d**

The use of a reflected light beam to measure the distance to the Moon was widely understood. However, the majority of candidates thought that the distance to the Andromeda galaxy (a member of the Local Group) could be measured using cosmological redshift.

Andromeda's gravitational link to the Milky Way means that it actually shows a blueshift and does not obey Hubble's Law.

### **Q3ai**

Although probably an unfamiliar telescope to most, almost all candidates recognised the need for the string to keep the eyepiece and objective lenses correctly aligned.

### **Q3aii**

Whilst almost all candidates attempted to divide the focal length of the objective lens by the focal length of the eyepiece, a significant number neglected to ensure that these two numbers were in the same units. Some candidates even arrived at a magnification less than 1.0 but did not go back and check their working.

### **Q3aiii**

A number of answers to this question did not gain any marks, for several reasons:

- they were unsupported: 'It would not be suitable.'
- they were not based on astronomical principles – 'The image would not be very good.'
- they did not acknowledge the mention of 'detailed observations' in the question – 'You would not be able to see Uranus'.

Although this telescope would probably be capable of rendering Uranus visible, it would be very unlikely to show any surface features or satellites, making 'detailed observations' impossible. As pointed out by many candidates, this would be a consequence of its relatively low magnification and its insufficient aperture – limiting both its light grasp and resolution.

### **Q3b**

This was a question where many candidates did not gain marks due to vague or unqualified answers such as 'they give better images', 'they are lighter' or 'they have bigger apertures'. Nevertheless, pointing out that reflectors do not suffer from chromatic aberration was a popular response.

### **Q4ai**

Many candidates gave answers that did not score marks on this question due to lack of detail or sufficient precision. A large number commented that one or other of the images was 'more detailed' without being any more specific.

Curiously, the division of candidates choosing the Harriot or the Galileo image as the 'more detailed' was roughly equal. A substantial number of candidates showed an appreciation of the fact that Galileo's image has been drawn at the quarter phase, allowing an impression of relief to be given, whilst only showing half of the Moon's nearside face.

### **Q4aii**

It is pleasing to see a growing awareness of the importance of early seventeenth-century lunar drawings in casting doubt on a geocentric model of the solar system. The many terrestrial features shown in these drawings raised questions about the assumption that the Moon was a perfect celestial disc.

**Q4bi**

Many candidates were fully aware of the implications of the changing size of Venus during its phase cycle, although some still focused only on its changing shape (which is consistent with both a geocentric and a heliocentric model).

**Q4bii**

Although some excellent responses were provided for this question, it was evident that a significant number of candidates had limited experience of this important method for determining an accurate value for the Astronomical Unit.

Although good use was made of labelled diagrams when answering this question, a number of candidates did not make it clear that their two observers on the Earth were situated at different latitudes. Without the marking of the poles or the equator on the Earth, some diagrams were consistent with observers situated on the same line of latitude, for whom this method would not work.

**Examiner Comments**

Candidates are advised to ensure that they are familiar with all important telescopic observations that are specifically mentioned in the Specification. Examples would include: Galileo's early telescopic observations and the use of transits of Venus to determine the size of the Astronomical Unit.

**Q5a**

The dipole nature of the Earth's magnetic field was widely understood although many ignored the incoming Solar Wind and drew a symmetrical field. A large number of candidates were unclear about the position of the Van Allen belts, although most understood that aurorae are best observed from locations close to the poles.

**Examiner Comments**

It is good practice to ensure that all features labelled on a diagram have been considered when deciding on an answer. The arrow on Figure 6 indicating the direction of the Solar Wind was not accounted for in the magnetosphere drawings of many candidates.

**Q5bi**

Most candidates were able to provide some of the links in the chain connecting sunspot activity and aurorae. The fact that sunspot activity is an indicator of solar activity in general was probably the least well understood.

**Q5bii**

Many candidates' responses were essentially repetitions of the question, without giving any specific information about how the solar wind can affect particular systems such as radio waves, satellites, or power lines etc.

**Q5biii**

A high proportion of candidates were aware of the solar wind's role in cometary tails, although many were convinced that it was only important in the production of the ion tail. The stripping of early atmospheres from the inner planets such as Mercury was also a popular answer.

### Q6a

The lengthy wavelength of radio waves was well understood by candidates, although not all made its important link to the resolution of the telescope clear. Answers based around the much lower intensity of radio sources were also credited as reasons for needing a large diameter receiving dish.

### Q6bi

Some candidates calculated the actual area of each dish and then divided them whilst others found the ratio of their diameters and then squared it to find the ratio of approximately nine.

### Examiner Comments

Candidates are reminded of the importance of stating clearly what they are doing when completing a 'Show...' question like this. Simply multiplying or dividing numbers for no obvious reason is not necessarily showing anything astronomical as such.

For example:

- $76^2 / 25^2 = \mathbf{9.24}$

This is the correct calculation but is not particularly showing anything, as there is no astronomical justification for any of the mathematical operations.

A much more convincing answer to this 'Show...' question would be:

- Area of Lovell telescope is related to  $76^2 = 5776$
- Area of VLA dish is related to  $25^2 = 625$
- Ratio =  $5776 / 625 = \mathbf{9.24}$

### Q6bii

The term 'aperture synthesis' was in evidence in this question with many candidates very clear about the very large 'virtual aperture' of the VLA that allows its team of relatively small dishes to achieve such impressive resolutions in radio wavelengths.

### Q6biii

Only a small number of candidates were able to provide the correct answer for this question. Although many calculated that the VLA's virtual aperture of 21km was 276 times larger than the Lovell's 76m, the majority then multiplied the Lovell's angular resolution by this, rather than dividing it.

It is important that candidates are aware that a high-resolution telescope will have a small angle as its angular resolution, not a large one.

### **Q7a**

The wide selection of data in Table 2 provided candidates with plenty of content on which to base their answers to this extended answer question. Most candidates worked through the list of stars in order, helping to give a clear structure to their answers.

Although some candidates confused the two stellar magnitudes given, most realised that the Apparent Magnitude was not relevant when determining a star's classification as a red giant.

### **Examiner Comments**

Candidates can often use the question, or the information given to provide a clear structure for their extended written answers. In this case, analysing each star in turn provided this structure.

### **Q7bi**

Almost all candidates were familiar with the use of Greek letters in the Bayer classification, although care needed to be taken over the exact quantity for which they provide a rank order. Strictly, these letters rank the stars in order of apparent magnitude. 'Brightness' is a much more general term and 'absolute magnitude' or 'luminosity' is not correct.

### **Examiner Comments**

Candidates should always be very wary of using terms like 'brightness' in the GCSE Astronomy examination, as it is very vague. It is almost always best replaced with a more specific term such as apparent magnitude, absolute magnitude, or luminosity, depending on the context of the question.

### **Q7bii**

Most candidates were clearly familiar with the use of the distance-modulus equation for converting between apparent and absolute magnitudes. When using the distance-modulus equation, care needs to be taken when substituting for apparent magnitude ( $m$ ) and absolute magnitude ( $M$ ). Confusing these two terms was at the heart of many incorrect answers to this question.

### **Examiner Comments**

As with all calculations, providing clear working was essential for those candidates with incorrect answers who hoped to gain partial credit.

### **Q7biii**

Although it was possible to solve this question using the distance modulus equation, it simply required candidates to realise that a difference of three magnitudes is equivalent to a brightness difference of sixteen, which is produced by moving an object four times further away.

### **Q8a**

Most candidates wrote about the role of Saturn's gravity in attracting solar system debris into its ring structure. However, others also mentioned its tidal effect in turning potential moons into further supplies of ring material.

**Q8b**

A number of candidates discussed the complex gravitational field in this region of the Saturnian system, although many simply commented on Hyperion's irregular shape.

**Q8c**

A large number of candidates attributed the labelled gaps to the presence of planets or dwarf planets, even though the labelled range of the chart in Figure 12 is comfortably between the orbits of Mars and Jupiter. With the possible exception of Ceres, it is therefore impossible for any planet to be orbiting anywhere near these gaps.

**Examiner Comments**

Candidates should always look at all the information provided for a question. In this case, the fact that the distance axis in Figure 12 is between 2 and 3.5 AU – a range that does not contain the orbits of any planets. The formulae and data sheet can be used to confirm this.

**Q8di & Q8dii**

The stable orbital motion of objects at these points in the Earth-Sun system was well understood and used by many candidates to explain the accumulation of asteroids and the reduced fuel requirements of space probes at these points.

**Q8biii**

A range of effective answers was provided to this question – being above the Earth's atmosphere, orbiting a Lagrangian point and avoiding the infrared radiation of the Sun.

**Q9a**

Almost all candidates gained some credit on this very familiar calculation of the length of the sidereal day from star trail information, with many finding the correct answer. The need to use the data in Table 3 to find an average star trail length as a first step was not appreciated by some candidates who simply used the first angle in the table. As always in questions like this, the need to convert between hours and minutes provided an obstacle for some candidates.

**Examiner Comments**

As with all calculations, providing clear working was essential for those candidates with incorrect answers who hoped to gain partial credit.

**Q9b**

The various details of Hanaya's method for determining the length of the sidereal day, as shown in Figure 14 and Table 3 each provided material on which candidates could comment in their answer to this question.

Showing good scientific skills, a number of candidates recommended taking further star trail measurements in order to arrive at a more reliable average whilst others suggested a longer exposure time and fewer obstructions in the photograph.

**Examiner Comments**

Candidates can often use the question, or the information given to provide a clear structure for their extended written answers. In this case, analysing each step in Hanaya's method provided this structure.

### Q9c

The differing definitions of sidereal and synodic time were well understood by the majority of candidates, with only a handful confusing the answer to this question with the sidereal and synodic month.

Most candidates took the sensible route of explaining the difference between these two time periods by giving a clear definition of each one. Some effective diagrams were provided to support these explanations, the most effective having clear labels for each of their parts.

### Examiner Comments

Candidates are advised to clearly label all parts of their diagrams, not relying on the examiner to assume what is meant by any part of it. A circle, for example, could represent a planet, a moon, an orbit, a lens, a crater, or a shadow, unless it is clearly labelled.

### Q9d

The fact that the position of the Pole Star does not align exactly with the Earth's axis of rotation was well known as the cause of the slight trailing of the star in Figure 14.

### Q10a

There was a widespread understanding of the importance of data about exoplanets in estimating quantities such as the proportion of stars with habitable planets around them.

These data were obviously not available when the Drake Equation was first proposed. Less effective answers to this question simply referred to improved technology and better-quality images, without focusing specifically on exoplanets.

### Q10aii

This question specifically asked for the **evidence** that almost all habitable planets contain life, i.e. that the Earth, as the only habitable planet in our solar system, contains life.

### Q10aiii

The lack of any substantial data to support these estimates was widely understood by candidates.

### Examiner Comments

As with Q10ai and ii, the more successful answers were more specific and avoided very general comments such as 'they are hard to estimate' etc.

### Q10bi

With the 'Show...' command word, this question required candidates to give clear indication of how and why they were using the numbers in Table 4 to arrive at a figure of around 0.9. Many candidates who had the correct answer simply wrote out their multiplication ( $1.1 \times 0.4 \times 2$ ) without any astronomical justification.

In particular, the origin of the 0.4 in this multiplication required further justification ( $1 - 0.6$ ) since it is not a number that appears in Table 4. Several candidates attempted to find the result of 0.9 by largely random manipulation of the numbers in Table 4, performing operations such as subtraction or division that had no astronomical justification.

**Examiner Comments**

Always include an astronomical justification for any numerical operation in a 'Show...' question. Simply writing out the sum alone may not be enough to gain marks in these types of questions.

**Q10bii**

The combination of the result of 0.9 (0.88) from Q10bi with the data in Table 5 in order to produce an estimate of around 6 600 000 for N was correctly performed by many candidates. The more successful answers showed clear working, thus ensuring partial credit in the event of an incorrect final answer.

**Examiner Comments**

As with all calculations, providing clear working was essential for those candidates with incorrect answers who hoped to gain partial credit.

**Q10c**

There was a wide range of possible answers for this question, relating to the Earth's atmosphere, interstellar dust, and the natural occurrence of this particular wavelength of radio waves. A few candidates lost marks by essentially making the same point twice or giving points that were very similar to the question.

**Examiner Comments**

In questions that specifically require two points, candidates should ensure that their points are different from each other and not the same as points made in the question stem.