



# Spacecraft Speed

Middle grades

## Lesson Summary

Students compare the speed of the Galileo spacecraft to more familiar speeds (walking, driving, etc.) and graph their results.

## Prior Knowledge & Skills

- Multiplication and division
- Linear and (optional) logarithmic graphing

## AAAS Science Benchmarks

### **The Physical Setting**

*The Universe*

### **Common Themes**

*Scale*

## NSES Science Standards

- **Earth and space science:** Earth in the Solar System
- **Science and technology:** Understandings about science and technology

## NCTM Mathematics Standards

- **Number and Operations:** Compute fluently and make reasonable estimates
- **Algebra:** Use mathematical models to represent and understand quantitative relationships

**Teaching Time:** One 45-minute period

## Materials

To share with the whole class:

- Butcher paper for graphing
- Cut out illustrations (person walking, satellite, person running, airplane, etc.)
- Logarithmic graph paper (optional)

## Advanced Planning

**Preparation Time:** 30 minutes

1. Gather materials
2. Review lesson plan

## Why Do We Care?

The Galileo spacecraft, launched in 1989, spent more than 8 years studying Jupiter and its satellites. In 2003, Galileo was deliberately plunged into Jupiter's atmosphere, where it was crushed by Jupiter's high pressure. Galileo's operations were powered by a radioisotope thermoelectric generator, which uses the heat from the radioactive decay of its fuel to make electricity. Galileo generated 570 watts of power: only enough to light about 10 light bulbs!

*Source: Galileo K-12 Educator's Resources, Project Galileo, NASA/JPL*

## Spacecraft speed and acceleration

**Resource used:** Galileo WWW Page (<http://www.jpl.nasa.gov/galileo/>)

**Activity description -- Junior High:** put the spacecraft's speed into perspective.

During its mission to Jupiter, the Galileo spacecraft traveled at an average speed of 44,000 miles per hour. How fast is this really? (either supply the data below, or have the students guesstimate, or have them add other examples)

- A human walks at about 7 kilometers (4 miles) per hour
- A human runs at about 22 kilometers (13 miles) per hour (marathon pace)
- A car's top (legal) speed in the US is 108 kilometers (65 miles) per hour
- A jet airplane can make 830 kilometers (500 miles) per hour
- Just prior to arriving at Jupiter, Galileo was traveling at 3,400 kilometers (2,040 miles) per hour (relative to the Sun)
- A satellite in low earth orbit travels at 28,000 kilometers (16,800 miles) per hour
- The Earth, moving around the Sun, has an average speed of 107,600 kilometers (64,560 miles) per hour
- Right after flying by Earth for the second time, Galileo was traveling at 152,640 kilometers (91,590 miles) per hour (relative to the Sun).

How long would it take to walk/drive/jet/Galileo from New York to California?  
*5,000 kilometers (3,000 miles): 30 days, 46 hours, 6 hours, and 2 minutes, respectively.*

Or, if there was a direct road to Jupiter (which is, at a minimum, 630,000,000 kilometers (378,000,000 miles) from the Earth), how long would it take to make the trip walking/driving/jetting?  
*10,273 years, 666 years, and 87 years, respectively*

Graphing all of this might make it easier to see in a glance how these speeds vary.

Easiest: have the students make up a linear graph that will show all of the speeds, using a long piece of butcher paper (which may need to wrap around several walls!). Cut out pictures to illustrate the data points (e.g. a woman walking or a drawing of a satellite).

More advanced (introducing logarithms): Have the students try three different methods (see attached illustration). Which graph makes it easiest to "read off" the actual speed of each object? Which graph makes it easiest to compare the speeds of each object?

Linear graph: Each tick mark indicates an equal number of kilometers per hour. Drawn on a sheet of notebook paper, differences between running, walking, and a car are easy to see, but nothing else fits on the graph.

Linear graph with expanded scale: Each tick mark indicates an equal number of kilometers per hour. Drawn on a sheet of notebook paper, humans, cars and planes all appear to move at the same speed.

Log graph: Each tick mark indicates a factor of 10 increase in the number of kilometers per hour. This makes it easy to tell that, for example, Galileo was moving roughly 100 times faster right after the second Earth flyby than it will be moving right before arriving at Jupiter.