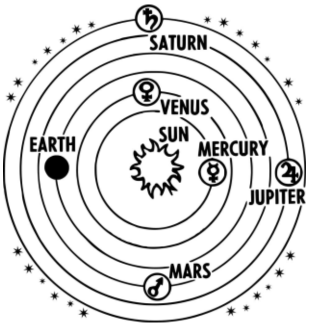
Orbit Shapes and AU - Teacher's Notes

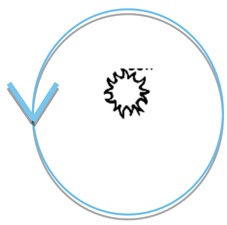
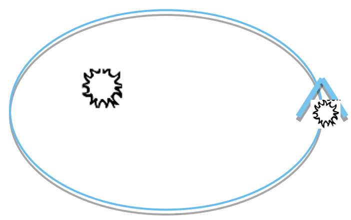
Orbit shapes



To the Copernican heliocentric model of the Solar System, further refinements were added by later astronomers and mathematicians. These were only possible using better telescopes and better mathematical techniques.

Johannes Kepler (1571-1630) used observations and measurements of his own and from his mentor Tycho Brahe to demonstrate that planets actually travel in elliptical orbits, not circular ones. This explained the earlier observations that planets seem to vary in distance from the Sun during their orbits and sometimes appeared to move backwards.

An ellipse is a curved shape with two centers or loci.

Circular orbit	Elliptical orbit
	

Kepler also proposed that the further a planet's orbit is from the Sun the more elliptical it becomes. See following teacher demonstration.

This means that when we measure the distance from the Sun for any planet we have to measure the mean or average distance as the true distance varies if they travel in an elliptical path.

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Astronomical Measurements

The Astronomical Unit (AU)
We humans are used to using measurements in millimeters, centimeters, metres and kilometers. Once we start measuring across the enormous distances of the Solar System however, we need to use another standard. We use the distance of the Earth from the Sun as one Astronomical Unit (1AU).

1 Astronomical unit is 149,597,870.7km

Planet	Distance from Sun (AU)
Mercury	0.39
Venus	0.72
Earth	1.00
Mars	1.52
Jupiter	5.2
Saturn	9.54
Uranus	19.2
Neptune	30.06

Of course when we start measuring distances across the Milky Way or further still, across the Universe we need to use measurements in light years or parsecs.

One light year is the distance light can travel in one year or 9.4607×10^{12}km.
One parsec (beloved of Star Wars fans), is roughly equivalent to 3.26 light years.

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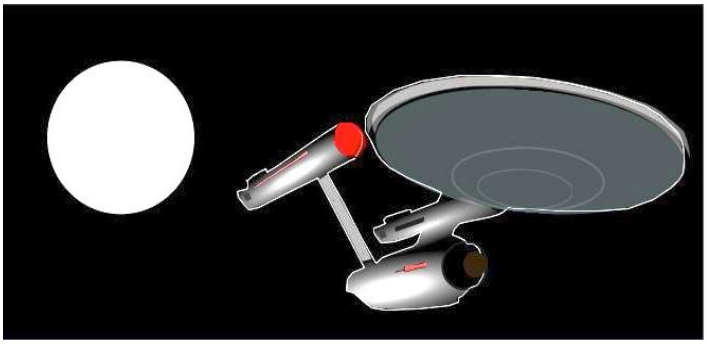
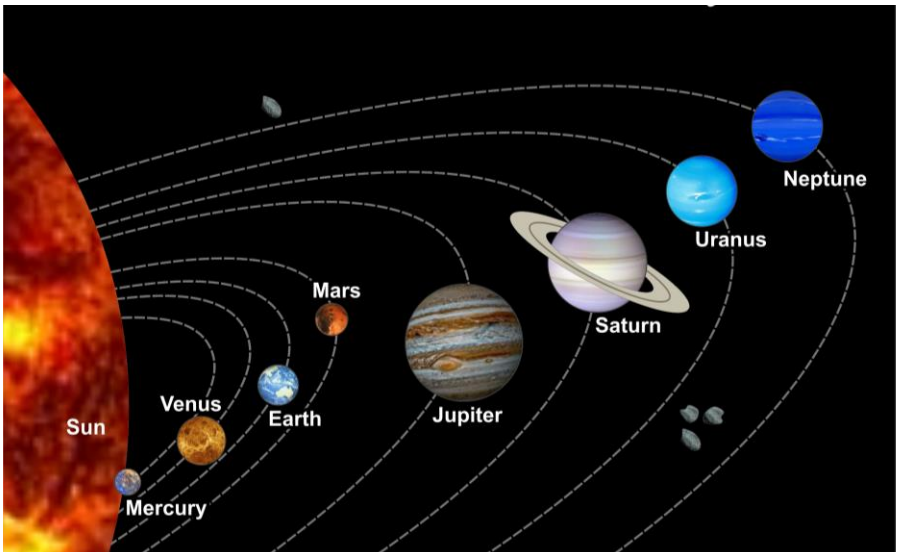


In Space, things which are moving tend to keep moving unless acted on by another force (Newton's First Law). There is almost no friction to slow things down because space is mostly empty. If a spacecraft has sufficient energy to exceed the gravitational pull of the Sun, once it is out of range it needs very little power because it will continue under its own momentum. It can pick up "free" energy by using the gravitational pull of a large object such as a planet. This can be used like a slingshot to fling it further into space. This technique saves precious fuel. Planets would also continue straight out into space unless they were acted on by the Sun's gravitational force.



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Drawing Elliptical Planetary Paths

Astronomers suggested that planetary orbits become more elliptical as they move further from the Sun. This activity demonstrates that this is true.

Ellipses have two loci to influence their shape. The constant thumbtack represents the Sun, the centre of our solar system. The second thumbtack represents the farthest position of each planet from the Sun in its orbit. As the planet approaches the Sun, the pull of gravity first speeds it up until it passes and the gravitational force pulls it back again.

Planets and other materials travel in elliptical orbits until they expend their energy and slowly progress, spiraling towards the Sun.

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Materials

- A sheet of cardboard or polystyrene larger than A4. I used a handy cool drink box. It was easy to stick the pins in to anchor the paper.
- A sheet of A4 paper, or A3 if you have a big box.
- Four thumbtacks or sticky tape to hold the paper on the surface of the cardboard.
- Two thumbtacks to act as the loci.
- Coloured pens, felt tip pens or coloured pencils.
- String, thread or wool.
- Scissors.
- A ruler.

Method

1. Attach the paper to the box or polystyrene sheet.
2. Draw a horizontal line across the middle of the sheet.
3. About a third of the way along the line stick in your first drawing pin or thumbtack. This is the centre of the Sun and its centre of gravity. (In the photo it is the yellow thumb tack)
4. Using the table provided, select three planets. I recommend using Earth, Jupiter and Saturn. Mark their distances from the Sun on the central horizontal line. If you select a scale of 1cm = 1AU, then Earth is at 1cm, Jupiter at 5.2cm and Saturn at 9.5cm.
5. Place a thumbtack at Earth's position and make a string loop to fit neatly between the planet and the thumbtack representing the Sun.
6. Insert a pen into the loop and draw the orbit of the Earth. It will be almost circular.
7. Repeat for Jupiter and Saturn. These will be noticeably more elliptical.