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 1997

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:

The wavelength of visible light may be taken as 0.5 μm.
The speed of light (c) = 3×10^8 m s^{-1}.
The mass of the Sun ($M_\odot$) = 2×10^{30} kg.
The radius of the Sun ($R_\odot$) = 5×10^8 m.
Stefan's constant (σ) = 5.7×10^{-8} W m^{-2} K^{-1}.
1 parsec = 3.26 light years.
1 astronomical unit (AU) = 149.5 $\times$ 10^6 km.
A zero magnitude star produces 10^8 photons m^{-2} s^{-1} nm^{-1}.

SECTION A – Answer SIX parts of this section

1.1) Explain the terms *solar time* and *sidereal time*. Calculate the length of the sidereal day in hours and minutes.

[7 marks]

1.2) How are the coordinates of right ascension and declination defined? Write down the approximate equatorial coordinates of the Sun on a date near the 21 September.

[7 marks]

1.3) Light from a star with apparent magnitude 15 is imaged using a two metre diameter telescope through an optical filter transmitting in the range 450 nm to 550 nm. Assuming an overall transmission efficiency of 50% and a detection efficiency of 10%, estimate the photon arrival rate.

[7 marks]

1.4) State both Stefan's law and Wien's law for the radiated flux from a black body at a finite temperature T K. Assuming that stars radiate as perfect black bodies, estimate the peak wavelength of emission of a red giant star with surface temperature of
2,890 K, given that the peak emission of the Sun is at 480 nm, corresponding to a surface temperature of 5,780 K.

[7 marks]

1.5) Explain, using a diagram, how hydrostatic equilibrium contributes to maintaining a controlled energy output from a main sequence star. State one other process that moderates the rate of energy production in such a star.

[7 marks]

1.6) Define the *parsec*. Calculate the apparent visual magnitude of a star with an absolute visual magnitude of +5, which is at a distance of 100 parsecs from the Earth.

[7 marks]

1.7) List the main characteristics of open star clusters that distinguish them from globular clusters of stars.

[7 marks]

1.8) Draw a Hertzsprung-Russell diagram for a cluster of relatively old stars. Compare this with a similar diagram for a significantly younger cluster of stars.

[7 marks]

SECTION B – Answer TWO questions

2) Make a sketch of the celestial sphere, including the celestial poles, the celestial equator and the position of the vernal equinox. Mark on the sketch the horizon, meridian, zenith and nadir for an observer at (50° N, 15° E) when the Greenwich sidereal time is 1h.

[15 marks]

A star with equatorial coordinates (20h, 50°) is viewed by the above observer. What are the altitude and azimuth of the star? You may use the following standard relationships for a spherical traingle:

$$\cos a = \cos b \cos c + \sin b \sin c \cos A, \quad \text{and} \quad \frac{\sin A}{\sin a} = \frac{\sin B}{\sin b} = \frac{\sin C}{\sin c}$$

[15 marks]

3) Write an essay to describe common methods of stellar mass determination.

[30 marks]

4) State Kepler's three laws for bodies orbiting the Sun in our solar system.

[10 marks]

Illustrate why, when viewed from the Earth, the positions of certain planets in our solar system appear to loop back and forth with changes in the seasons.

[10 marks]

A communications satellite in orbit remains above a fixed point on the Earth's surface. Given that the distance of the satellite from the Earth's centre is 41,800 km, calculate the ratio of the masses of the Sun and the Earth. You may assume circular orbits.

[10 marks]

5) Explain what is meant by the resolution of an optical telescope and discuss how this depends upon instrumental and environmental factors.

[7 marks]

State the advantages and disadvantages of alt-azimuth and equatorial mountings for optical telescopes.

[7 marks]

Estimate the diffraction-limited angular resolution of an optical (visible light) telescope with a primary mirror diameter of 4 metres. What baseline would a radio interferometer, operating at a frequency of 3 GHz, need to achieve the same angular resolution?

[8 marks]

Explain how the Cepheid variable stars provide a reliable method of estimating astronomical distances.

[8 marks]