

## Other moons

Recent observations of the largest planet in our solar system, Jupiter, have led to the discoveries of additional moons, or satellites, orbiting the planet. Jupiter, at least so far, has the greatest number of orbiting satellites of the eight planets, with 63. These satellites include both regular and irregular satellites, with some having prograde revolutions and others orbiting Jupiter in retrograde paths. Regular satellites are those that formed with Jupiter, while irregular satellites are those objects believed to have had orbits around the Sun and were subsequently captured by Jupiter's gravitational attraction.

Nearly 400 years ago, on January 7, 1610, Galileo Galilei turned his new telescope toward the planet Jupiter. As he observed the planet, he commented on three bright stars arranged in a straight line near Jupiter (see Figure 1). The following evening, he observed that these same three stars were now arranged in a different pattern. Over the course of the next several evenings, Galileo observed a fourth star. He determined that the change in the positions of these stars was not a result of Jupiter's proper motion against the fixed stars in the background, and concluded that these four bodies were not fixed at all, but rather were objects in orbit around Jupiter.

In a tribute to the Grand Duke Cosimo II de Medici and his very influential family, Galileo named these four stars the

Medicean stars. Galileo had tutored the Grand Duke in mathematics, and over the years the two stayed in touch. We now know these moons as Io, Europa, Callisto, and Ganymede—the Galilean satellites.

In his notes and later in a publication titled *Sidereus Nuncius*, or *The Sidereal Messenger*, Galileo described his observations of Jupiter and its four moons, as well as his observations of our Moon and the planet Venus. A translation of this book was completed in 1800, and an online copy is available for your students to read courtesy of the Linda Hall Library (see Resources).



*“On the 7th day of January in the present year, 1610, in the first hour of the following night, when I was viewing the constellations of the heavens through a telescope, the planet Jupiter presented itself to my view. . . . I noticed a circumstance which I had never been able to notice before, namely that three little stars, small but very bright, were near the planet; and although I believed them to belong to a number of the fixed stars, yet they made me somewhat wonder, because they seemed to be arranged exactly in a straight line, parallel to the ecliptic, and to be brighter than the rest of the stars, equal to them in magnitude. . . . On January 8th, led by some fatality, I turned again to look at the same part of the heavens, I found a very different state of things, for there were three little stars all west of Jupiter, and nearer together than on the previous night. . . . I therefore concluded, and decided unhesitatingly, that there are three stars in the heavens moving about Jupiter, as Venus and Mercury around the Sun. . . . These observations also established that there are not only three, but four, erratic sidereal*

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### Questions for students

1. As Galileo observed Jupiter, he noticed that there were times when not all of the Galilean satellites were visible. Explain how this might happen. (One or more of the Galilean satellites may not be visible as there will be times when they are either in front of or behind the disk of the planet.)
2. From your data, determine the approximate orbital periods for each of the four Galilean satellites. (Io orbits Jupiter in about 1.8 days; Europa orbits Jupiter in about 3.5 days; Ganymede orbits Jupiter in about 7.2 days; Callisto orbits Jupiter in about 16.8 days.)
3. From your data, determine which of the Galilean satellites is closest to Jupiter. Which is the farthest? (The moon with the shortest orbital period will be the moon that is the closest to Jupiter. Io is the closest to Jupiter of the Galilean satellites, while Callisto is the farthest away.)

**FIGURE 1**

**Observations of Jupiter's moons by Galileo** (from *The Sidereal Messenger*; see Resources)

FIG.	DATE	EAST.	WEST.
1	Jan. 7	• • ○ •	
2	8		○ • • •
3	10	• • ○	
4	11	• • ○	
5	12	• • ○ •	
6	13	• ○ • • •	

**FIGURE 2**

**The Juplet Applet showing Jupiter and the Galilean satellites**



bodies performing their revolutions around Jupiter.” (From *The Sidereal Messenger*, pp. 45–48; see Resources.)

### Tracking the Galilean satellites

Students may recreate Galileo’s observations of the Galilean satellites through the use of an online simulation or readily available astronomical software downloadable from the internet. Using the Java applet, Juplet (see Resources), students may input dates or times to see the position of the four Galilean satellites (Figure 2). From the data they graph, students can also determine orbital periods for these satellites in much the same way as Galileo did.

Initially, Juplet will display the planet and the satellite configuration for the date and time on the computer. Students can easily edit the date and time and after pressing the Enter key will see a different configuration. The positions of each satellite relative to Jupiter may be drawn on a data table similar to Galileo’s (Figure 3). Set up a data table, but add enough rows at the bottom so students will be able to observe and plot the satellite positions for at least one month. Use a different color or number for each satellite. After the data have been plotted, students should connect the dots for each satellite with a curved line. Once this has been completed, students may use their data to answer the Questions for Students (see box on page 78).

### Visible planets

- Mercury will be visible over the western horizon after sunset during the first half of the month.

**FIGURE 3**

**Data table for Jupiter and the paths of the four Galilean satellites**

Date	East	Jupiter	West
		●	
		●	
		●	
		●	

### The February Snow Moon

Date	Moon event
2/1	<b>Full Moon</b> Right ascension: 8 <sup>h</sup> 38'; Declination: 21°4'
2/4	Descending node Illuminated fraction: 0.94%
2/7	Apogee Distance: 404,981 km Apparent size: 0.4918°
2/10	<b>Last quarter</b> Right ascension: 14 <sup>h</sup> 43'; Declination: -20°57'
2/17	<b>New Moon</b> Right ascension: 21 <sup>h</sup> 43'; Declination: -16°20'
2/18	Ascending node Illuminated fraction: 0.01%
2/19	Perigee Distance: 361,443 km Apparent size: 0.5510°
2/24	<b>First quarter</b> Right ascension: 3 <sup>h</sup> 45'; Declination: 24°38'

- Venus will be visible over the western horizon after sunset and will be a few degrees above and to the left of Mercury.
- Mars will be visible as a morning planet over the eastern horizon a couple of hours before sunrise.
- Jupiter will rise after midnight and will be easily seen over the southern horizon before sunrise.
- Saturn will rise in the east at about sunset and will be visible all night.

### Resources

- SFA star charts—[observe.phy.sfasu.edu](http://observe.phy.sfasu.edu)
- Daily Moon rise and set—[aa.usno.navy.mil/data/docs/RS\\_OneDay.html](http://aa.usno.navy.mil/data/docs/RS_OneDay.html)
- Monthly Sun and Moon rise and set—[www.sunrisesunset.com/custom\\_srss\\_calendar.asp](http://www.sunrisesunset.com/custom_srss_calendar.asp)
- Lunar perigee and apogee calculator—[www.fourmilab.ch/earthview/pacalc.html](http://www.fourmilab.ch/earthview/pacalc.html)
- Virtual reality Moon phase pictures—[tycho.usno.navy.mil/vphase.html](http://tycho.usno.navy.mil/vphase.html)
- Juplet—[www.shallowsky.com/jupiter.html](http://www.shallowsky.com/jupiter.html)
- The giant planet satellite and moon page—[www.ifa.hawaii.edu/~sheppard/satellites](http://www.ifa.hawaii.edu/~sheppard/satellites)
- The Sidereal Messenger—[www.chlt.org/sandbox/lhl/gal1880/page.67.a.php?size=480x640](http://www.chlt.org/sandbox/lhl/gal1880/page.67.a.php?size=480x640)