



DEPARTMENT OF PHYSICS & ASTRONOMY

Spring Semester 2006-2007

CONCEPTS OF ASTRONOMY

2 Hours

Answer TEN questions. If you answer more than ten questions marks will be awarded for your ten best answers.

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

All questions are marked out of ten.

- 1 You have constructed a gnomon 10 m high and notice that the shortest shadow on midwinter's day is 45.11 m long and the shortest shadow on midsummer's day is 5.89 m long.

What is the latitude of your gnomon, and what is the obliquity of the ecliptic?

- 2 The planet Venus reaches its greatest western elongation (47°) every 584 days. What is its sidereal orbital period and what is the radius (in au) of its orbit?
- 3 Observant astronomers notice that the brightest star in the sky, the Sun, has an apparent magnitude of -26.74 , and the next brightest star, Sirius, has an apparent magnitude of -1.46 . If it was assumed that *all* the visible stars had exactly the same luminosity, and are randomly spaced in the solar vicinity, how many stars would you estimate to be closer than 10 pc? Why is this estimate wrong?
- 4 Observations of asteroidal absolute magnitude reveal that the fifth largest asteroid in the Main Belt is 511 Davida, which has a diameter of 337 km. The hundredth largest is asteroid 81 Terpsicora, diameter 124 km. Estimate how many asteroids the Belt contains with diameters greater than 1 km.
- 5 Using the data in the table below, estimate the apparent magnitude difference between Jupiter and Saturn when they are both at opposition.

	Radius (km)	Albedo	Heliocentric distance (au)
Jupiter	71300	0.70	5.203
Saturn	60100	0.75	9.539

- 6 Noting that the surface of planet Earth has an albedo of 0.37 and an emissivity of 0.63, estimate the mean temperature. How would the temperature change if
- (i) we increased cloud cover, producing an albedo of 0.50, but kept the emissivity constant;
 - (ii) we removed all the greenhouse gases, producing an emissivity of 0.90, but kept the albedo constant?
- 7 In 8500 BC the passage of Earth through the perihelion of its orbit coincided with the winter solstice. If the eccentricity of the Earth's orbit is 0.01672 estimate the duration of winter and spring.
- 8 A binary star system consists of two stars each of solar mass. What are their orbital periods if the mean separation is 10 au? How would the period change if:
- (i) the star masses were doubled;
 - (ii) the separation was halved?
- 9 The Main Sequence of the Hertzsprung Russell diagram is such that stars of class A0, G2 and K5 have absolute magnitudes of + 1.3, + 4.8 and + 7.3 respectively, and effective surface temperatures, T_e , of 10000, 5770 and 3895 K respectively. (The G2 star is the Sun.) Obtain a relationship between luminosity and effective temperature for the Main Sequence.
- If the radius, R , and the temperature, T_e , of a Main Sequence star obey the relationship $R \propto T_e^\delta$, what is δ ?

- 10 The absorption of starlight in our atmosphere can be represented by

$$S = S_0 e^{-\frac{k}{\alpha}}$$

where S_0 is the flux at the top of the atmosphere, S is the flux at ground level and α is the altitude of the star above the horizon. Estimate k , knowing that the 'extinction angle' is such that a fifth-magnitude star can be only just be detected in a clear dark sky when it has risen to an altitude of 8° , a fourth-magnitude star when it has risen to 4° and a third-magnitude star when it has risen to 2.7° .

- 11 In an average sample of the Earth's crust we find 88 ^{207}Pb atoms for every 1 atom of uranium ^{235}U . Assuming that $^{235}\text{U} \rightarrow ^{207}\text{Pb} + 7\ ^4\text{He} + 4\ e^-$, and that the half life of this radioactive decay is 7.10×10^8 y, estimate the age of the Earth.
- 12 Observing a spectrum of the solar corona you notice that the CaXIII is considerably stronger than the CaXV line. Laboratory analysis indicates that the CaXIII and CaXV lines have ionisation potentials of 655 eV and 814 eV respectively. If you assume that collisional excitation is the predominant excitation mechanism in the corona, estimate the coronal temperature.
- 13 Noting that the mass difference between four hydrogen atoms and one atom of helium is $4m_H - m_{He} = 0.029 m_H$, what is the annual solar mass loss due to energy production?

If, initially, 74 % of the solar mass was hydrogen, what will this percentage be after its 10^{10} year Main Sequence lifetime?

- 14 Show that the Continuous Creation Theory indicates that matter is being created at a rate of $3 H_0 \rho_0$, where H_0 is Hubble's constant and ρ_0 is the density of the nearby universe.
- Estimate ρ_0 and thus calculate the matter creation rate assuming that H_0 is $73 \text{ km s}^{-1} \text{ Mpc}^{-1}$.
- 15 An astronomical spectroscopist notices that the measured radial velocity of the star Arcturus (ecliptic latitude 30.78°) is $+21.1 \text{ km s}^{-1}$ on January 15th and -30.2 km s^{-1} on July 15th. What is the average Earth-Sun distance?
- 16 A spacecraft on a Hohmann transfer orbit leaves Earth on a trajectory that is tangential to the Earth's orbit and approaches Mars on an orbit that is tangential to Mars' orbit. If Mars is 1.52 au from the Sun, draw the orbit of the spacecraft and calculate how long it would take the spacecraft to get there. Assume the orbits of Earth and Mars are co-planar and circular.
- 17 The Andromeda galaxy, M31, has an apparent *I*-band magnitude of 6.0 and a rotational speed of 270 km s^{-1} . If the distance of M31 is 770 kpc, and the rotational speed of the Milky Way Galaxy is 220 km s^{-1} , estimate the absolute *I*-band magnitude of the Milky Way, stating any assumptions that you make.
- 18 The main subcluster of the Virgo cluster of galaxies is approximately 4 Mpc in diameter and contains about 600 large galaxies with an rms velocity (relative to the cluster centre of mass) 760 km s^{-1} . Estimate the total mass of the cluster and the fraction of that mass that is made up of stars.

END OF QUESTION PAPER