Using an Orrery – a teachers' guide

Orreries are models of the Solar System showing the planets around the Sun. They help students understand the arrangement and motions of the Solar System. Whilst "orrery" sounds like a technical term, it is the name given to these types of models after the Earl of Orrery, who was very interested in models of the planetary system.

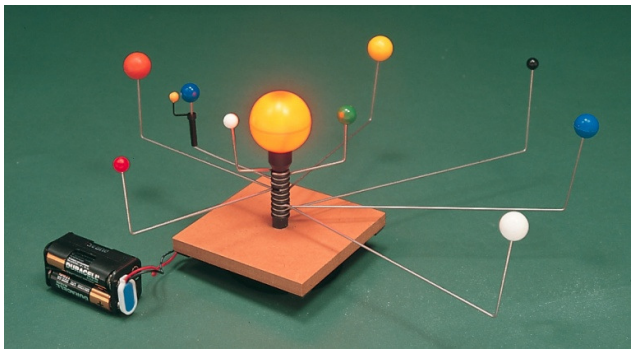
Features of Orreries

Orreries range from low-cost products like the Orbit™ Orrery up to luxury items of brass with jewelled planets. As a learning tool, the following points will be of interest:

- How many of the nine planets does it show?
- Does it also show the Earth's Moon? (Other planets also have moons but they are not as important to us)
- Does the sun light up? (This shows that the Sun is the source of light in the Solar System. We see the moon and planets because they reflect this light.)
- How are the planets rotated (by hand or motor-driven)?
- If motor-driven, do the planets rotate at their correct speeds (Mercury very fast and Pluto very slowly) or all at the same speed?
- Build quality, cost and availability of after sales support.

The Orbit™ Orrery (featured right)

- The planets are shown as far as Pluto.
- The Sun lights up when batteries (not supplied) are fitted.
- The planets are individually rotated around the Sun by hand.



Teachers' Guide

The following guide is based on using the Orbit™ Orrery, although much of it will apply to other Orreries.

1. Introducing the solar system

Set the model up with the Sun lit and planets spaced out around it. In this situation the following points can be seen:

- The Sun is at the centre of the Solar System
- The Solar System has nine major planets, of which the Earth is one
- The planets rotate around the Sun in *orbits*
- The Moon rotates around the Earth

In a darkened room*, the following can also be seen:

- The sun is the source of light in the Solar System
- The planets and Moon are visible because they reflect the light from the Sun
- The sunlight divides the surface of the planets and Moon into a lit side (daytime) and unlit side (night-time)

*An alternative to darkening the room is to get a big box, cut peep holes in the sides (about 150mm x 50mm) and place the box upside down over the Orbit™ Orrery. This is very effective and really intrigues the younger students.

The order of the nine planets starting closest to the sun is: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.

2. Which way do the planets go?

If you imagine that you are in space above the North Pole, looking down on the Solar System then;

- the planets all go round the Sun anti-clockwise
- the Moon goes round the Earth anti-clockwise
- the Earth rotates on its axis anti-clockwise

This point of view is sometimes called 'from North of the Ecliptic', the Ecliptic being the plane cut out in space by the Earth's orbit of the Sun. If, however, you are in space above the South Pole the direction of these motions will all appear to be clockwise.

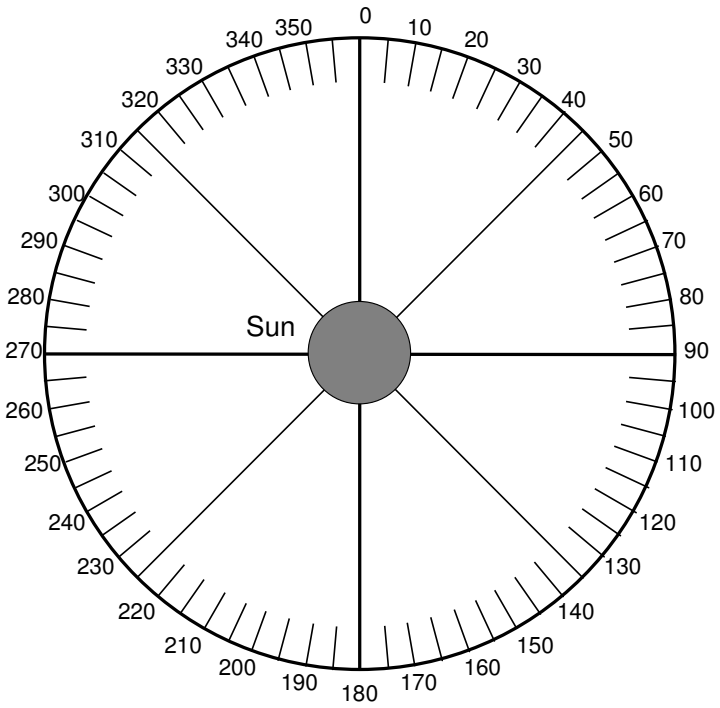
3. How quickly do they go?

The time a planet takes to orbit the Sun depends on how far away it is from the Sun. The nearer the Sun the shorter the time. Measured in Earth years and days the times are Mercury 88 days, Venus 225 days, Earth 1 year, Mars 1 year 321 days, Jupiter 11 years 321 days, Saturn 29 years 131 days, Uranus 85 years, Neptune 166 years and Pluto 250 years.

4. Where are they now?

The positions of the planets relative to each other and to the Sun are constantly changing. To set up an orrery, Heliocentric (Sun-centred) Longitudes are most useful. Positions for 2011 are given below. To position your planets cut out the degree scale printed right and place it on your orrery. Then align the planets with the longitudes given.

NB: The direction of zero degrees is not important for the activities in this leaflet. It is important if one wants to consider the positions of the stars relative to the planets or the height of the planets above the horizon due to the Earth's tilt. More detailed models such as the Helios Planetarium cover these topics.

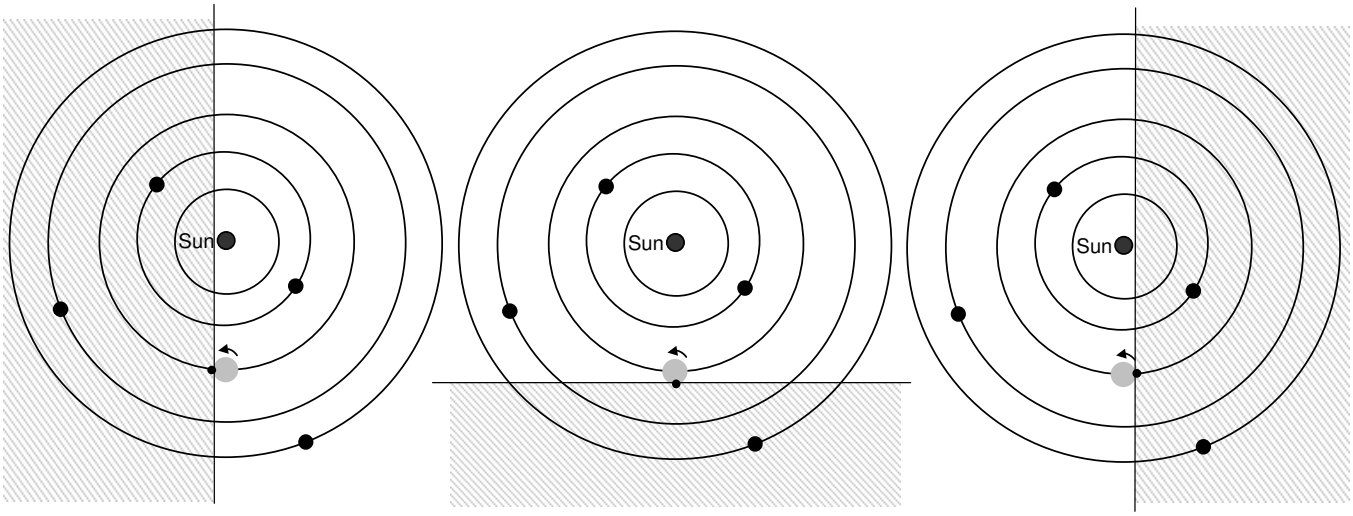


2011 Heliocentric longitudes for setting up the Orbit™ Orrery

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1st	1st	1st	1st	1st	1st	1st	1st	1st	1st	1st	1st
2011												
Mercury	156	259	352	165	262	11	178	273	33	193	284	51
Venus	139	189	234	283	331	20	68	118	169	217	266	313
Earth	100	132	160	191	220	250	279	308	338	7	38	69
Mars	294	313	331	351	9	28	46	63	79	94	109	122
Jupiter	8	11	13	16	19	22	24	27	30	33	36	38
Saturn	191	192	193	194	195	196	197	198	199	200	201	202
Uranus	0	0	0	1	1	1	2	2	2	3	3	3
Neptune	328	328	328	329	329	329	329	329	330	330	330	330
Pluto	275	275	276	276	276	276	276	276	277	277	277	277

5. Which planets can I see when?

The diagram below shows why you can see different planets at different times. The diagram shows the positions of a person on the equator evening sunset, midnight and morning sunrise as viewed from north of the ecliptic. The straight lines represent where the observer's horizon cuts through the ecliptic (the plane of the planets' orbits) to the East and West. The shaded area is the visible sky.



Sunset Midnight Sunrise

You can see that the person could only ever see the inner planets Mercury and Venus (the planets closer to the Sun than Earth) in the morning or evening. When planets are only visible in the morning or evening they are called "morning stars" or "evening stars" respectively. The outer planets (those farther from the Sun than Earth) may be seen at different times depending on their position.

If used with the orrery set up with today's longitudes, this method gives an approximate guide to which planets one could see tonight. This method is only approximate as the distances between the different planets and the Sun are not to scale.

Looking at the Orbit™ Orrery lit up, two other factors that determine how easily a planet is seen are visible:

- The larger planets reflect more light
- The planets closer to the sun reflect more light.

With the naked eye one can see the planets from Mercury to Saturn. Other factors affecting visibility include the proximity of the planet to Earth, cloud cover, physical obstructions and light pollution.

6. The Moon

Whilst a number of planets have moons only the Earth's moon is shown on the model. The Moon orbits the Earth in an anti clockwise direction when viewed from North of the Ecliptic. This is the same direction as the Earth's rotation and orbit. At this scale the moon's phases are difficult to see. The Orbit Tellerium is a much more sophisticated model and demonstrates the moon's phases and eclipse cycle very well.

7. Some Questions and Answers

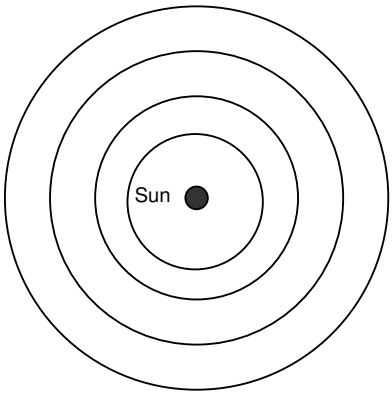
Is the model to scale?

Whilst the larger planets Jupiter and Saturn on the model are bigger than the smaller planets like Earth and Venus they are not to scale nor are the distances separating them. The distances separating the planets is so vast that it is not possible to accurately represent them on a desktop model, whilst still being able to easily see the planets. A set of posters printed to scale with distance information is recommended for this purpose.

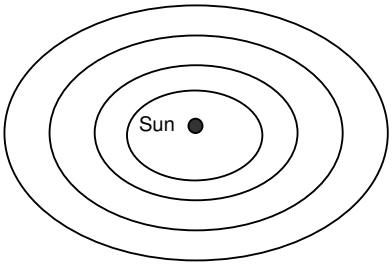
Are all the orbits really in a flat plane?

Very nearly. The only divergent orbits are those of Mercury, which is set at 7°, and Pluto at 17° to the Earth's orbit. All other planets have orbits set within 3.5° of the plane of the Earth's orbit. This plane is called the Ecliptic.

Are all the orbits so very circular?
The orbits of Mercury and Pluto have a pronounced ellipse. In the case of Pluto, its ellipse occasionally takes it inside the orbit of Neptune. The orbits of the other planets are very nearly circular although all are slightly elliptical. The orbit of the Earth, for example, moves from between just under 148 to just over 150 million kilometres from the Sun. At the size of this model there would be no discernible difference between such an ellipse and a circle. Many people are used to looking at pictures of the solar system seen from one side. A circle seen from one side looks very elliptical and this is the source of much confusion. The two drawings below illustrate this point.



Four circular planetary orbits



The same orbits seen from the side about 30° above the Ecliptic.

Example work material

1. The planets in alphabetical order are:-
Earth Jupiter Mars Mercury Neptune Pluto Saturn Uranus Venus
Write them out in order from the planet nearest the Sun to the planet furthest away from the Sun.
Answer: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto.

2. How long is a year on the planet Earth?
Answer: 365 ¼ Earth days

3. Describe some of the things that happen on the Earth during the course of every year.
Answers: Earth's rotation - day's and nights, the seasons, moon's cycle and eclipses.

4. What is a moon?
Answer: An object that orbits a planet; a satellite of a planet.

5. The planets are seen to go round the Sun in an anticlockwise direction as seen from above the North Pole and in a clockwise direction as seen from above the South Pole. Can you explain why?

What direction is this arrow pointing, clockwise or anticlockwise?
Hold the paper to the light and look at it from the other side. Which way is the arrow pointing now?

6. Write out this piece of text filling in the blanks with words drawn from the list below.
The ____ system is made up of the ____ in the centre and the ____ going round it. The Sun is a small ____ and creates a lot of ____ and ____. We see the planets because they ____ the ____'s ____. The nearest planet to the Sun is ____ with ____ next to it. Some planets like Earth have a ____ that ____ them. These also ____ the Sun's light. The time it takes Earth to orbit the Sun is called an Earth ____ and takes____. Venus will take ____ time than Jupiter to go round the Sun once, because it is ____ to the Sun.

Word list: absorb, closer, day, darkness, heat, less, light, Jupiter, Mercury, moon, more, night, orbits, planets, reflect, Saturn, solar, star, Sun, year, Venus, 24 hours, 365 days.

.