Answer THREE questions from Section A and THREE questions from Section B.

You are advised to spend no more than 10 minutes on each Section A answer, and about 30 minutes on each Section B answer.

The numbers in square brackets indicate the provisional allocation of maximum marks for sub–sections of the question.

SECTION A

1. Provide a simple labelled drawing of a German-type equatorial telescope mount, showing the relationship to the compass directions and to the earth's axis of rotation. (Assume location in the northern hemisphere) [3]

   For a real telescope, give three reasons why motion of only one axis of an equatorial mount is not sufficient to track a star accurately? [3]

   What would an equatorial telescope look like if sited on the equator? [1]

2. Sketch the optical layout of (i) a true Cassegrain reflector telescope and (ii) a Cassegrain which has the Nasmyth focus arrangement. Show in both sketches how the light passes through each telescope to the final focus. What is the advantage of the Nasmyth configuration? [5]

   Give two reasons why the refractor system was abandoned for the production of large telescopes. [2]

3. Describe briefly two major motivations for observing from space rather than from the ground. [2]

   Write four examples of ways in which space-telescopes have to survive environmental conditions that are considerably harsher than earth-based telescopes. [4]

   Give the name of one typical model philosophy used to mitigate the risk of failure. [1]

4. What is the spectral type of stars that are responsible for the ionization state of H II regions? State the upper wavelength limit for photons able to ionize atomic hydrogen, and the energy (in any system of units) associated with that limit. [2]

   What do the terms *photoionization* and *recombination* mean in the context of a pure hydrogen nebula? During which process is radiation emitted? [3]

   State the two main types of emission line that dominate the spectra of photoionized nebulae. What type of emission lines do hydrogen and helium produce in typical photoionized nebulae? [2]

5. Which are the main sources of interstellar dust in the Cosmos? List two broad categories of ISM dust and describe the type of elements each category is thought to be based on. [4]

   Briefly discuss how the presence of dust affects the abundance of certain elements in the ISM, and state which broad category of elements is affected the most. [3]

6. What is the main difference between a reflection nebula and a diffuse emission nebula (H II region)? [4]

   Quote the percentage (by number) of hydrogen atoms, helium atoms, and heavier elements in the generic ISM. [3]

SECTION B

7. Outline the simple difference between active and adaptive optics. [1]

   Explain the principle of the passive Whiffle Tree to support the mass of a large telescope mirror. Show why, with different levels of complexity, simple systems can be built with 3, 9, 27, 81, etc, points of support. [6]

   Give examples of the environmental disturbances that make the passive support system inadequate on its own. What methods are used to correct the form of the mirror in the presence of these disturbances? [6]

   Illustrate with sketches the principles of monolithic honeycomb mirrors, monolithic thin-meniscus mirrors and segmented mirrors. [3]

   Which of these three approaches is scalable to extremely large telescopes and why? Give three examples of limiting factors in the others. [4]

8. Give three examples of the factors in a telescope that govern how much light it can deliver to an instrument. [3]

   Compare and contrast a simple Newtonian telescope and a Schmidt camera, and discuss the performance features governing light-gathering power, field-of-view, and wavelength-coverage. [10]

   Why does the Schmidt camera mirror that is larger than its corrector plate for the same light-gathering power, and what particular advantage does this confer? [2]

   Comment on a particular disadvantage of the Schmidt with regard to the implementation of a detector. [1]

   How can this disadvantage be resolved when using large photographic plates? What steps could be taken to implement an array of small CCDs instead of a photographic plate? [4]

9. Explain the difference between Form and Texture on an optical surface. At a simple level, what do these affect in terms of the performance of an instrument? Estimate quantitatively the typical texture of a very good optical surface. [4]

   Explain the difference between peak-to-valley and rms as two ways to describe a surface-error. [2]

   What is meant by an 'aspheric surface' on a lens or mirror? Give an example in a telescope where an asphere is used. [2]

   When a full-size polishing tool rubs across a severely aspheric mirror, what happens to the physical contact between tool and mirror? What does this do to the asphere as polishing progresses? Describe two simple approaches that can be used to overcome this problem in manual polishing. [4]

   Compare and contrast the principle features of the stressed mirror method and the stressed lap method, as applied to polishing large aspheric mirrors.[8]

10. Discuss the main observational evidence for the existence of Giant Molecular Clouds in the Galaxy. What is the single most important diagnostic in the search for molecular hydrogen in the ISM and how has it been used?[7]

    Outline the process of triggered star formation in molecular clouds. Include references to the effects of OB-type stars and supernovae in this process.[6]

    What is the relationship between Giant Molecular Clouds and H II regions? Indicate a key observational fact that points towards a close relationship.[4]

    In which part of the electromagnetic spectrum would you concentrate your efforts in order to detect a group of nascent stars in a molecular cloud, and why? [3]

11. List the four main classes of low- and intermediate-mass protostars corresponding to the various stages of star formation, and outline the basic physical processes characterizing each class. [5]

With which of the above classes are the T-Tauri stars associated? What are 'proplyds' and where have these objects been observed? [4]

Give an approximate range for the mass of T-Tauri stars (in units of solar mass). What is the order of magnitude difference between their annual mass loss compared to that of the Sun? [2]

Sketch a simple cartoon of an idealized site of isolated star formation showing the protostar, the accretion disk, the bipolar outflows, and the Herbig-Haro objects. Briefly describe each component and its function. [6]

Which of above components is the main observational signpost of a star formation site, and why? [3]

12. Outline the main steps involved in the determination of the abundance of oxygen relative to hydrogen in an H II region from measurements of its forbidden lines. Include references to terms such as electron density, electron temperature and observed line fluxes. [9]

Briefly outline the geometric situation underlying the observation of (a) an absorption line spectrum and (b) an emission line spectrum of a gas cloud in space illuminated by a star. [4]

Name the single most important physical factor that influences whether absorption or emission lines are seen. [2]

Briefly describe the spin-flip transition of atomic hydrogen. In which part of the electromagnetic spectrum is its associated radiation seen? Why is it important in ISM studies? [5]

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