UNIVERSITY COLLEGE LONDON

EXAMINATION FOR INTERNAL STUDENTS

MODULE CODE : **PHAS1102**

ASSESSMENT PATTERN : **PHAS1102A**

MODULE NAME : **Physics of the Universe**

DATE : **13-May-11**

TIME : **14:30**

TIME ALLOWED : **2 Hours 30 Minutes**

TURN OVER

Answer ALL SIX questions from Section A and ANY THREE questions from Section B

The following may be assumed if required:

Gravitational constant	G	6.673×10^{-11} m^3 kg^{-1} s^{-2}
Speed of light	c	3.0×10^8 m s^{-1}
Stefan-Boltzmann constant	σ	5.7×10^{-8} W m^{-2} K^{-4}
1 year	yr	3.16×10^7 s
1 parsec	pc	3.1×10^{16} m
Solar mass	$M_\odot$	2.0×10^{30} kg
Solar radius	$R_\odot$	7.0×10^8 m
Solar bolometric luminosity	$L_\odot$	3.8×10^{26} W
Solar bolometric magnitude	M_{bol}(Sun)	+4.75
Proton mass		1.0078 amu
Helium mass		4.0026 amu

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

Section A

(Answer ALL SIX questions from this section)

1. Describe the spectral classification scheme for stars in terms of temperature and colour. Define the stellar luminosity classes and say what physical parameter determines the luminosity class of a star. [7]

2. State the three spectroscopic rules discovered empirically by Gustav Kirchhoff, and give a general astronomical example for each. [7]

3. Explain the 'lighthouse' model for pulsars, and thus explain why not all neutron stars are seen as pulsars. [6]

4. State Hubble's Law. How can the Hubble Constant be used to roughly estimate the age of the Universe? Why is it only a *rough* estimate? [6]

5. List, with *brief* explanations, three methods for evaluating the masses of clusters of galaxies. [8]

6. What is a 'Cepheid variable'? Why is a Cepheid variable a useful tool in determining distances to galaxies? [6]

Section B

(Answer ANY THREE questions from this Section)

7. Contrast how the evolution of a 30 $M_\odot$ star differs from that of a 1 $M_\odot$ star, from the main sequence to the end state. [10]

   By first considering the hydrogen to helium mass deficit, calculate the main-sequence lifetime (in years) of a 5 $M_\odot$ star if it has a luminosity of 600 $L_\odot$ and 10% of its mass is converted from hydrogen to helium. [7]

   After the star leaves the main sequence, its temperature decreases by a factor of 5 and its luminosity increases by a factor of 2. How does the radius change (bigger or smaller), and by what factor? [3]

8. Define the *apparent*, *absolute*, and *bolometric* magnitudes of a star. What is the UBV Johnson system and why was it introduced? [8]

   A star has a bolometric luminosity of 10^{30} W. What is its surface temperature if its radius is 30 times that of the Sun? Calculate the wavelength of the peak of the energy distribution of radiation from this star, and indicate the main observational waveband to which this corresponds. [6]

   Calculate the flux received at Earth if the star is at a distance of 100 parsec, and determine the star's absolute bolometric magnitude. [6]

9. List the proton–proton chains (PP I, PP II, PP III) of nuclear reactions which convert hydrogen to helium in the Sun. [10]

   By first outlining the basic physical properties of neutrinos, discuss the solar neutrino problem and how it has been solved. [10]

10. Summarize the key physical and dynamical properties of spiral galaxies (such as our own Galaxy). [5]
    Discuss the nature of the spiral arms. [5]

    Sketch a diagram of the 'rotation curve' for a spiral galaxy. Comment on the shape of the rotation curve, and the main inference to be drawn from it. [6]

    Suppose that the Sun is in a circular orbit of radius 8.0 kpc about the Galactic Centre, and takes 2.25×10^8 yr to complete one orbit. What is the corresponding orbital velocity (in units of km s^{-1})? What is the mass of the Galaxy contained within the Sun's orbit (in units of $M_\odot$)? [4]

11. Discuss any *two* of the following topics in the context of the 'Big Bang' model: [14]

- the evolution of source counts;
- the cosmic microwave background (include a qualitative discussion of its formation);
- primordial nucleosynthesis (a full answer will outline general processes, but specific details of nuclear reactions are not required).

We might suppose the rate of expansion of the Universe to be slowing down, because of the mutual gravitational attraction of galaxies. Explain how we might set about measuring the rate of change of the expansion, and the results that have emerged in practice from such measurements. [6]

END OF PAPER