Moons of our Solar System

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"When you go outside at night and look up, you may see lots of stars and the round, white moon. Have you ever wondered if there are other moons out there, and if there are, are they round and white like ours?". Explore the moons of our Galaxy. Students will investigate, analyze, collect data and compare. Case study: How Many Moons Does Jupiter Have? Galilean moons

Educational context

AGE

11-12

DURATION

3-4 hours

Prerequisites

EDUCATIONAL OBJECTIVES

Basic knowledge about the solar system, Periodic motion, velocity

COGNITIVE OBJECTIVES

Students will understand the method Galileo used to study the moons of Jupiter.
Use of Stellarium for learning of celestial object motions

AFFECTIVE OBJECTIVES

Students are called to use a simulation with several parameters that they must organize in order to draw their conclusions.

PSYCHOMOTOR OBJECTIVES

Students collaborate with each other to produce their results, following the instructions of their teacher and the spreadsheet. They present their results and discuss them with the rest of the classroom.

Erasmus+

CONNECTION TO THE CURRICULA

• Geography 6 th grade of the Greek curriculum	• -Chapter: ''Our Solar System''
• History 6 th grade of the Greek curriculum	• Chapter: ''Developments in Europe in recent times (15t-19th century) – The Renaissance (Copernicus, Galileo)''
• Mathematics 6 th grade of the Greek curriculum	• -Chapter: ''Data Comparison''

EDUCATIONAL APPROACH

Inquiry based learning

EDUCATIONAL GOALS

- Astronomical observation, observation planning
- Recognise a satellite
- Names and characteristics of moons (when Discovered, Discoverer, Myhtology, Magnitude, Distance, Visibility etc.)
- Discover historical data about moons investigations (How Galileo's observations of the Galilean moons provided evidence for the heliocentric model of the solar system)
- Compare moons with Earth
- Understand the importance of LCO use

STEP 1 - TEACHING AND PEDAGOGY

This activity will allow students to recreate Galileo's discovery of the four largest moons of Jupiter. Before embark on this activity, it is a good idea to acquaint students with the basic features of the old geocentric model of Aristotle and Ptolemy. Many of the features and ideas represented in this model will seem strange to students, and even contradict things they have already been taught. Children in the 21st century are the beneficiaries of centuries of scientific struggle and learning. Nevertheless, an understanding of the scientific ideas from Galileo's time can be useful in showing our children how science changes and evolves as new facts and ideas are discovered.

The geocentric system of Aristotle has the Earth in the center of everything – and it is completely unmoving; it neither spins on its axis each day, nor does it orbit the Sun every year. In fact, in the geocentric system, everything orbits the Earth! The Sun, the Moon, the various planets, and even the distant stars all revolve around the Earth at different speeds and distances. It was this idea that everything orbits the Earth which was the first crack in the geocentric theory that Galileo would exploit in his quest to prove the heliocentric system correct.

The whole point of this model is to allow students to see what Galileo did when he first turned his telescope on Jupiter in 1609. Some of this is difficult for children, we have been brought up learning that moons go around planets – Galileo had no such advantage! In his day, Galileo was taught that everything went around the Earth. The core point of this exercise is to ask students to use what they see as experimental data and compare it to the predictions made by the geocentric model. Galileo originally thought that these bright objects near Jupiter were stars, but just a few days' observations convinced him that this could not be true. If Jupiter were moving through space, it would simply pass the stars by, but the stars themselves would not move. These objects were clearly dancing attendance on the giant planet, and it did not take many days before Galileo realized that they were actually moons in orbit. The interesting part was that the old geocentric theory said that "everything circles the Earth" – these new moons clearly did not do that.

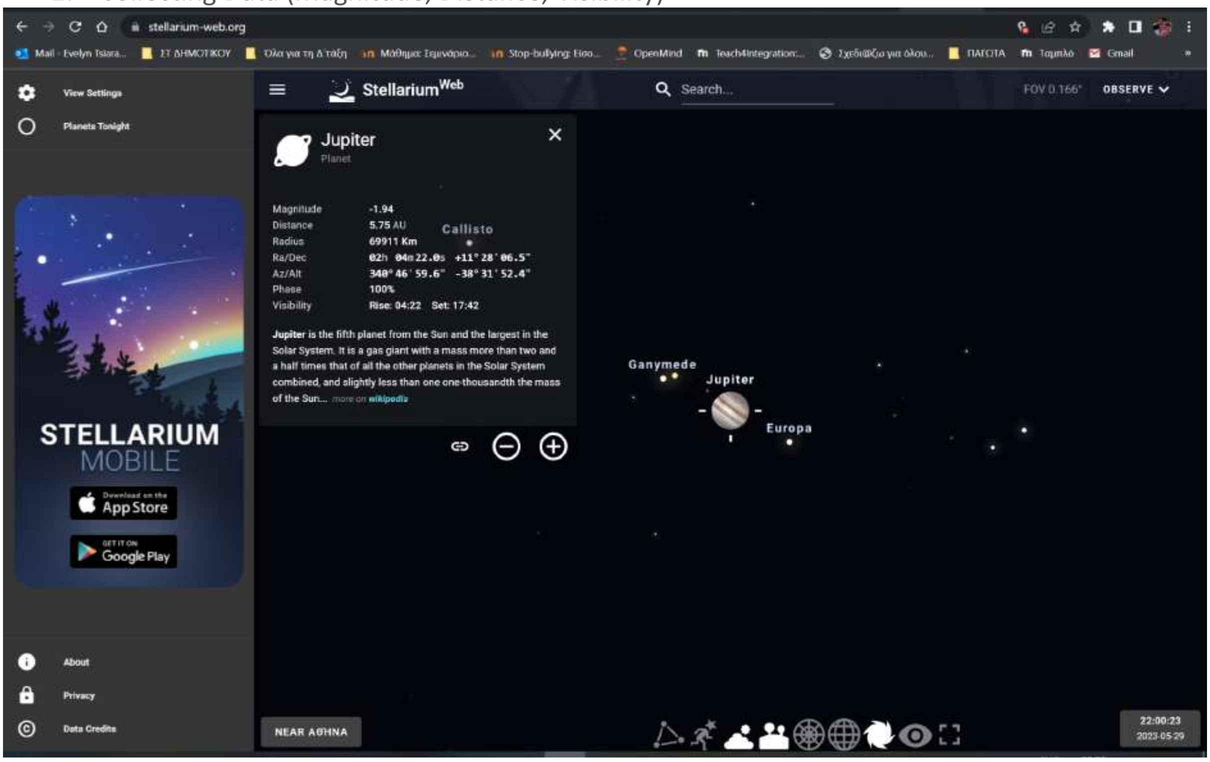
Galileo named the new moons individually. Students should be able to see easily that the moons orbit is the planet Jupiter. Ask them: "How do we know this? What evidence is in our drawings that these are moons and not stars?" The answer of course, is that the moons of Jupiter never wander far from the planet. Jupiter might pass by a background star and move on, but it would not drag that star along with it!

Expansion: They can also collect and present historical data about moons (e.g. when discovered, discoverer, Mythology etc.)

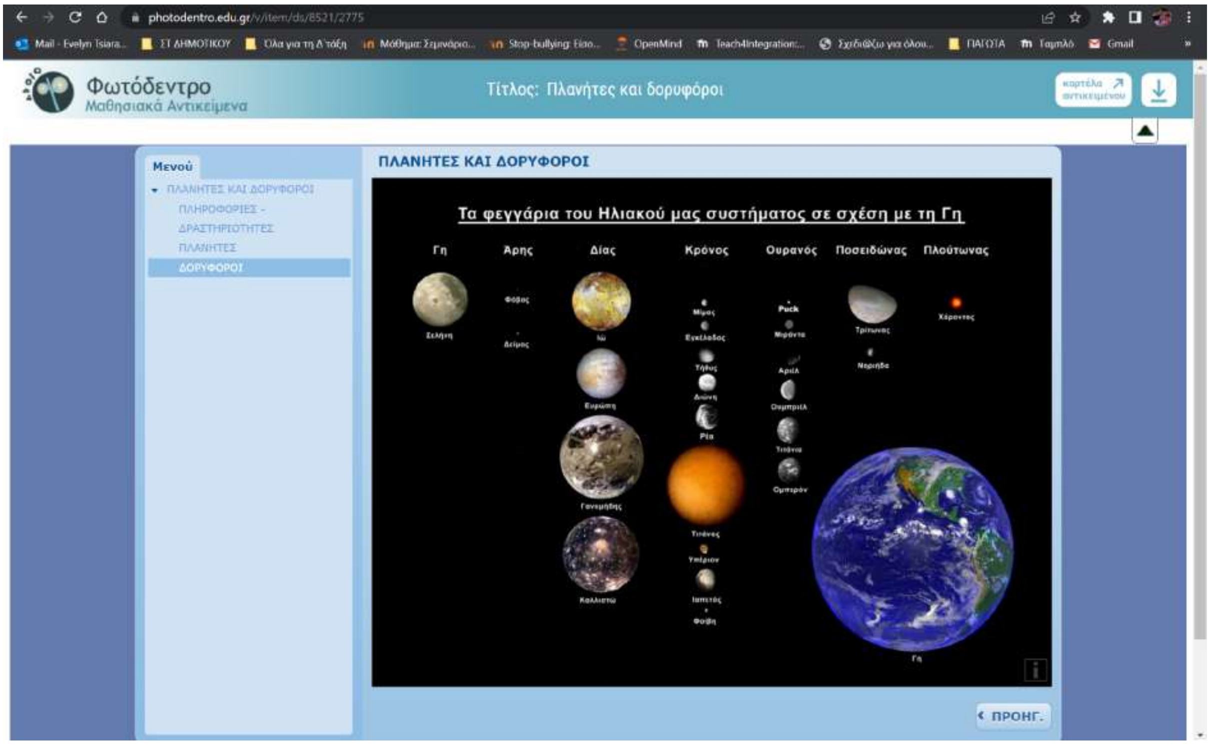
STEP 2 - CONDUCTING THE ACTIVITY

1. Observe moons of planets (Earth, Jupiter, Mars, Saturn, Neptune) through Stellarium connecting with a robotic telescope.

2. Collecting Data (Magnitude, Distance, Visibility)

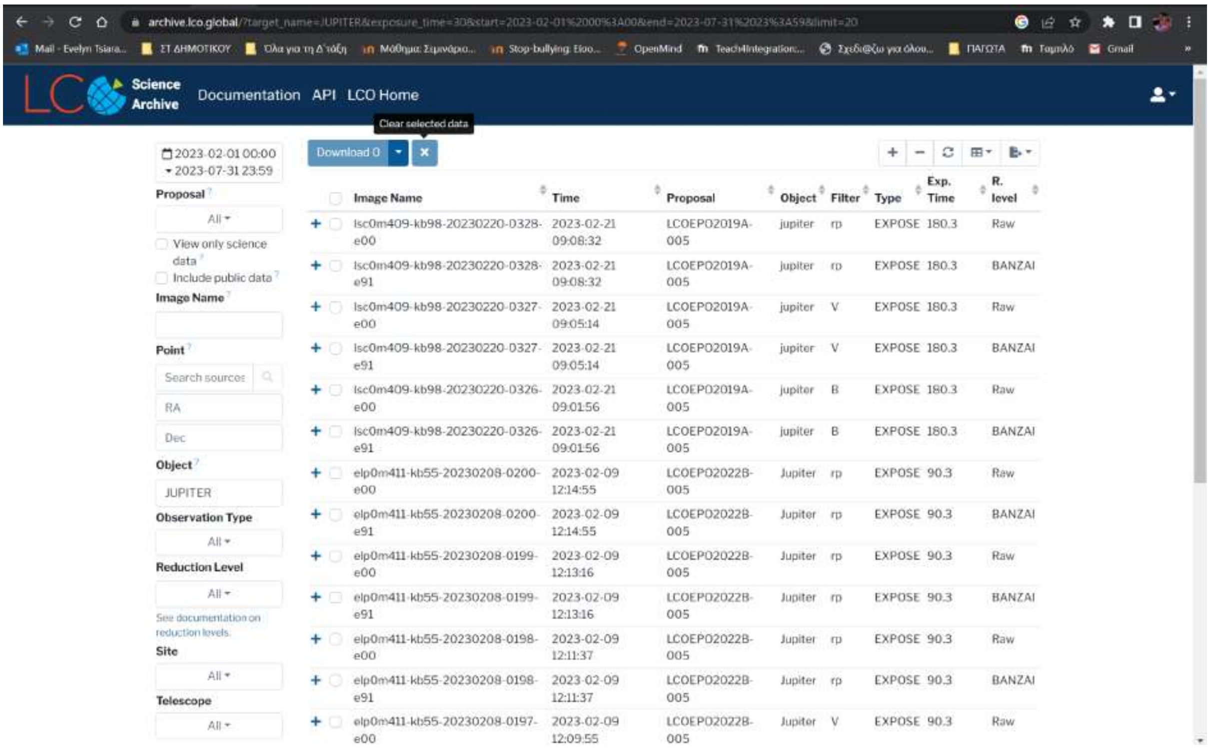


3. Compare moons with Earth https://photodentro.edu.gr/v/item/ds/8521/2775



STEP 3 - CASE STUDY "JUPITER'S MOONS"

1. Search LCO archives for Jupiter



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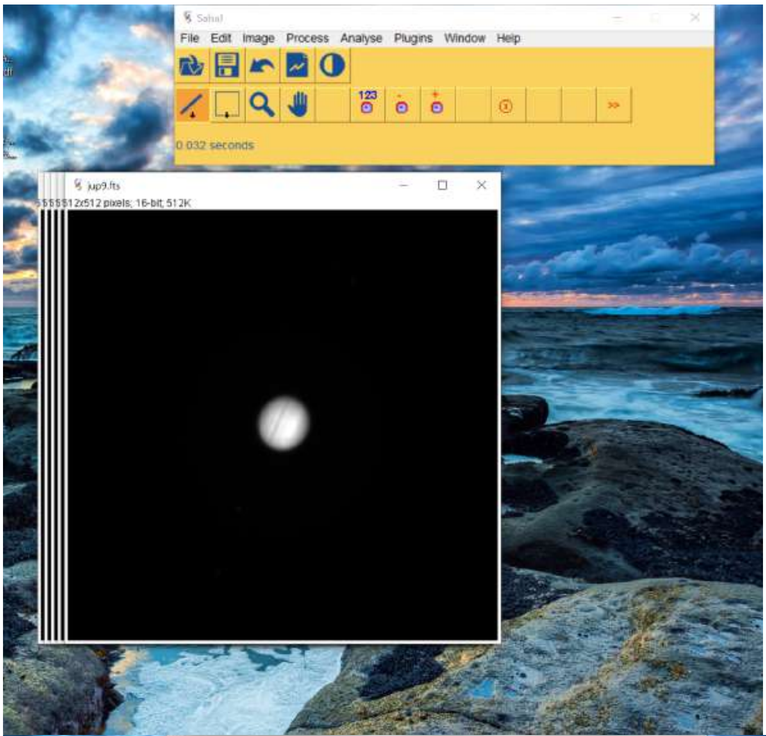
2. Use SalsaJ – make a video of Jupiter's moons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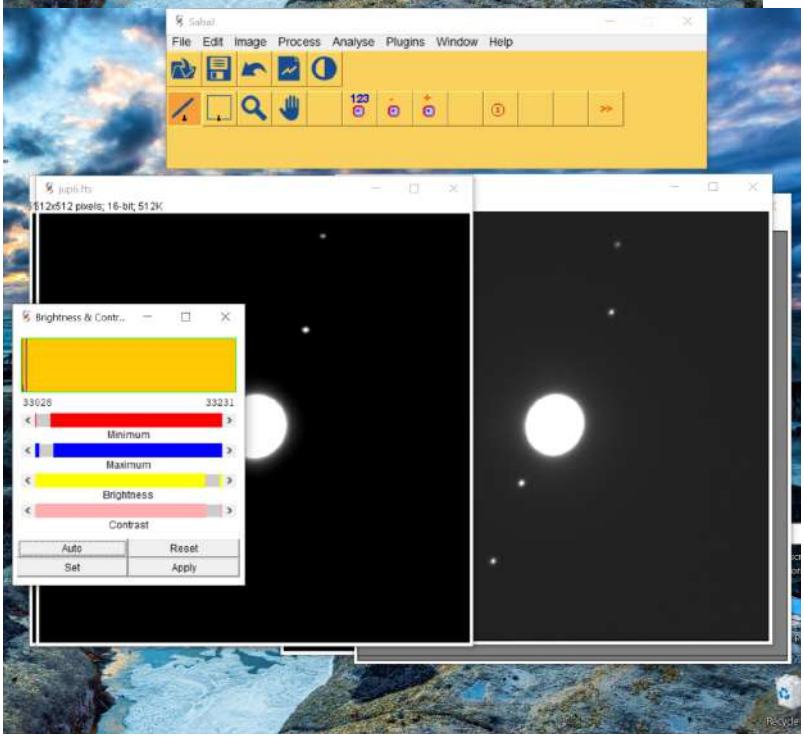
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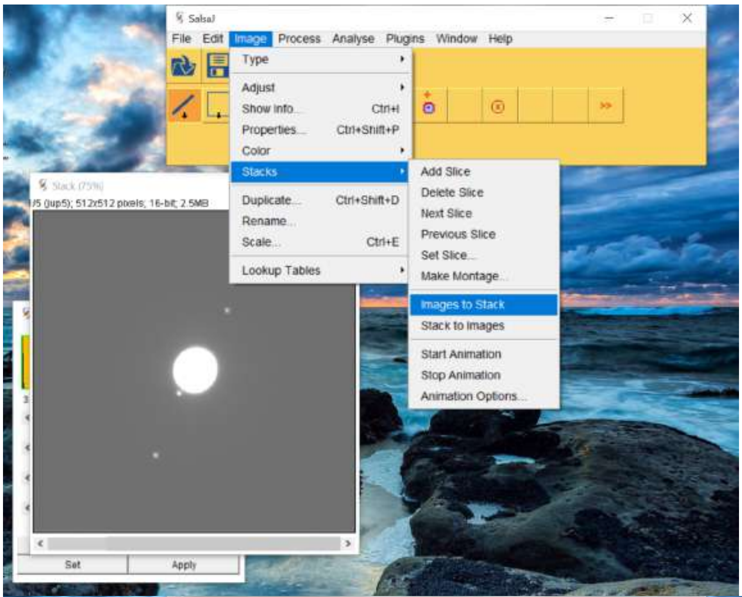
SalsaJ
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Lookup Tables
Add Slice
Delete Slice
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Make Montage...
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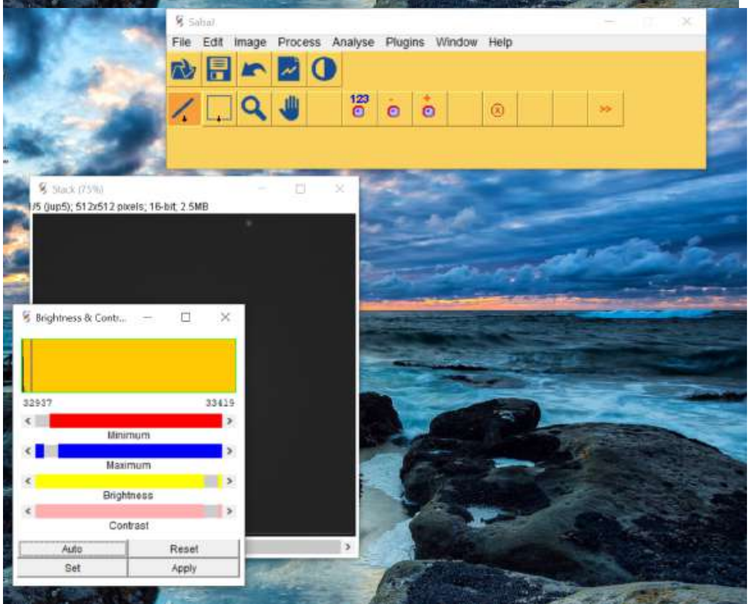
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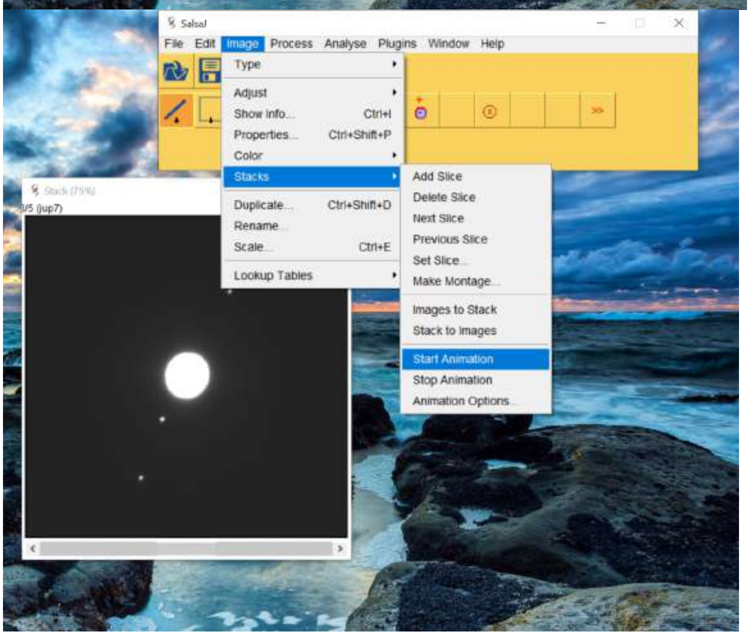
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Make Montage...
Images to Stack
Stack to Images
Start Animation
Stop Animation
Animation Options...
Stack (75%)
3/5 (jup7)

STEP 4 - ANALYSIS & INTERPRETATION

How Galileo's observations of the Galilean moons provided evidence for the heliocentric model of the solar system

On January 7, 1610 Galileo Galilei pointed a small twenty-power telescope at Jupiter. What he observed changed the way we understood the universe. Galileo noticed what appeared to be three small stars near Jupiter. The next evening he again observed three faint stars, but they now appeared on the other side of the planet. Over the next several weeks he watched up to four faint stars weave back and forth near Jupiter. Galileo named them the "Medicean Stars" in honor of his patron Cosimo II de' Medici, but we now know them as the Galilean moons of Jupiter.

At first it wasn't clear to Galileo what these "stars" were, or why they were always found near the king of planets. But Galileo was a patient and accurate observer, and over time it became clear that the motion of these objects followed Kepler's laws. The same laws that described the motion of the planets around the Sun. Clearly they orbited Jupiter in much the same way as our Moon orbits the Earth. And if moons could orbit a planet, then perhaps it was true that the Earth orbited the Sun after all.

With this discovery and his observations of the phases of Venus later that same year, Galileo gave us proof of a heliocentric universe. Earth was not fixed at the center of the cosmos, but rather moved around the Sun just as other planets did. But Galileo's discovery not only changed our view of the heavens, it also changed the Earth. Quite literally.

One of the great challenges of cartography has been determining just where on Earth you are. Determining your latitude can be done by observing the position of the stars. For example, the angle of the "north star" Polaris above the horizon is a good basic indication of your latitude. Determining longitude, however, is a very different matter. The Sun, planets and stars travel east to west across the sky, and so there is no clear point of reference for measuring longitude. To make an accurate longitude measurement, you need an accurate clock you can use to measure when particular stars pass overhead, for example. Since the Earth rotates at a steady rate, a time measurement can be used to determine your position east or west of a reference location.

Galileo realized that since the moons of Jupiter obeyed Kepler's laws, they could serve as a kind of heavenly clock. A clock more precise than any human-made clock of the time. So he began to compile a table of eclipses of the Galilean moons. That is, when a particular moon would pass into Jupiter's shadow or reappear from behind Jupiter. In 1668, Giovanni Domenico Cassini improved upon these tables, creating a timetable accurate enough for cartography. For the first time cartographers could make truly accurate longitude measurements. Many of the accepted distance between cities (used since the Roman Empire) were found to be off by hundreds of miles. The affect of Galileo's moons can be seen in the difference of world maps made before and after Cassini's tables.

STEP 5 - CONCLUSION & EVALUATION

Discussion Questions:

How did you know that the moons were orbiting Jupiter and not just nearby stars?

Answer: This very question was asked of Galileo! He was able to show that each of the moons had a particular distance from Jupiter (the size of its orbit), and that each moon had a particular orbital period (the time it took to circle Jupiter). The moons also never left Jupiter, they continually stayed near the giant planet – no stars would do this. These points together were conclusive!

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