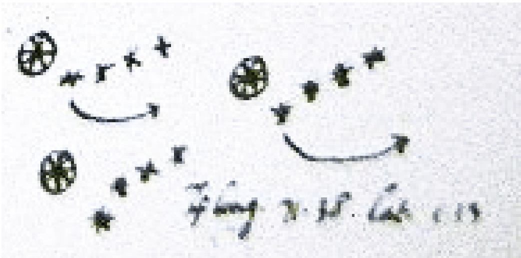


Four moons of Jupiter by Galileo - 1610

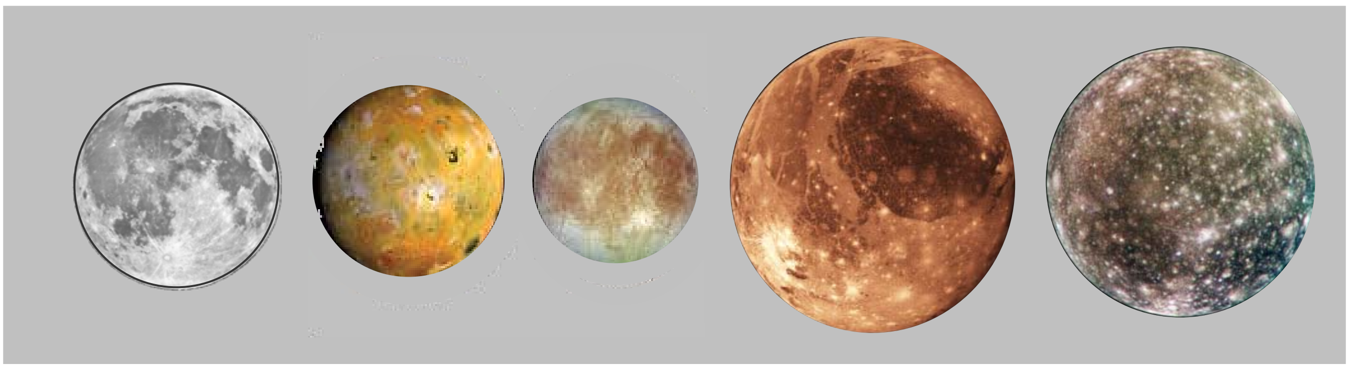
Galilean Moons of Jupiter

CLEA Simulation

In 1610 Galileo discovered that Jupiter had four moons orbiting the planet.

In this activity, you will "observe" Jupiter and its Galilean moons as they orbit Jupiter using the CLEA simulation. You will record the moons' positions. From this information, you will be able to determine the orbital periods for at least the one of Jupiter's moons.

The four Galilean moons are shown compared to the moon for size:



Moon **Io** **Europa** **Ganymede** **Callisto**

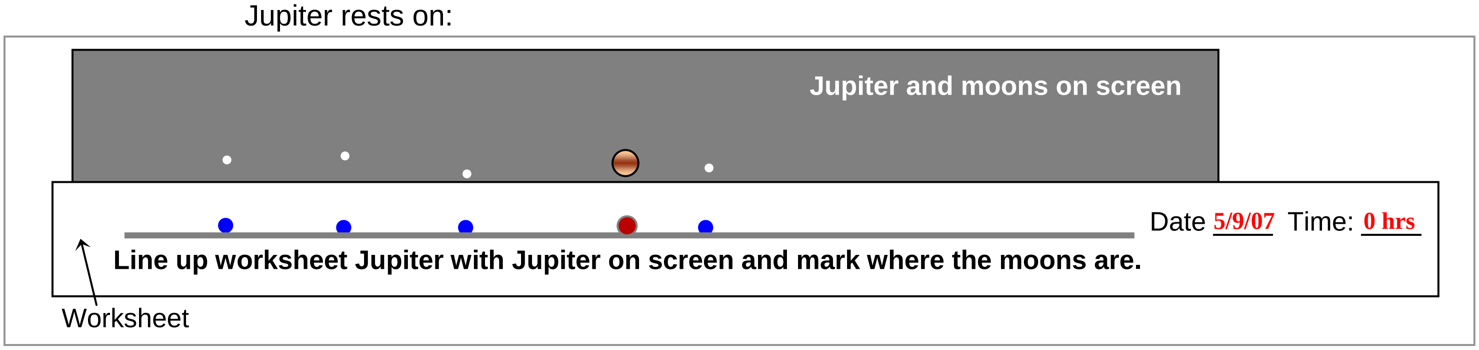
1. What To Do (Procedure):

- Start the CLEA Jupiter's Moons simulation software.
- Make sure that the date and time in the software are real time.
- Set the observational interval to 8 hours.

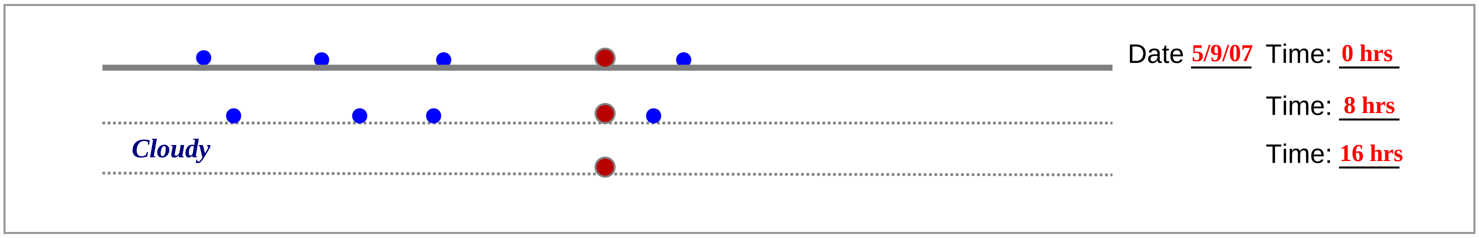
2. Observations:

As the software is stepped forward at 8-hour intervals, the moons change position with respect to Jupiter. You will record the position of the moons on the worksheet provided.

- Hold the worksheet up to the monitor.
- Align the Jupiter image on the monitor with the one on the worksheet. You may want to fold the worksheet every couple of lines.
- On the worksheet mark where the moons are by putting a dot just above the line that Jupiter rests on:



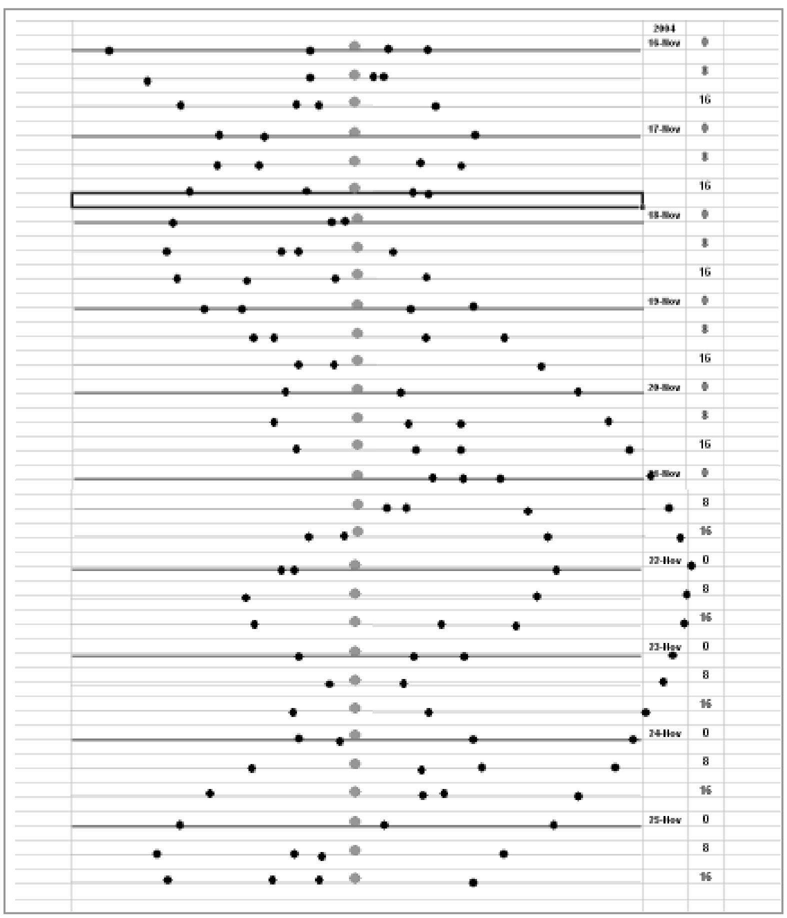
- Advance the screen to the next interval (8 hours later) and mark the positions of the moon again.
- If it is “cloudy”, write that at the left side of the interval blank.
- Repeat until you get to the bottom of the worksheet.



3. Analyzing the Data

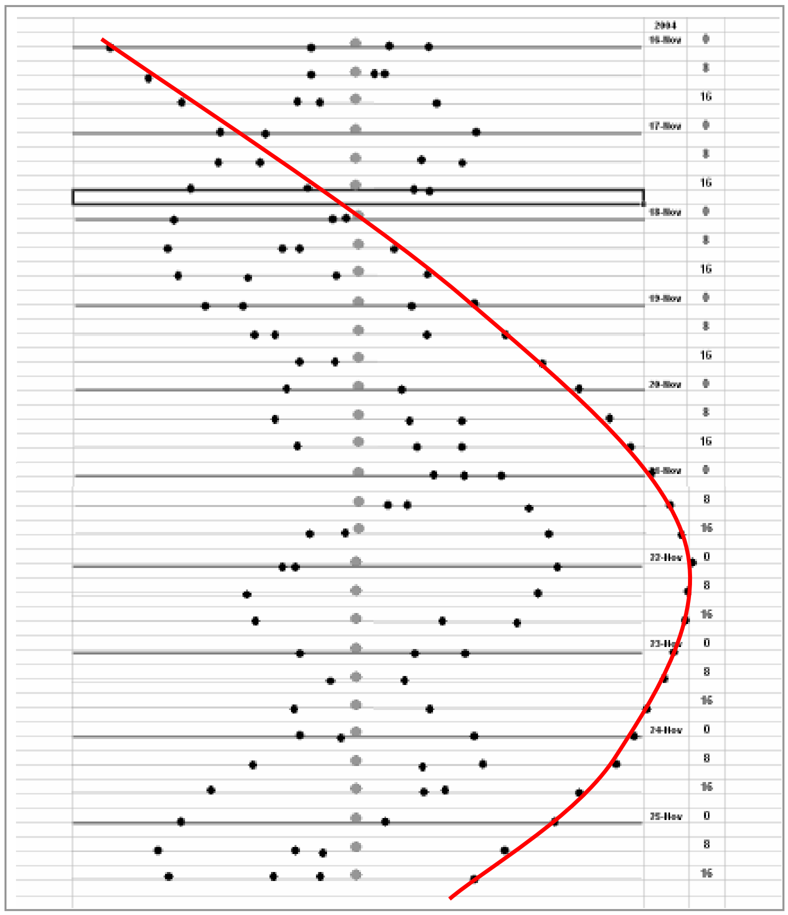
When you make all the observations and record the positions of the four moons, you will have a plot that resembles the one below. This is for November 2004 and is not going to be the same as your plot.

Notice how the moon positions appear to define several smooth curves. These are **POSITION-TIME CURVES**. They show where a satellite is and when it is there.



One family of dots starts at the upper left, goes to the far right, then back again to the lower middle. The moon represented by these dots is the one that gets farthest away from Jupiter.

- Using a pencil, smoothly draw a freehand curve for the dots that go across the entire plot as shown.



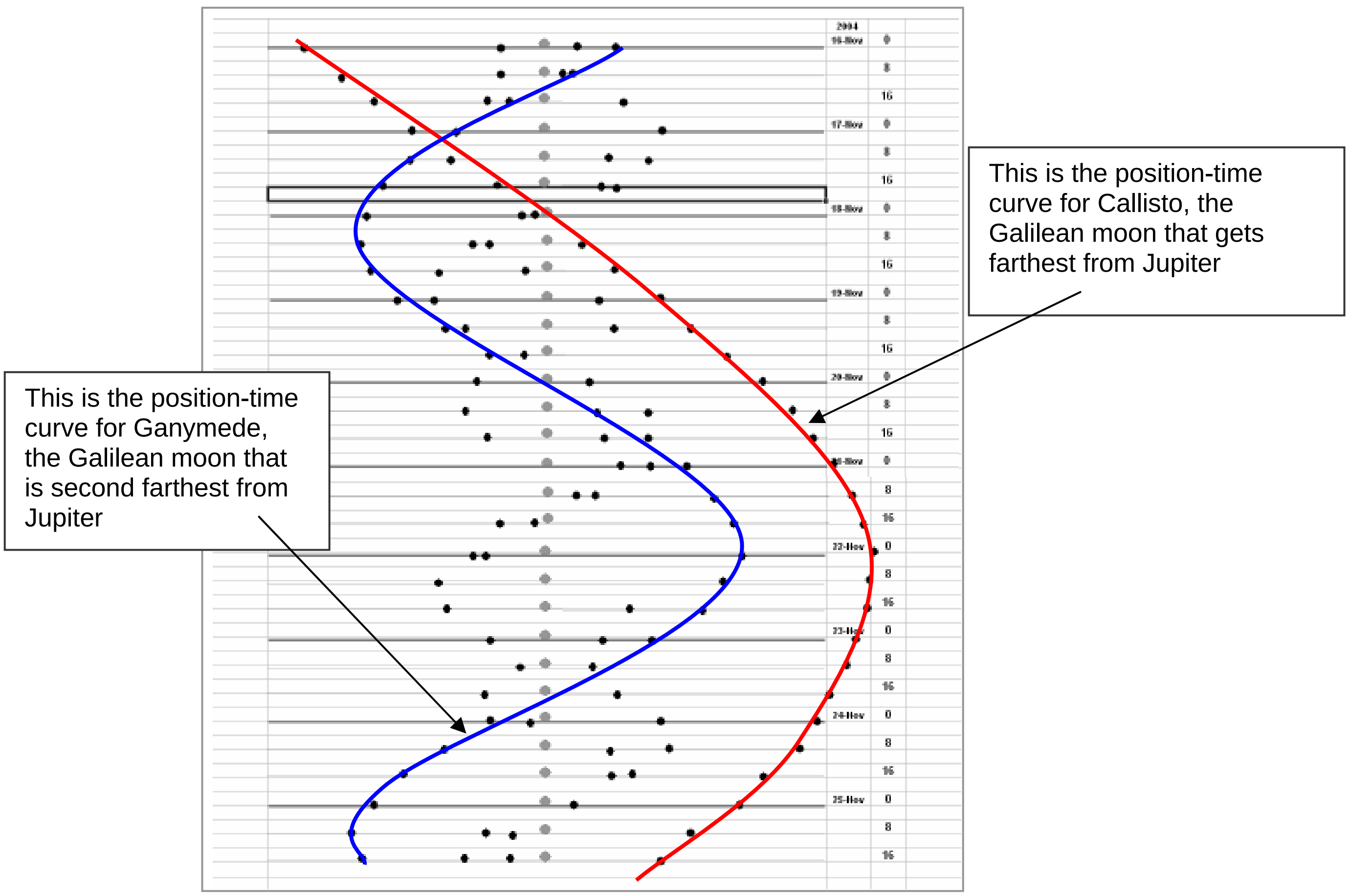
This is the position-time curve for the Galilean moon Callisto.

- Next draw in the position–time curve for the moon that is second farthest from Jupiter

These dots don't extend side to side as much as for Callisto, but they are second in their spread across the plot. By drawing in the curve for Callisto first, it is easier to see the patterns in the remaining dots.

This curve is the position-time curve for Ganymede. Identifying which dots are part of a particular moon's position-time curve is made easier if you look for the curve portions that are farthest to the left and right.

By taking care of Callisto first, Ganymede's curve is the next set of dots that extend farthest left and right.



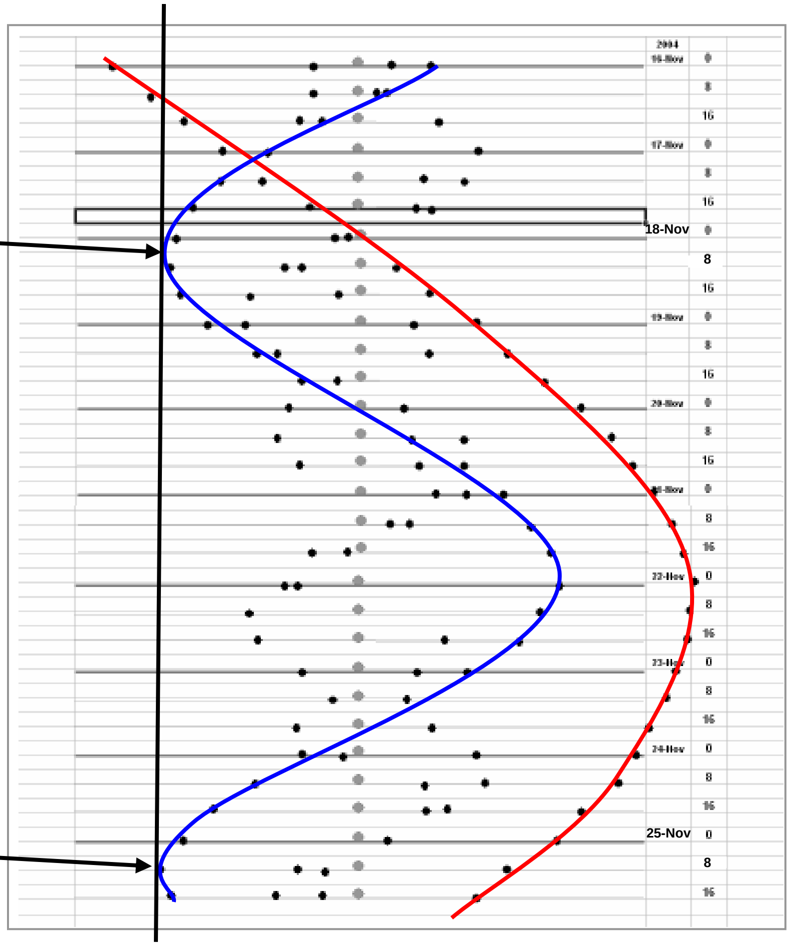
In the next section you will see how to use the position-time curve for each moon to determine the time it takes to orbit Jupiter.

4. Finding the orbital period of Ganymede – Extremes of the Curve

- For Ganymede, use a ruler or straight edge to find the two consecutive points when the satellite is at the greatest distance from Jupiter and on the same side of Jupiter.

Here

And Here



On this plot, the first point happens on Nov 18 at 8:00 am

The second point happens on Nov 25 at about 8:00 am

The time it takes Ganymede to orbit Jupiter is the time from the first point (Nov. 18, 8 am) to the second (Nov. 25, 8 am).

The time for Ganymede to orbit Jupiter as determined from these observations is called its **ORBITAL PERIOD**. This would be:

P = 7.00 days

The accepted period for Ganymede is:

P = 7.16 days

The experimental value differs from the accepted value by 0.16 days. This equals almost 4 hours and the two periods are in good agreement.

This experimental value is 2% shorter than the accepted value – pretty close!

To find the percent difference between the two, use this formula:

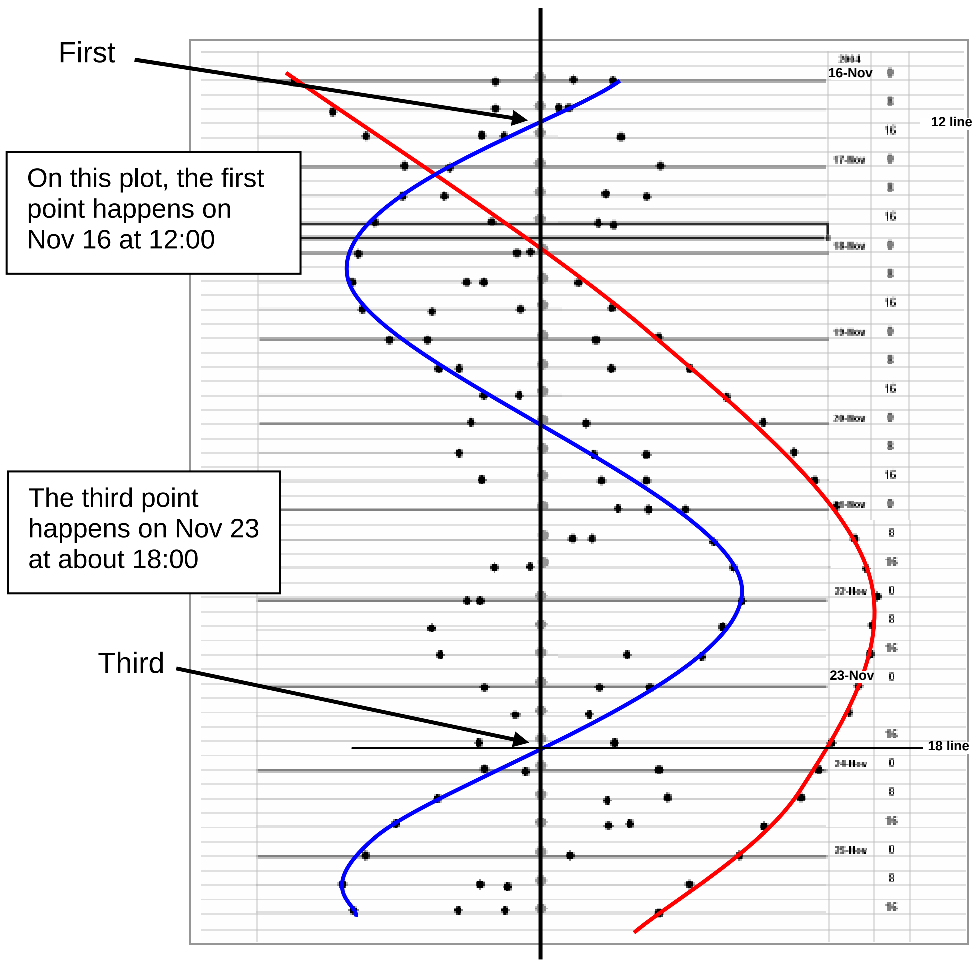
% Difference =

$$\frac{\text{Accepted} - \text{Experimental}}{\text{Accepted}} \times 100\%$$

5. Finding the orbital period of Ganymede – Crossing Jupiter

Another way to determine the orbital period can be found by getting the times when the position-time curve crosses the position of Jupiter.

- Draw a line down through the Jupiter positions.
- Find the first and third places where Ganymede's position-time curve crosses the vertical Jupiter line.



- Determine the difference in time from the first to the third intersection.

The time for Ganymede to orbit Jupiter as determined from these observations is called its **ORBITAL PERIOD**. This would be:

P = 7 days and 6 hours
or 7.25 days

The experimental value differs from the accepted value by 0.09 days, or about 2 hours. The percent difference between the experimental and accepted values is 1% .

This method is preferred over using the times for the points when the curve is farthest to the side. The time where the curve crosses Jupiter can be read more precisely with this method.

