Diploma in Astronomy—First Term 2004-5

Solar System: Problem Paper 1.

19th October 2004

Solutions should be returned by Tuesday 9 November. After that date they can be accepted, but once model solutions are posted, they cannot receive credit for marks (but can count towards completion of the course). The weighting for each question is given in ().

1. A (fictitious) superior planet, Kerplooie (they had a very strange language), was observed from Earth by the ancient Baboonians over many centuries. They found an average synodic period of 1187.716 days between oppositions. Assuming the sidereal period of Earth is 365.256 days (as given in lectures), calculate the sidereal period of Kerplooie. (5)

2. Use the results from (1), plus Kepler's third law, $P^2 = ka^3$, to deduce the semi-major axis a of Kerplooie's orbit in astronomical units. Explain your choice of units and state what value of k should be adopted (see lecture notes). How does Kerplooie's a compare with Mars' ($a = 1.524$ AU)? (5)

3. In the lectures on Earth we talked about the Greenhouse Effect and the way in which a planet's expected mean temperature can be calculated. Assume that Kerplooie is a "terrestrial" planet with a nearly circular orbit. Use the semi-major axis of Kerplooie's orbit from (2), assume that its rotation period is 22.5 Earth hours (what does this imply for the temperature calculation?), assume that its Bond Albedo is 0.27, and assume that it has a Greenhouse temperature increase of 28 degrees C (same as K) due to CO_2 and H_2O in its atmosphere.

Deduce the mean temperature of Kerplooie.

Hint: Remember that the Solar Constant for Earth, 1367.5 watts/m^2, does not apply to Kerplooie; you will need to use the Inverse Square Law to deduce the energy received per square metre at Kerplooie's distance from the Sun (see Chapter 19-2). You may scale the value for Earth if you wish, as long as you do this correctly. (10)

Total marks possible for Paper 1: 20