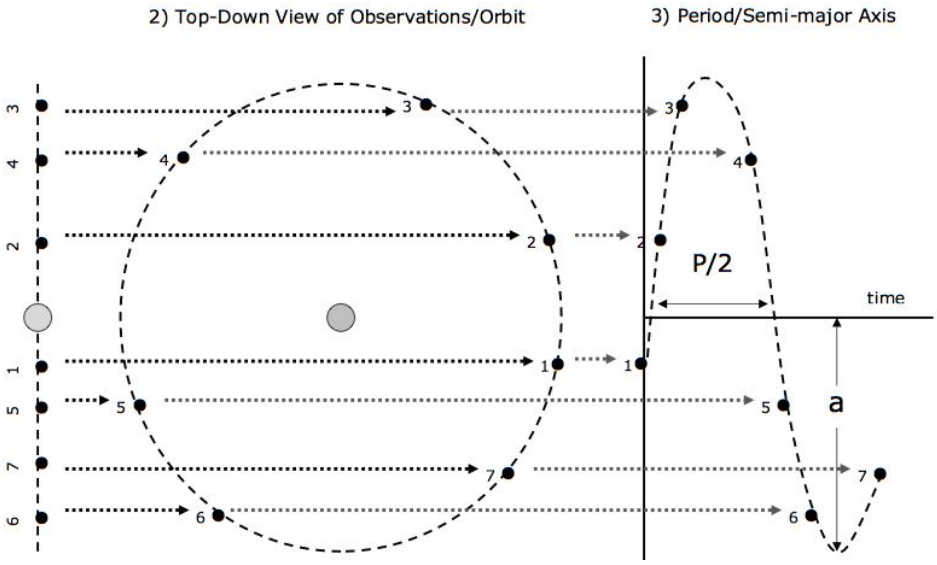
**Lab 3 Guide: Jupiter's Moons**

This guide is intended to outline the practical steps for completing the lab. There is a fair bit of option background information in the first two sections of the lab that you may read if you'd like. The main points will be summarized here.

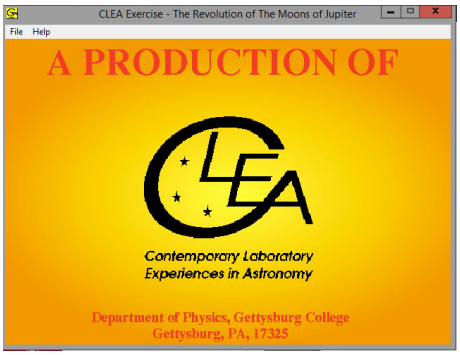
**Summary of Background:**

Galileo discovered Jupiter's moons in 1610 using a homemade telescope. He was able to measure the orbital period and semimajor axis for each moon and used Kepler's 3rd law to estimate Jupiter's mass. In this lab, we will use a simulator to do a similar exercise. The image below shows how graphing a moon's position (East or West of Jupiter) vs. time forms a sine curve, off which we can read the period and semimajor axis.

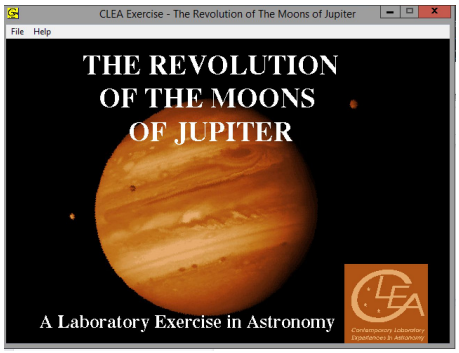


**Setup: Read Carefully!**

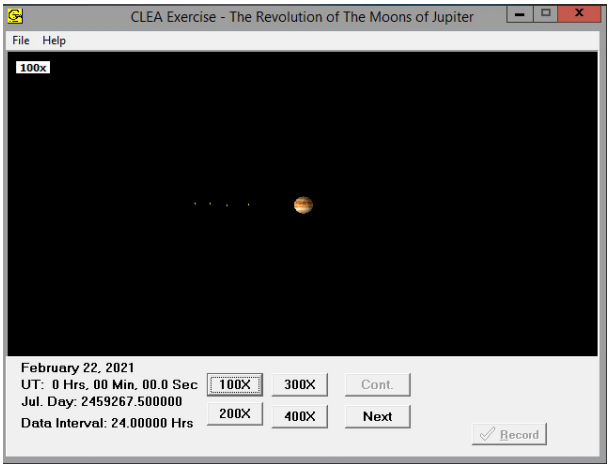
0. Open CLEA: Jupiter's Moons
    a. If using Citrix, open Citrix, log in, open CLEA.
    b. If using Windows, proceed to step 1.




1. Click "File" → "Log In"
    a. Enter your group's names, then click "Ok."
    b. Click "Yes"




2. Click "File" → "Run"
    a. Click "Ok" in pop up window to accept default date and time
    b. **Notice: "Data Interval" should read 24 hours** (bottom left of screen)
    c. Try a few different magnifications. 100x will probably be best.

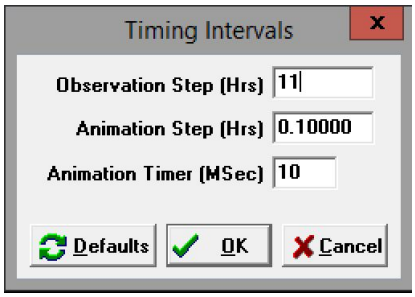



3. Click "Next" a few times.
    a. **Notice:** the moons now move around Jupiter
    b. If clouds appear, simply click "Next" again.

4. Click "File" → "Features"
    a. Select "Use ID Colors." This assigns each moon a color
    b. **Optional:** Select "Show Top View." This shows a bird's eye view of the system.
        i. Click "View" and select "Normal" and "Show Eclipse Zone".

## Do Questions #1-3 in ELMS!

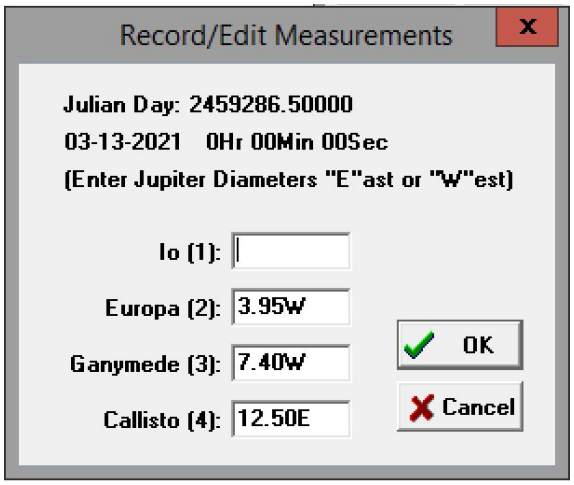
5. Click "File" → "Timing"
    a. **Set "Observation Step" to 11 hrs**
    b. Click "Ok" to close the timing window



**Taking Data pt. 1: Read Carefully!**

Now you are ready to start collecting data! It is important to finish this portion **during the lab period**.

1. Recording A Measurement:
    a. Click on a moon in the main window.
    b. Click "Record" to open the measurement window. **Do not click "OK" yet!!**
    c. Repeat steps a) and b) for the other moons **(except the pink one, Io)**
    d. **Notice:** your measurement window should now look like this (with different numbers of course)




    e. **Notice:** If moon 2, 3, or 4 is not visible, record the others (not Io) and continue.
    f. Now click "Ok" to close the window and save your measurement. **Only do this if you have numbers for all 3 moons!**
    g. Summary: (click + record) x3 → "Ok"

2. Click "Next" in main window to advance the simulation 1 step.

3. Repeat steps 1 and 2, **7 more times**.
    a. Keeping a tally on scratch paper might help.

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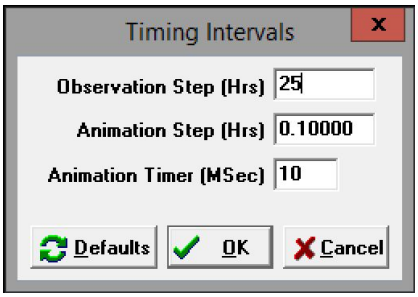
**Taking Data pt. 2: Read Carefully!**

4. Click "File" → "Timing"
    a. **Set "Observation Step" to 25 hours**
    b. Click "Ok" to close the timing window




5. Repeat steps 1 and 2, **11 times** with the new 25hr timing.
    a. Keeping a tally on scratch paper might help.

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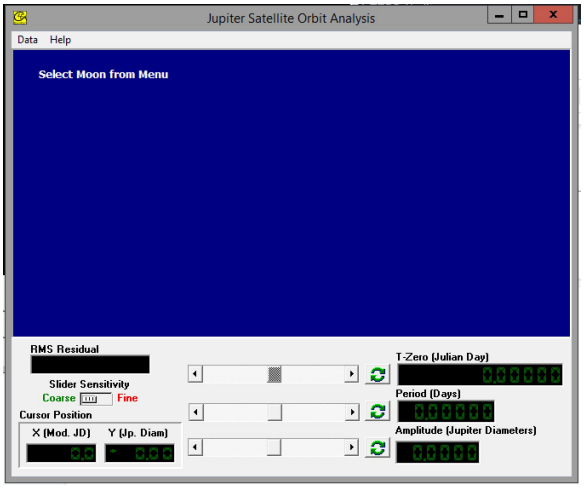
**Data Analysis pt. 1: Read Carefully!**

1. Click “File” → “Data” → “Analyze”




2. Click “Data” → “Select Moon” → “Callisto”
    a. The screen should update with yellow data points

3. Compare your Callisto data to Figure 10 in ELMS
    a. Read the paragraph above Question #4

**Do Question #4 in ELMS!**

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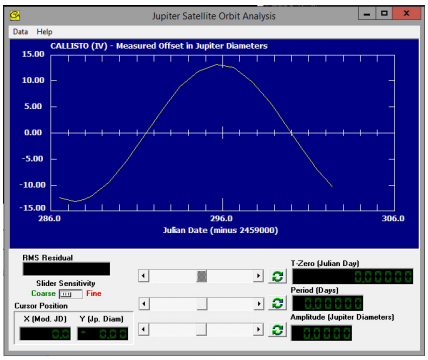
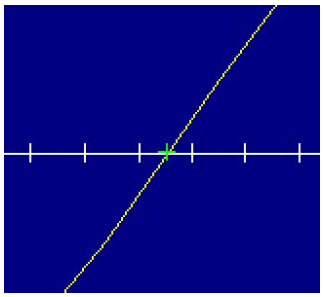
**Data Analysis pt. 2: Read Carefully!**

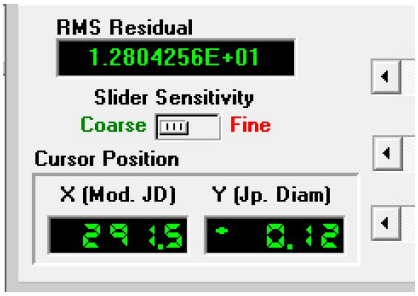
1. Click "Data" → "Plot Type" → "Connect Points"
    a. Now your points should be connected by a yellow line
    b. **Notice:** time is on the x axis, distance from Jupiter is on the y axis



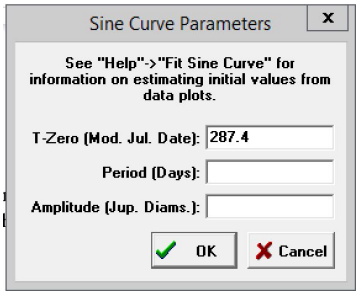

2. Click "Data" → "Plot" → "Fit Sine Curve" → "Set Initial Parameters". **Leave this window open for the following steps!**

    **a. Getting T-Zero:**
        i. Click on the first point where the yellow line **slopes up**, crossing from negative Y to positive Y **(see blue picture)**
        ii. Record the green number in the **X box (Mod. JD)** (bottom left). In the example below, you'd record 291.5






        iii. Type this number in the "T-zero" box. **Do not click "OK" yet!!**



iv. If you are stuck, **ask for help**!!

**b. Getting a period value:**

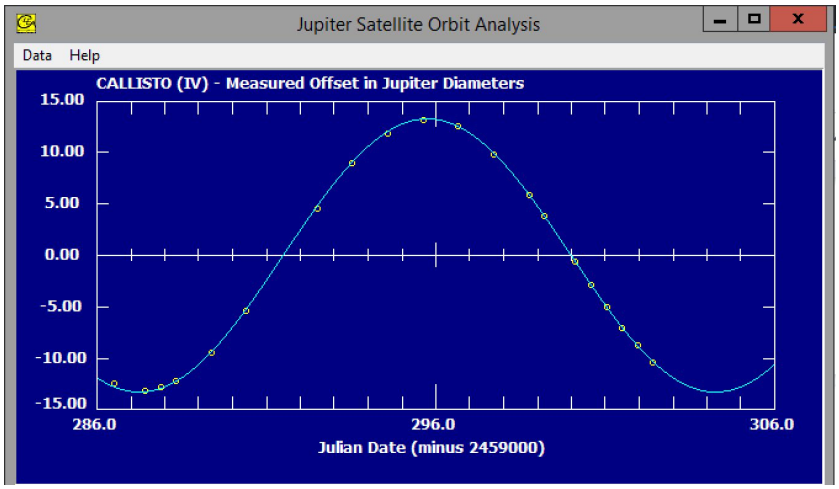
i. Click on the first point where the yellow line **slopes down,** crossing from **positive to negative**
ii. Write down the green number in the **X (Mod. JD)** box
iii. Subtract your "T-zero", then multiply by 2
iv. Type your final answer into the "Period" box
v. If you are stuck, **ask for help!**

**c. Getting an amplitude value:**

i. Click on the top of the tallest peak in the yellow curve
ii. Record the green number in the **Y box (Jp. Diam)** (bottom left, next to X box)
iii. Type this number into the "Amplitude" box

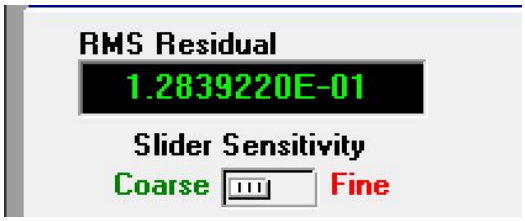
d. Once all three boxes are full, click "Ok"

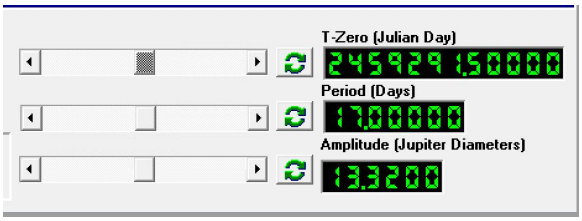
i. Now your graph should look like this
ii. **Notice:** If your blue line is significantly off from the points, **call the TA!!** This will save you a lot of time and extra work.



**Fine Tuning: Read Carefully!**

Under the graph is the RMS box. This tells you how well the blue curve fits your data. We want this number to be in the "???E-2" range. In the example below (left picture), which is the RMS for the curve above, we need to fine tune our fit to reduce the RMS. To do this, we will use the sliders (right picture) while watching the color of the RMS.




The RMS will stay green as long as it is getting smaller, so we will stop adjusting when it turns red. **Follow the steps below EXACTLY.**

1. Make sure the switch under the RMS box is set to "Coarse"

2. Click on one of the arrows for the **2nd (period)** slider. Watch the RMS.
    a. Continue clicking the arrow until the RMS turns red

3. Start clicking in the opposite direction until the RMS turns red again

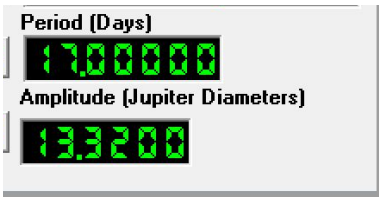
4. Click once in the opposite direction and stop (RMS should be green).

**Repeat steps 1-4 for the other two sliders**.

5. Now, click the switch under the RMS box from "Coarse" to "Fine."

**Repeat steps 2-4 for all sliders.** Your RMS should now be "???E-2"!

6. Write down the final RMS, Period, Amplitude, and the moon's name. An example Period and Amplitude are shown below.




These values will go in a table in **Question #5**. **DO NOT SKIP THIS STEP!**

*****Repeat "Data Analysis pt. 1", "Data Analysis pt. 2", and "Fine Tuning" for the other two moons (Europa and Ganymede). *****

**!!!!!!!!Make a copy of your table in your Google doc as a backup of your answers!!!!!!**

## Do Question #5 in ELMS!

## STOP! Check your table with TA before moving on!!!

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## Do the rest of the questions

**When the lab ends,**

1. If using Citrix,
    a. Close the simulator
    b. Log out of Citrix
    c. Close Citrix