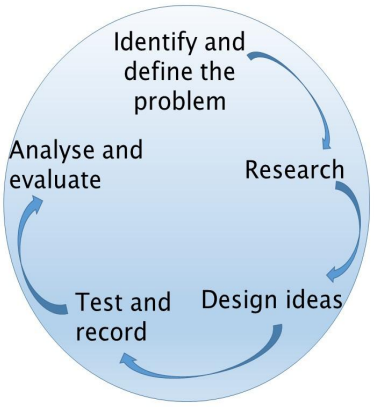
Making an Orrery – Student Booklet

The Challenge

The Science technician has been clearing out the storeroom and has come across an old orrery that shows the planets of the Solar System and Earth's moon. The planets spin around the Sun at different rates, and are different sizes, however, this model is not very accurate. You have been asked to investigate how to make this more accurate so you can build your own orrery.



Background Information

There are eight planets in the Solar System; Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. The planets all rotate around the Sun in a (semi) circular motion known as an orbit. The time taken for each planet to orbit the Sun is different, this is called the planet's orbital period. The planets also have days of different lengths (how long the planet takes to rotate on its axis). Each planet is a different size. Scientist try to model the relationship between the planets using models known as orreries.

Figure 1. An orrery

Making an Orrery – Student Booklet

Background Research

1. How long does it take the Earth to rotate on its axis?
2. How long does it take the Earth to revolve around the Sun?
3. How long does it take the Moon to revolve around the Earth?
4. Complete the table below:

Planet	Orbital period (length of one year in Earth days)	Distance from the Sun (10^6 km)
Mercury		
Venus		
Earth		
Mars		
Jupiter		
Saturn		
Uranus		
Neptune		

5. Which planets are known as gas giants?
6. Which force keeps the planets orbiting the Sun?
7. Does the Sun rotate? If so, how long does it take to rotate?
8. What might be a problem with modelling the rotation of the Sun and the gas giants?
9. Draw and label a diagram to show the position of the Earth, Sun and Moon during a lunar eclipse.
10. Draw and label a diagram to show the position of the Earth, Sun and Moon during a solar eclipse.

Making an Orrery – Student Booklet

Mathematical Modelling

Objective

To compare the orbital period and diameter of different planets and discuss the difficulties you might face in creating an orrery to scale.

1. Calculate the distance of each planet from the Sun using astronomical units.
2. Calculate the distance from the Earth to its Moon in astronomical units.
3. If a scientist wanted to make a model of the Solar System and keep the distances from the Sun to each planet to scale how far would each planet be from the Sun if the Earth was placed 10cm away?
4. What would be difficult about building an orrery of our Solar System to scale?
5. Calculate how many times bigger the Sun is compared to each planet.
6. A student decided to use an exercise ball to represent the Sun in their model. The ball had a diameter of 1.5m (or 150cm). If they were to make the planets to scale calculate how big each planet would be and suggest an item they could use to represent each planet.

Timing the Turns

Objective

To compare the length of days and years of planets and consider how this could be represented in a model.

1. Calculate the number of Earth days it takes each planet to rotate on its own axis.
2. Plot a graph showing the length of a day on each planet versus its distance from the Sun.
3. Do you notice any relationship between the length of a day on a planet and the distance from the Sun?
4. Calculate the number of Earth years it takes each planet to orbit the Sun.
5. Plot a graph to show the length of one year versus the distance from the Sun.
6. Do you notice any relationship between the length of year (orbital period) and the distance from the Sun?
7. If you were going to make a model that spun so the planets rotated at a speed which represented their true speed in relation to one and other, how fast would you make an Earth day? Work out how long it would take for each planet to complete a day, and a year at this speed.

Making an Orrery – Student Booklet

Designing an Orrery

Objective

To design an Orrery that shows the Earth and its moon orbiting the Sun, with either the distances between the Sun and Moon and Earth to scale, or the time taken to revolve to scale. Use this to explain lunar and solar eclipses.

Step 1. Research some designs for Orrery and discuss their strengths and weaknesses, considering factors such as ease to build, materials used, scale used and ability to model eclipses.

Step 2. Draw at least designs for your own orrery ensuring you add a scale and detail the materials you would use.

Step 3. Compare the strengths and weaknesses of your designs. Consider ease of build, materials, scale and ability to model eclipses, if you are able to make it to scale or not, and then decide which design you would like to build.

Step 4. Complete an equipment list

Step 5. Write a method for how you will build your orrery, ensuring that you have taken safety into account and explained how you will minimise any hazards.

Step 6. Show your method, equipment list and design to your teacher to get feedback and make any necessary changes.

Step 7. Once you have gained your teachers permission you can build your orrery.

Step 8. Compare your finished orrery to your design and method to evaluate.

a) How different is your design to your actual model?
b) Did you follow your method or did you have to add in extra steps? If so, rewrite your method so that somebody else could produce your design.
c) What are the strengths and weaknesses of your final model?
d) If you could make any changes to your model what would they be and why do you think that this would improve the model?