UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:-

B.Sc. *M.Sci.*

Astronomy 1B11: Foundations of Astronomy

COURSE CODE	:	**ASTR1B11**
UNIT VALUE	:	**0.50**
DATE	:	**23-MAY-03**
TIME	:	**10.00**
TIME ALLOWED	:	**2 Hours 30 Minutes**

03-C0078-3-90

TURN OVER

Attempt all questions for part A, and any three from part B.

The numbers in square brackets in the right-hand margin indicate the provisional allocation of maximum possible marks for different parts of a question.

The following may be assumed if necessary:

Speed of light, $c = 2.998 \times 10^8$ m s^{-1}
Gravitational constant, $G = 6.670 \times 10^{-11}$ N m^2 kg^{-2}
Astronomical unit, AU $= 1.496 \times 10^{11}$ m
Solar mass, $M_\odot = 1.989 \times 10^{30}$ kg
Solar luminosity, $L_\odot = 3.90 \times 10^{26}$ W
Stefan-Boltzmann constant $\sigma = 5.670 \times 10^{-8}$ W m^{-2} K^{-4}

SECTION A

1. Explain, very briefly, the meaning of the following astronomical designations, and the nature of the objects to which they refer: α Ori; HR 123; RR Tau; 61 Cyg B; NGC 1976; Cygnus X-1. [6]

2. Write down the 'distance modulus' equation that relates the apparent and absolute magnitudes of a star to its distance; include the effect of interstellar absorption. [2]

   The B1 supergiant star HD 152236 has an apparent magnitude of $m_V = +4.73$ and an observed colour index of $(B - V) = +0.49$ magnitudes. Assuming the conventional relation between colour excess and interstellar absorption, and that stars of this spectral type have absolute magnitude $M_V = -0.19$ magnitudes and colour index $(B - V)_0 = -0.19$, find the distance to the star. [5]

3. Explain with the aid of a diagram what is meant by the Rayleigh criterion in the context of the resolving power of an astronomical telescope, and write down the criterion. [5]

   What is the theoretical angular resolution (in arcseconds) of the 2.4-m Hubble Space Telescope at a wavelength of 550 nm? [2]

4. Draw a labelled diagram showing the outer layers of the Sun, from the photosphere outwards, indicating the approximate dimensions and temperatures of the various layers. [6]

5. Draw a labelled diagram showing qualitative information about the internal structure of the Earth, and explain briefly how seismology has allowed this structure to be determined. [7]

6. Why are the surfaces of the Moon and Mercury covered by impact craters, while the surface of the Earth is not? [2]

   With the aid of a labelled diagram, explain how the impact cratering rate on the Moon has changed with time. How has this relationship been determined? [3]

   Would you expect the surface of Venus to be heavily cratered? [2]

SECTION B

7. Assuming that planetary surfaces heated by Sunlight re-radiate as blackbodies, show that the effective equilibrium temperature, $T_{\rm eff}$ (K), of a planet with albedo A orbiting at distance D from the Sun is [10]

$$T_{\rm eff} = [(1-A)L_{\odot}/16\pi\sigma D^2]^{1/4}$$

   where σ is the Stefan-Boltzmann constant. What implicit assumption has been made concerning the rotation rate of the planet?

   Given that the Earth has an albedo of $A = 0.39$, use this expression to estimate the Earth's average surface temperature. Comment on the value you obtain. If this temperature applied to the Earth, what is the approximate wavelength range in which most of the energy falling on the surface would be re-radiated? (Hint: use Wien's Law, which shows that a blackbody of temperature 3000 K would emit most of its energy at wavelengths near 1 micrometre). How does this answer help to explain the difference between the estimated and actual surface temperatures? [6]

   Suppose the Earth were ejected from the Solar System, and that the only heat source reaching its surface was the $0.06 W/m^2$ from internal radioactive decay. Calculate the effective temperature under these conditions. In which part of the electromagnetic spectrum would astronomers search for such an interstellar planet? [4]

8. Write an account of the major surface features of the planet Mars. Your answer should include a discussion of volcanoes, canyons, channels, impact craters, and the presence of a hemispheric asymmetry. [12]

   With the aid of a phase diagram for water, explain why liquid water cannot exist at the surface of Mars today. Given the evidence for liquid water in the distant past, what does this imply about the evolution of the Martian atmosphere and the possibility of past life on that planet? [8]

9. State the three rules of spectral analysis discovered empirically by Gustav Kirchhoff, and give a general astronomical example of each. [6]

Describe briefly how spectroscopy can help to determine

- the the presence of atoms and molecules and their abundances in astronomical objects; [3]
- the temperatures and densities of interstellar clouds from level populations and line widths; [5]
- the rotational velocities of stars. [3]

Suppose that the line of sight towards an HII region passes through a warm diffuse gas of H atoms and also a denser cold cloud of H atoms. Sketch the profile of the H atom 21 cm line that you might expect to observe. [3]

10. State Kepler's three laws of planetary motion. [6]

By considering circular motion of two masses m_1, m_2 under the influence of gravitation orbiting about their common centre of mass, show that Kepler's third law may be written [8]

$$P^2 = 4\pi^2 a^3 / G(m_1 + m_2)$$

where P is the orbital period and a is the separation of the two masses.

Using this form of Kepler's third law, determine

- the mass (in kg) of the Sun, assuming the Earth's mass to be negligible in comparison to that of the Sun; [3]
- the orbital period (in years) of a binary star system of two stars of masses 0.4 and 1.2 times that of the Sun, separated by 1000 Astronomical Units. [3]

11. Describe three indirect methods of detecting planets orbiting stars other than the Sun. Which of these methods has been the most successful, and why? [10]

Summarise briefly the discoveries of extra-Solar planets to date. How do these planetary systems differ from the Solar System? What are the major biases affecting the present results? [6]

Discuss briefly the methods for and prospects of detecting Earth-like planets around other stars, and for determining whether or not life has evolved on their surfaces. [4]

END OF PAPER