QL CLASS ACTIVITY

Title: Weighing Jupiter

Author(s) and Attribution: Andrew Cahoon

Summary: In this activity, students will make observations of Jupiter and the Galilean moons using planetarium software and extract the mass of Jupiter from a log-log plot of observational data. Newton's version of Kepler's Third Law describes how the period of an orbiting body is related to the semi-major axis of its elliptical orbit and the mass of the object around which it orbits. Therefore, by making measurements of the period and semi-major axis of the moons, students can determine the mass of Jupiter. In order to accomplish this goal, students will learn that power law relationships result in straight lines on a log-log plot. Then they will learn how to extract the parameters of a model from the slope and y-intercept.

Context for Use: This activity would be appropriate in an introductory astronomy or physics course during a unit on gravity and orbital motion or in an algebra or calculus course when logarithmic functions are introduced or reviewed. The activity is designed to be completed over two class periods or in one lab session. Students will need access to computers with planetarium software installed. Internet access is not required (though the activity could easily be modified to include a research element).

Learning goals (Measurable Outcomes) of your activity:

Students completing this activity will be able to:

- Use and interpret Kepler's Third Law
- Solve algebraic equations involving power laws and logarithmic functions
- Create and interpret a log-log plot of data

Quantitative Concepts/Skills: Please see the given list of QL skills/concepts.

- Perform basic arithmetic: fractions, decimals, unit conversions, and scientific notation
- Perform basic algebraic and symbolic manipulations
- Use geometric concepts to solve problems
- Interpret real-world problems given symbolically: regression of linear functions
- Be able to communicate quantitative information effectively in written form

Background: Students should have been introduced to Newton's version of Kepler's Third Law and logarithmic functions and should have a working knowledge of basic algebra principles. Students will also need some introduction to spreadsheet software (like Excel) and planetarium software (enough to know how search for and center on desired objects and advance forward and backward in time).

Materials Needed:

- Computer with planetarium software and spreadsheet software
- Ruler

Resources:

- Stellarium is an easy-to-use open source planetarium software (http://www.stellarium.org)
- A derivation of Newton's version of Kepler's Third Law (this is optional for advanced/interested students): http://www.youtube.com/watch?v=dAI8BgCudDQ
- Wikipedia article on log-log plots: http://en.wikipedia.org/wiki/Log-log_plot
- Ask Dr. Math on using log-log plots: http://mathforum.org/library/drmath/view/55520.html

Assessment plan: Learning outcomes will be assessed by pre- and post-tests administered the class before the activity is started and the class after the activity is completed. In addition, instructors may choose to require a formal lab report after completion of the main activity.

Main Activity and related files: There are a total of 5 documents in this activity:

1. Weighing Jupiter Activity Class Plan
2. Pre-test
3. Kepler's Third Law Practice Problems worksheet
4. Weighing Jupiter (main activity)
5. Post-test