Drawing Orbits

Apparatus

board which pins can be pushed into, string, pencil, pins, table of planetary orbit data (see below)

Action

The students push one pin into the board to mark the position of the sun. Another pin is pushed in at the second focus of the orbit. The distance between the foci is equal to the difference in the aphelion and perihelion distances. The string is cut to the aphelion distance plus the perihelion distance, suitably scaled down, plus a little bit for tying. One end of the string is tied to each pin, and used to guide the pencil in drawing an elliptical orbit.

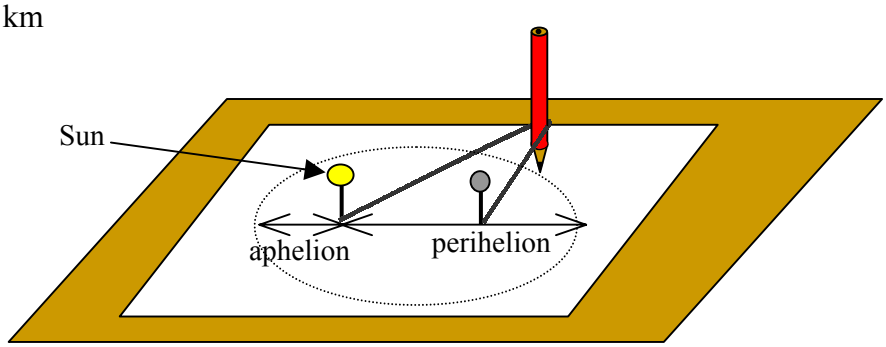
Alternatively, they cut a piece of string to a (scaled down) length equal to twice the sum of the aphelion and perihelion distances ($l = 2(a+p)$). They tie the string in a loop and put it around the pins and hold the pen in the loop so that it pulls the loop taut and use the string to guide the pen to draw the orbit.

The Physics

The planets move in elliptical orbits around the sun. The closest point to the sun is called the perihelion and the furthest point is called the aphelion. The sun is at one focus of the ellipse. The string should be a length equal to the sum of the aphelion and the perihelion, so that the pencil is at most the aphelion distance from the sun. The distance between the foci is equal to the difference between the aphelion and perihelion distances. The eccentricity of the orbit is the ratio of the distance between the foci to the length of the major axis, which is (aphelion – perihelion) / (aphelion + perihelion), which is equal to 0 for circle and is between 0 and 1 for an ellipse.

Planet	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Aphelion	70	109	152	249	817	1515	3004	4546	7304
Perihelion	46	108	147	206	741	1353	2741	4445	4435

Distances × 10^6 km



Accompanying sheet

Drawing Orbits

Place one pin at the sun position, and another at the other focus
for one of the planets.
How do you know where the other focus should be?

Now cut a piece of string to a (scaled down) length equal to the
sum of the aphelion and perihelion distances.
Use the string to guide the pen to draw the orbit.

Repeat for one or two other planets.
Which planets have the most eccentric orbits? Which have the least eccentric?