The University Of Sheffield.

DEPARTMENT OF PHYSICS AND ASTRONOMY

Autumn 2006-2007

OBSERVING THE NIGHT SKY **2 HOURS**

Answer THREE questions, TWO from section A and ONE from Section B.

Answers to different sections must be written in separate books, the books tied together and handed in as one.

A formula sheet and table of physical constants is attached to this paper.

All questions are marked out of ten. The breakdown on the right-hand side of the paper is meant as a guide to the marks that can be obtained from each part.

TURN OVER

SECTION A: CELESTIAL SPHERE

1.

(i) Explain briefly the meanings of the following terms:

(a) *precession of the equinoxes;* [0.5]
(b) *proper motion.* [0.5]

(ii) The table below is an extract from a typical star catalogue. The first column gives the star name. Explain briefly the meaning of each of the other five columns and why they are all necessary in order to accurately locate a star in the night sky. [3]

Star name	α			δ			Equator.	μ_α	μ_δ	Epoch.
	h	*m*	*s*	°	′	″		*s/yr*	*″/yr*	
FT01+82	01	18	45.749	+82	07	22.63	J2000.0	0.0299	−0.022	1992.84
FT03+82	03	11	01.374	+81	37	04.44	J2000.0	0.0127	−0.030	1990.26
FT05+82	05	13	17.101	+82	06	52.99	J2000.0	−0.0011	−0.006	1988.08

(iii) Determine the altitude and azimuth of the star Arcturus (right ascension = 14h 16m, declination = +19°11′) as seen from London (latitude 51°30′N) when the local sidereal time is 17h 15m. [6]

2.

Determine, for an observer in Sheffield (53°23′N, 1°28′W):

(i) the altitude of Sirius, declination −16°43′, at transit; [1]

(ii) the azimuths at which Sirius rises and sets; [3]

(iii) how much time (in solar and sidereal units) elapses between its rising and setting; [4]

(iv) how much earlier (in solar and sidereal units) Sirius transits at Rome than at Sheffield. The longitude of Rome is 12°30′E. [2]

3.

(i) In the context of planetary motions, explain what is meant by the terms *synodic period* and *sidereal period.* [1]

(ii) Derive an expression for the synodic period of an inferior planet and an expression for the synodic period of a superior planet. [3]

(iii) The synodic period of Mars was measured to be 779.9 days. Using the fact that 105.9 days after opposition, the elongation of Mars was measured to be 90°, calculate the distance of Mars from the Sun in AU. You may assume that Mars has a circular orbit. [6]

4.

(i) Explain briefly the meaning of the terms *apparent solar time* and *local sidereal time.* [1]

(ii) When do apparent solar time and local sidereal time coincide? [1]

(iii) One night, a certain star is observed to transit at midnight. Calculate, in solar hours, minutes and seconds, when it will next be at the same altitude. You may assume that the number of solar days in a year is 365.2425. [3]

(iv) Calculate the time (GMT) of sunrise and sunset at Sheffield (53°23′N, 1°28′W) on March 21st when the equation of time is $E = -7\text{m}17\text{s}$. (In your calculation, assume for simplicity that sunrise and sunset occur when the solar disc is centred on the horizon. Take the obliquity of the ecliptic to be 23°27′.) [5]

SECTION B: ASTRONOMICAL INSTRUMENTS

5.

You are going to construct a Keplerian telescope and have been given a bi-convex objective lens of diameter D_o and focal length f_o, and a bi-convex eye-piece lens of focal length f_e.

(i) Draw a diagram, including ray paths, showing the telescope in normal adjustment. [1]

(ii) Show that the magnification of the telescope is given by f_o/f_e. [1]

(iii) Give the Rayleigh expression for the theoretical resolution limit of your telescope. If the wavelength of ‘visual light’ is about 5×10^{-7} m, estimate the theoretical best resolution if $D_o = 0.1$ m. [2]

(iv) Considering that you are observing from the surface of the Earth, what is a reasonable estimate of the size of the seeing disc? Why is this much larger than the theoretical resolution limit? [2]

(v) Show that the brightness of the image in the focal plane of the telescope is proportional to $(D_o/f_o)^2$. [2]

(vi) If the unrestricted dark-adapted eye has a pupil size of 0.008 m and can just detect stars of magnitude 6, what is the faintest stellar magnitude you can see through your $D_o = 0.1$ m telescope? [2]

TURN OVER

6.

Describe briefly the optical design, positioning and mounting of:

(i) the Greenwich Transit Telescope;
(ii) the UK 1.2 m Schmidt Telescope;
(iii) the McMath Solar Telescope;
(iv) the Hubble Space Telescope.

What tasks are each of these telescopes specifically designed to perform? [6]

Explain briefly the difference between 'active optics' and 'adaptive optics'. [1.5]

Discuss the following statement:
"The rate of advance of astronomy is directly proportional to the size of the biggest telescope at the time." [2.5]

END OF QUESTION PAPER