King's College London

UNIVERSITY OF LONDON

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the authority of the Academic Board.

B.Sc. EXAMINATION

CP/1600 Physical Basis of Astronomy

Summer 1998

Time allowed: 3 Hours

Candidates should answer SIX parts of SECTION A, and TWO questions from SECTION B.

Separate answer books must be used for each Section of the paper.

The approximate mark for each part of a question is indicated in square brackets.

You must not use your own calculator for this paper.
Where necessary, a College calculator will have been supplied.

TURN OVER WHEN INSTRUCTED

You may use the following equalities:

Wavelength of visible = 0.5 μm.
Speed of light (c) = 3$\times$ 10^8 m s^{-1}.
1 parsec = 3.26 light years.
Sun's mass ($M_\odot$) = 2$\times$ 10^{30} kg.
Sun's radius ($R_\odot$) = 5$\times$ 10^8 m.
Stefan's constant (σ) = 5.7$\times$ 10^{-8} W m^{-2} K^{-1}.
1 astronomical unit (AU) = 1.495 $\times$ 10^8 km.
A zero magnitude star produces 10^8 photons m^{-2} s^{-1} nm^{-1}.
The following relationship for a spherical triangle may be assumed

$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$

where the symbols have their usual meaning.

SECTION A – Answer SIX parts of this section

1.1) With reference to the elements of an eliptical orbit, explain the terms **perihelion** and **aperhelion**. Explain why the interval of time taken for the Sun to return to its highest position in the sky on consecutive days varies throughout the year.

[7 marks]

1.2) State Wien's law for a blackbody radiator. Estimate the peak wavelength of the cosmological background radiation if this radiation corresponds to that of a blackbody with a temperature of 2.7 K. (You may assume that the Sun is a blackbody with a temperature of 6000K and a peak wavelength of emission of 480 nm.)

[7 marks]

1.3) Draw a diagram to illustrate the principles of operation of a photomultipler detector. What is the main reason why the photomultiplier is inappropriate for infra-red astronomical observations?

[7 marks]

1.4) Explain what is meant by a G2 category of star. What would be the types of star corresponding to the categories **i)** B0 and **ii)** M0? Explain the term *colour index* and the significance of the U, V, and B letter assignments to a star.

[7 marks]

1.5) Describe the dominant energy production process in a main sequence star such as the Sun. Briefly describe an experiment that confirms the nature of the energy production mechanism in the Sun. Give a reason why the energy production is not able to run out of control.

[7 marks]

SEE NEXT PAGE

1.6) Describe the shape of our galaxy, the Milky Way. Give an indication of the position of the Sun, and indicate the regions where globular star clusters **and** open star clusters are more likely to be found.

[7 marks]

1.7) State Kepler's three laws of planetary motion.

[7 marks]

1.8) Three of the satellite moons of Jupiter - Io, Europa and Ganymede - orbit at distances of 421,600, 670,900 and 1,070,000 km from the centre of the planet, respectively. Calculate the approximate orbital periods, in days, of the outer two moons if Io has a period of 1.77 days.

[7 marks]

SECTION B – Answer TWO questions

2) Describe the purpose and operation of the "Precision Analogue Photon Address" (PAPA) detector. State the wavelengths over which this type of detector can be used and give physical reasons for any cut-off in response. What are the main advantages of the PAPA detector over that of a "Charge Coupled Device" (CCD) detector?

[15 marks]

Estimate the exposure time required to detect 1 000 photons from a star of apparent magnitude +15 when it is imaged by a 2 metre diameter telescope. Assume an overall transmission and detection efficiency of 5% and the use of a filter transmitting in the wavelength range 450-650 nm. [Note: a zero magnitude star gives rise to about 10^8 photons per square metre per second, per nanometre bandwidth.]

[15 marks]

3) Draw a clearly labelled sketch of the celestial sphere, including the celestial equator, the poles, the vernal equinox and the ecliptic. Mark on the sketch the horizon, meridian and zenith for an observer at 50^0N 25^0E when the Greenwich sidereal time is 18h 30m.

[15 marks]

Around June 21st in one particular year, the equatorial coordinates of Venus were (3h, 23.5^0). Draw a diagram to show whether Venus was visible in the morning or the evening for an observer at latitude 45^0 N, longitude 15^0 E. Calculate the interval of sidereal time for which Venus was visible either before sunrise or after sunset.

[15 marks]

4) Draw a Hertzsprung-Russell diagram showing the relative positions of the main sequence, the Sun, the red-giant region and the white-dwarf region.

[10 marks]

Describe the main features of galactic (open) star clusters and globular star clusters.

[10 marks]

Discuss the significance of cluster H-R diagrams to theories of stellar evolution and sketch typical H-R diagrams for clusters containing (a) young stars, (b) old stars and (c) middle aged stars.

[10 marks]

SEE NEXT PAGE

5) In relation to solar system planetary orbits define, using diagrams as necessary, the following terms: semi-major axis, eccentricity, inclination, ecliptic plane and astronomical unit.

[10 marks]

The minimum and maximum heights of an artificial Venusian satellite above the solid surface of the planet are 696 and 2 601 km respectively. The satellite has an orbital period of 123 minutes. If the the semi-major axis and sidereal period of the Venusian orbit about the Sun are 0.723 AU and 0.615 years, respectively, calculate the radius of Venus.
(1 AU is 1.495×10^8 km and the mass of Venus is $2.48 \times 10^{-6} M_\odot$)

[20 marks]