

Group Members:

The Galilean Satellites and the Mass of Jupiter¹

This lab makes use of computer software developed at Gettysburg College and is part of their Project CLEA, which is an acronym for Contemporary Laboratory Experiences in Astronomy.

You will measure the position of one of Jupiter's moons from images displayed by a computer program. You will need to determine the period of the orbit and the semimajor axis of the orbit of this moon. This data will allow you to use Newton's version of Kepler's third law to determine the mass of Jupiter.

Newton's version of Kepler's third law tells us that the mass of Jupiter (plus the negligible mass of the moon in question) should be given by

$$Jupiter's\ mass = \frac{(semimajor\ axis)^3}{(period)^2}$$

where the mass will be in solar masses if the semimajor axis is in Astronomical Units and the period is in (Earth) years.

Instructions for collecting data

- 1) Start the program **Jupiter Moons** and login to the program.
- 2) Choose which of the moons you will use. Your instructor may assign you a specific moon otherwise choose one yourself.
- 3) From the main menu, choose **File** and then **Run** to start the program. Next, from the File Menu, select **Timing**. Enter the observation step in the screen that appears (suggestions: 2 hours for Io, 4 hours for Europa, 6 hours for Ganymede, 24 hours for Callisto).
- 4) Measure the position of your moon by using the mouse. When you put the cursor on the image and press the mouse button, the cursor will change to cross hairs and the location of the cursor will appear. If a moon is at the location of the cross hairs, it will be identified.
- 5) Record the distance of your moon from the planet and the time corresponding to the image in the data table below. The position data can be found in the lower right corner of the screen while the time data is in the lower left. The unit of distance is Jupiter's diameter. The time is either hours or

¹ Adapted from *Galilean Satellites and the Mass of Jupiter Student Manual*, CLEA Project, Department of Physics, Gettysburg College, Gettysburg, Pennsylvania.

Convert the orbital radius from JD to AU by multiplying by 0.0009558 AU per JD

Orbital Radius in AU = _____

10) Finally, calculate the mass of Jupiter using Newton's form of Kepler's third law.

$$Mass = \frac{Radius^3}{Period^2} = \frac{(\text{_____} AU)^3}{(\text{_____} year)^2} = \text{_____} \text{ in Solar Masses}$$

11) Convert the mass to Earth masses. The Sun's mass is 332,900 Earth masses.

$$\text{_____ Solar Masses} \times 332900 \text{ Earth Masses per Solar Mass} = \text{_____ Earth Masses}$$

The accepted value for the mass of Jupiter is 318 Earth masses. Determine your % difference using the following formula

$$\% \text{ Diff} = \frac{318 - \text{Your Value}}{318} \times 100 = \text{_____}$$

Orbital Position versus Time

