Astronomy 2E03, Winter 2013 - Assignment 1

Due Date: Monday, February 4, 2013
Assignments are due in class.

This assignment will require you to derive information based on your student number. Please enter your student number in the second row below. The top row will be referred to as the digit position. All students enrolled in this class will have a zero or one in their student number at digit position 7. Answers not based on your student number will not receive any credit.

7	6	5	4	3	2	1

1. In this question, we will suppose that a planet is orbiting the Sun in an orbit with the same semi-major axis as Jupiter's orbit but with a different mass. The factor by which the mass is greater is given by the digits 4, 3, and 2 of your student number, in order, divided by 5. For instance, if your student number were 1126410, the factor would 128.2.

a) [3 marks] Calculate the orbital period in Earth years of this more massive planet. Be sure to include the planet's mass in the calculation. Show your work.

b) [2 marks] What is the fractional difference of the orbital period with respect to Jupiter's orbital period? Show your work.

c) [3 marks] If this more massive planet had moons orbiting it at the same semi-major axes as the four Galilean moons which orbit Jupiter, what would their orbital periods be in Earth days? Show your work.

2. This question concerns the effect of gravity on a object in the gravitational field of a star. The mass of the star, in solar masses, is given by the digits 6, 5, and 4, in order, of your student number, divided by 20. An object at a distance in AU given by the digits 3, 2, and 1, of your student number, divided by 5 begins falling towards the star from rest. The radius of the star, in solar radii is given by the digits 5, 4, and 3, of your student number, divided by 10.

a) [5 marks] Using a spreadsheet (Excel, OpenOffice Calc, or any other you might have) with 50 intermediate distances (between the initial position and the stellar radius). Between each radius, assume that the gravitational acceleration is constant and based on Newton's law of universal gravitation for the midpoint of the two adjacent radii. Derive the velocity of the particle as it arrives at each radial distance closer to the star and the time taken to

cross each difference in radius. Note that the initial velocity for every step for the first will be the final velocity derived from the previous radial step. Sum the time intervals to give an estimate of the time taken to fall between the initial position and the stellar surface. Show your work.

b) [5 marks] Derive an integral expression for the time taken for the object to fall from its initial distance to the outer surface of the star based on calculus, equations of motion, and Newton's law of universal gravitation. Show your work. (You may look up and use the solution to the integral once you have identified the correct one.)

c) [3 marks] Determine the time in Earth days for the object to fall from its initial position to the surface of the star using the stellar mass and stellar radius derived from your student number. Show your work.

3. Answer parts a), b), and c) of question 2.9 in your textbook but, instead of the ratio 333, use digits 5, 2, and 1 of your student number.
[Parts a), b), and c) are worth 3 marks each.]

4. Answer parts a), b), and c) of question 2.24 in your textbook but, instead of reducing the factor 0.5, use a factor of the digits 5, 2, and 1 of your student number, divided by 1000. [Parts a), b), and c) are worth 3 marks each.]

Should any of the above combinations of digits from your student number be **all** zeroes, contact me and I will give you an “effective student number” to use for questions of this nature.