LAB A16 – ORBITS OF SATELLITES **Name**_____
PH355
10/29/03

Goal: You are an astronomer studying a newly discovered planet and its moons (you will use the software Interactive Physics to view a simulation of the motion of the moons and planet). By carefully observing the motion of the moons, you will test whether their orbits obey the predictions of Newton's Law of Universal Gravitation. You will also use your observations of the moons to determine the mass of the planet they are orbiting. This lab is to be done individually.
Prelab: Derive expressions for the period, speed and acceleration of a satellite in circular motion around a planet, in terms of the mass of the planet and radius of the satellite's orbit.

Procedure:

1. Open the simulation file orbits.ip from the desktop of your computer. You will be prompted to enter a password to run the Interactive Physics software. Your instructor or a lab assistant will provide that to you.

2. You should see five small circles around the center of the screen – those are the planet and 4 moons. Notice the gridlines running across the screen, and the axes with scales on the edges of the screen. By moving the mouse cursor around the screen, you can read the x- and y-positions of any object. The planet should be located exactly at the origin of the grid.

Click on the Run button near the top center of the screen to start the simulation. Observe how the moons move around the planet. Also notice the Time box in the upper left of the screen. It records the total elapsed time for the simulation. To stop the simulation, click on Stop. To start the simulation again from the beginning, click Reset.

Although Interactive Physics has many other features, we will not be using them in this simulation. **Do not click on any of the other buttons on the screen. Doing so could modify your simulation.**

Data: For each moon, determine the period and radius of the orbit as accurately as you can with the available measuring instruments. Record your data in the table below. Then use your measured period and radius to calculate the moon's speed and acceleration.

	Radius (m)	Period (s)	Speed (m/s)	Acceleration (m/s^2)
Moon 1				
Moon 2				
Moon 3				
Moon 4				

Analysis: In the prelab, you derived expressions that show how the period, speed and acceleration of a satellite depend on the radius of the satellite's orbit. Each of those expressions is a power law, in other words the expression for each variable (P, v or a) has the form $C R^n$ where C is some constant (that should be the same for all satellites orbiting the same planet) and n is a number representing the power of R.

Use your data table to create graphs of P vs. R, v vs. R and a vs. R. For each graph, use your TI calculator to perform a power law regression to the data. Sketch each graph (including your data points and the fit curve) below. Below each graph, as we have done in other labs when we fit data, write the math and physics equations (using variables only) describing the graph, then make a matching table that shows how the math and physics variables match up. Your matching tables should have 3 columns (math variable, physics variable, fit values).

1. P vs. R
Graph:

Math Equation:
Physics Equation:
Matching Table:

2. v vs. R
Graph:

Math Equation:
Physics Equation:
Matching Table:

3. a vs. R
Graph:

Math Equation:
Physics Equation:
Matching Table:

4. For each graph, compare (find % difference between) the expected value of the power n and the value obtained from your fit to the data:

Expected n for P vs. R graph:

Actual n:

% diff:

Expected n for v vs. R graph:

Actual n:

% diff:

Expected n for a vs. R graph:

Actual n:

% diff:

5. For each graph, use the fit value you obtained for the constant C to determine the mass of the planet. Show all calculations completely (including algebra steps and substitution of numbers with units). You may assume that the universal gravitation constant $G = 6.67\ 10^{-11}$ N m^2/kg^2 is given.

Mass of planet determined from P vs. R graph:

Mass of planet determined from v vs. R graph:

Mass of planet determined from a vs. R graph:

Followup questions:

A satellite is in a circular orbit of radius R around a planet. Compare the period, speed and acceleration of the satellite's motion to those of another satellite in a circular orbit of radius 2R around the same planet (i.e calculate the ratios P_2/P_1, v_2/v_1 and a_2/a_1). Express your answers in simplest form.