

1. Stellar radii of main sequence stars of mass M are proportional to $M^{0.5}$ while luminosities are proportional to M^4 . What is the relation between the main sequence lifetime and effective temperature? Calculate the predicted main sequence lifetime of a star with $0.5 M_{\odot}$ if the lifetime of the Sun is 10^{10} years. Discuss whether this can be tested observationally, explaining your answer.
2. It is proposed to observe a galaxy which has Right Ascension 18h 30min and declination -45° . What time of the year would it be best for the observations to be carried out? What is the optimum latitude for the observatory? Explain your answer.
3. The star formation rate in the Milky Way is approximately $1 M_{\odot} \text{ yr}^{-1}$. If stars form with an initial mass function $N(M) \propto M^{-2.3}$ between 0.2 and $50 M_{\odot}$ estimate the core collapse supernova rate in the Galaxy. Why might the historical supernova rate for the Milky Way be lower than this estimate? State any assumptions you have made.
4. Using **only** the information set out below, estimate the ratio of the mean densities of the Earth and Sun.
 - (a) The angular diameter of the Sun as seen from Earth is half a degree;
 - (b) The length of 1° of latitude on the Earth's surface is 100 km;
 - (c) The length of a year is 3×10^7 s;
 - (d) The acceleration at the Earth's surface due to gravity is 10 m s^{-2} .[Hint: you should not look up any other quantities to solve this problem.]
5. What is the mass of Pluto if its largest moon Charon orbits Pluto every 6.4 days in a circular orbit 0.00013 AU away? If Pluto orbits the Sun at an average distance of 39.5 AU, what is its *maximum* angular size in arcsec when viewed from the Earth? You may assume that Pluto has a density twice that of water and an orbital eccentricity of 0.25. What is the minimum aperture (in metres) that a telescope would require in order to spatially resolve the disk of Pluto at 550 nm? You may neglect atmospheric seeing.

6. Kepler-11f, a transiting planet orbiting a solar-type star, has a mass 2.3 times larger than the Earth and a radius 2.6 times larger than the Earth. What is the surface gravity of Kepler-11f? What would be its average daytime surface temperature if it has a orbital period of 47 days? You should assume that Kepler-11f has an emissivity of 0.5, an albedo of 0.5, is tidally locked, and has a Martian-type atmosphere.
7. The temperature of the atmosphere of Venus decreases approximately linearly from 750 K at ground level to 260 K at an altitude of 60 km. Calculate the variation of pressure with height for Venus' atmosphere. Hence, find the height at which the pressure is equal to 1 (terrestrial) atmosphere, given that the pressure is about 90 atmospheres at ground level. Take the surface gravity of Venus to be 8.9 m s^{-2} and an atmospheric composition of CO_2 .
8. It is proposed to use Hubble Space Telescope to make V-band photometric observations of a distant quasar, in order to determine whether or not it is significantly variable. If the quasar has an approximate apparent brightness of $m_v \sim 23$ mag, and the CCD imaging instrument used for the observation detects a total of 10^{10} photons per second from the bright star Vega in the V-band, what is the minimum exposure time required to achieve a photometric accuracy of 5% in measuring the brightness of the quasar? You may assume that the sky background and instrument noise are negligible.
9. It is sometimes suggested that a good way to dispose of nuclear waste would be to drop it into the Sun. The spacecraft carrying the waste would obviously start out with the same orbital velocity as the Earth. Calculate the minimum amount by which you would have to change this velocity to ensure that the spacecraft does indeed hit the Sun. You may assume that the Earth's orbit is circular.
10. At the present time natural uranium ores contain 2.43% atoms of ^{235}U and 97.57% of ^{238}U by number. Estimate the age of the Earth, given that the half-lives of ^{235}U and ^{238}U are 7.13×10^8 and 4.51×10^9 yr, respectively. You may assume that the two isotopes were equally abundant when the Earth was formed.

END OF QUESTION PAPER