UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:–

B.A. *B.Sc.* *M.Sci.*

Astronomy 1B11: Foundations of Astronomy

COURSE CODE	:	**ASTR1B11**
UNIT VALUE	:	**0.50**
DATE	:	**18–MAY–05**
TIME	:	**10.00**
TIME ALLOWED	:	**2 Hours 30 Minutes**

TURN OVER

Answer ALL SIX questions from section A and THREE questions from section B.

The numbers in square brackets in the right-hand margin indicate the provisional allocation of maximum marks per sub-section of a question.

Symbols and quantities used in expressions:

Gravitational constant	G	=	6.7×10^{-11} N m^2 kg^{-2}
Speed of light	c	=	3.0×10^8 m s^{-1}
Solar bolometric luminosity	L_S	=	3.9×10^{26} W
Solar mass	M_S	=	2.0×10^{30} kg
Jupiter's mass	M_J	=	1.9×10^{27} kg
Earth's mass	M_E	=	5.8×10^{24} kg
	1AU	=	1.5×10^{11} m

SECTION A **[Part marks]**

1. With the help of a sketch, describe the equatorial coordinate system, explaining on what it is based, how the coordinates are measured and where their zero-points lie, including the definition of 'First Point of Aries' (or Vernal Equinox). **[6]**

2. An astronomer is using the United Kingdom Infrared Telescope (UKIRT, on Mauna Kea, Hawaii, at latitude +19° 28' 20", longitude $10^h\ 21^m\ 53^s$ West) to observe a star with right ascension $2^h\ 10^m\ 15^s$ and declination +12° 48' 54" when the Local Sidereal Time (LST) is $5^h\ 20^m\ 50^s$. What is the hour angle of the star? What is the LST at Greenwich (i.e. the GST) at this time? **[3]**

   At what LST will the star be highest above the horizon at UKIRT, and what will be its altitude then? (use a diagram to illustrate the situation) **[3]**

3. Briefly discuss the difference between chromatic and spherical aberration and say in which types of telescopes these effects occur. **[2]**

   Describe how these effects can be corrected in different types of telescopes, and give two practical examples of such applications. **[5]**

4. Draw a labeled diagram of the internal structure of the Earth and explain how seismology has allowed us to determine this structure. [7]

5. Illustrate with a diagram the circumstances of a lunar eclipse. [4]

   Explain why lunar eclipses do not occur every month, and describe what the Moon looks like during a full lunar eclipse. [3]

6. All of the four giant planets have planetary rings. Describe what these consist of, why they can exist and what distance from the centre of the planet they can exist to [it is not necessary to provide a numerical answer, only provide a physical description]. [4]

   Describe the characteristics of the atmosphere of Titan. [3]

SECTION B

7. a) Describe briefly the principal techniques used to establish the cosmic distance scale, distinguishing between 'direct' and 'indirect' methods. [11]

   What is meant by the 'Tully-Fisher relationship' and by 'Hubble's law'? [5]

   b) For relatively nearby galaxies, the hydrogen Balmer Hα line (6562 Å) can be redshifted out of the visible part of the electromagnetic spectrum. At what minimum redshift is the line redshifted into the infrared part ($\lambda > 7200$ Å) of the spectrum? To what distance does this correspond if the Hubble parameter H_o is equal to 72 km s^{-1} Mpc^{-1}? [4]

8. a) What are the differences between 'apparent', 'absolute' and 'bolometric' magnitudes of a star? Explain what the 'bolometric correction' is. What are the effects of interstellar dust on the magnitudes and colours of stars? **[6]**

b) If a star has an apparent visual magnitude V = -0.4 and a parallax of 0.3 arcsec, and if its colour excess is E(B-V) = 0.5, what are its distance modulus and its absolute visual magnitude? **[4]**

c) Consider a stellar binary system where the two components have V magnitudes of 3.1 and 5.1, and (B-V) colours of 1.1 and -0.1, respectively. Which star is the bluer and which one the hotter of the two, and why? Calculate the flux ratios of the two stars at B and V, and then find V and (B-V) for the combined light of the system. **[7]**

d) Define what luminosity is. What is the absolute bolometric magnitude of a star with a luminosity of 10^{33} W, if the Sun's absolute bolometric magnitude is 4.75? **[3]**

9. a) What different types of lines are observed in the spectra of stars and of hot ionised nebulae? Discuss the physical processes that lead to the difference. Briefly explain why we observe lines at well defined wavelengths. What is the 'ionisation potential' and what is its relevance to absorption/emission lines? **[5]**

Describe the Doppler effect, and write down the equation that expresses it for radiation of wavelength λ. Why is this effect important in astrophysics? In which ways does it alter the width of the lines observed in astrophysical spectra? **[5]**

b) Doppler velocities are used in finding extrasolar planets. To date most of the planets found are Jupiter-like. Determine by how much the velocity of the Sun is perturbed by Jupiter and the Earth respectively, remembering that the distance of Jupiter from the Sun is 4 AU. **[7]**

The spectral resolution for the Hα line at 6562 Å is 0.002 Å at the Observatoire de Paris solar telescope. Using the information determined above, show that it is possible to observe the perturbation of Jupiter, but not that of the Earth, on the Sun's velocity. **[3]**

10. State Kepler's empirical laws of planetary motion. [4]

Derive Kepler's second law from considerations of conservation of angular momentum. [6]

The eccentricity e of an ellipse is related to the semi-major axis a and semi-minor axis b through the formula $e^2 = (a^2-b^2)/a^2$. In a polar coordinate (r,θ) reference frame the relationship between r and θ for an ellipse is:

$$r = \frac{a(1-e^2)}{1+e\cos\theta}$$

Derive expressions for the perihelion and aphelion velocities in terms of the orbital period P, the orbital eccentricity e and the semi-major axis a. [6]

Pluto has the mostly highly elliptical orbit of the planets in the solar system with e=0.25, a period of 248.53 Earth years, a minimum distance to the Sun of 4446 million km and a maximum distance of 7381 million km. Determine how fast Pluto travels (in km s^{-1}) at its closest and furthest points from the Sun.

[4]

11. With the aid of a sketch, describe the structure of the Sun. Your description should include a summary of the way energy is generated by the proton-proton chain and then is transported to the surface. [10]

Discuss the main observational features of the solar activity cycle. Describe the role of the global magnetic field and its development with time. [10]