# The Paths of the Planets

In the early 1600s, Johannes Kepler (1571–1630) studied the motions of the planets to find a good mathematical model for them. In 1619, he published his third law of planetary motion, which says how the orbital periods of the planets are related to their distances from the sun. In Kepler's time, Uranus and Neptune had not been discovered, but here is the data for all 8 planets:

| planet | distance (millions of km) | period (days) |
|--------|---------------------------|---------------|
| Mercury | 57.9 | 88.0 |
| Venus | 108.2 | 224.7 |
| Earth | 149.6 | 365.2 |
| Mars | 227.9 | 687.0 |
| Jupiter | 778.6 | 4,331 |
| Saturn | 1,433.5 | 10,747 |
| Uranus | 2,872.5 | 30,589 |
| Neptune | 4,495.1 | 59,800 |

1. Plot the distance ($x$) and period ($y$) of each planet, and find a polynomial model that fits the data as well as possible. You may have to experiment with both the degree of your polynomial function and the number of terms.

2. Make another plot that uses the square root of each distance instead, and find a polynomial model that fits those points as well as possible.

3. Which model do you think is best?

4.
    a. Jupiter has a lot of moons. Look up the periods and distances of some of them, and use that data to make a polynomial model of the relationship between period and distance for Jupiter's moons.

    b. Use your model to predict the period of another one of Jupiter's moons using the radius of its orbit.

c. How good was the prediction? What are some possible sources of error?

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1. Plot the distance ($x$) and period ($y$) of each planet, and find a polynomial model that fits the data as well as possible. You may have to experiment with both the degree of your polynomial function and the number of terms.

2. Make another plot that uses the square root of each distance instead, and find a polynomial model that fits those points as well as possible.

3. Which model do you think is best?

4.
   a. Jupiter has a lot of moons. Here are the periods and distances of the Galilean moons, which were discovered in 1610:

| moon | distance (thousands of km) | period (days) |
|------|---------------------------|---------------|
| Io | 421.8 | 1.77 |
| Europa | 671.1 | 3.55 |
| Ganymede | 1070.4 | 7.16 |
| Callisto | 1882.7 | 16.69 |

Use the data to make a polynomial model of the relationship between period and distance for Jupiter's moons.

b. Another moon of Jupiter, number LXXI, was discovered in 2018. Its distance from Jupiter is 11,483 thousand km. According to your model, what should its period be?

c. The actual period of the moon is 252.0 days. How close was the prediction? What are some possible sources of error?