

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 1999

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
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0th magnitude objects produce 10^8 photons $\text{m}^{-2} \text{s}^{-1}$ per nm wavelength.

Stefan's constant $\sigma = 5.7 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-1}$.

Electron charge $e = 1.6 \times 10^{-19} \text{ C}$.

Mass of Sun $M_{\odot} = 2.0 \times 10^{30} \text{ kg}$.

Radius of Sun $R_{\odot} = 5.0 \times 10^8 \text{ m}$.

1 AU = $1.5 \times 10^8 \text{ km}$.

1 parsec = 3.3 light years.

Speed of light $c = 3 \times 10^8 \text{ m s}^{-1}$.

SECTION A – Answer SIX parts of this section

- 1.1) Explain how, from the timing of the orbits of the moons of Jupiter, an estimate of the speed of light can be obtained.

[7 marks]

- 1.2) Explain the role of deuterium in the production and regulation of the energy output of a main sequence star.

[7 marks]

- 1.3) Given that the radiant energy arriving at the Earth from the Sun is 1 kW m^{-2} , estimate the power output of the Sun. Calculate the surface temperature of the Sun by assuming that it radiates as a black body.

[7 marks]

- 1.4) Describe the main features of

- a) Globular star clusters,
- b) Open (or galactic) star clusters.

[7 marks]

- 1.5) The orbit of the Moon about the Earth has the same sense of rotation as that of the orbit of the Earth about the Sun. Calculate the orbital period of the Moon about the Earth relative to a fixed point on the celestial sphere, if the phases of the Moon repeat every 29.5 days.

[7 marks]

- 1.6) Show that the distance d to an astronomical object is given by

$$d \approx 10^{(m-M+5)/5} \text{ parsecs}$$

where M is the absolute magnitude and m is the apparent magnitude of the object.

[7 marks]

1.7) With aid of suitable diagrams, describe the circumstances that give rise to partial, total and annular solar eclipses. Why are lunar eclipses observed more commonly than solar eclipses?

[7 marks]

1.8) Explain what is meant by a G2 category of star. Compare stars in the categories B0 and M0 with the Sun. Explain the term *colour index* and the significance of the U, V, and B magnitude assignments of a star.

[7 marks]

SECTION B – Answer TWO questions

- 2) Explain the basis of the equatorial and horizon coordinate systems. Draw a clearly labelled diagram of the celestial sphere to illustrate the elements of these coordinate systems.

[10 marks]

Given that the cosine and sine formulae for a spherical triangle, using the usual angle definitions, may be written in the following form

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

obtain a relation between the altitude of a star, its declination, an observer's latitude and the hour angle.

[10 marks]

The equatorial co-ordinates of the star β Pollux are (7h45m, $28^\circ 0'$). Calculate the local times of rising and setting of the star for an observer at Greenwich ($51^\circ 30' \text{ N}$, $0^\circ 0' \text{ W}$) on March 22nd.

[10 marks]

- 3) Write short notes on each of the following

a) the interpretation of the Hertsprung-Russell diagram for star clusters,

[10 marks]

b) a solar neutrino experiment,

[10 marks]

c) supernovae.

[10 marks]

- 4) Describe, with the aid of a suitably labelled diagram, the principles of operation of a photomultiplier tube detector. Explain the main advantages and disadvantages associated with this type of detector and compare these with those of a charge coupled device detector.

[15 marks]

A photomultiplier tube is used, in conjunction with a telescope which has a mirror of 2 metres diameter, to measure the flux in the wavelength range 400-500 nm which is received from a star of apparent visual magnitude +12. The combined transmission and detection efficiency is 10%. Estimate the output current of the photomultiplier, if it has 10 amplification stages each with an average gain of 5 for secondary electron emission.

[15 marks]

- 5) Write an essay on the methods commonly used for the determination of the masses of stars.

[30 marks]