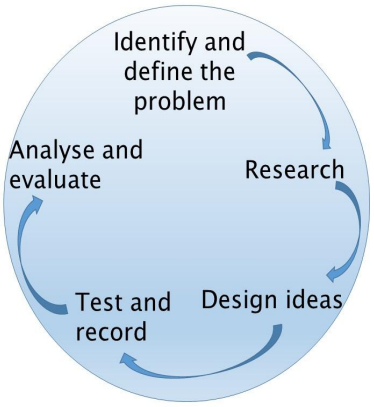
Making an Orrery – Student Booklet

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

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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.

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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.

The distance between the Earth and the Sun is known as one Astronomical Unit (AU). This distance is about 1.5 x 10^8 km. Complete the table below to compare planets in our Solar System.

Planet	Distance from Sun to planet (km)	Distance from Sun to planet (AU)
Earth	150,000,000	1
Mercury	57,900,000	
Venus	108,200,000	
Mars	228,000,000	
Jupiter	778,000,000	
Saturn	1,427,000,000	
Uranus	2,871,000,000	
Neptune	4,497,000,000	
Earth to Moon	384,400	

2. 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?

Planet	Distance from Sun (cm)
Earth	10
Mercury	
Venus	
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	

Earth to its Moon =

3. What would be difficult about building an orrery of our Solar System to scale?

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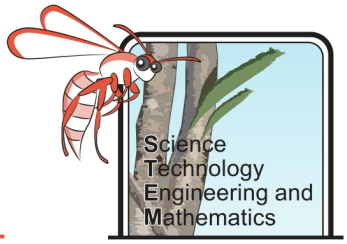

4. The planets range greatly in size. Below is a table giving the diameter of each planet.

Planet	Diameter (km)
Earth	12,926
Mercury	4,875
Venus	12,104
Mars	6,787
Jupiter	142,796
Saturn	120,660
Uranus	51,118
Neptune	48,600
The Sun	1,390,000

Earth's Moon = 3,474

5. Calculate how many times bigger the Sun is compared to each planet to complete the table below.

Planet	How many times bigger the Sun is in diameter
Earth	
Mercury	
Venus	
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	
Moon	

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.

Planet	Model size (cm)	Suggested item
Earth		
Mercury		
Venus		
Mars		
Jupiter		
Saturn		
Uranus		
Neptune		

Earth's Moon =

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Timing the Turns

Objective

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

The Earth takes 24 hours to complete one rotation on its axis, this is known as an Earth day.

1. Complete the table below to compare the length of a "day" on other planets.

Planet	Period of rotation (hours)	Period of rotation (Earth days)
Earth	24	
Mercury	1,408	
Venus	5,832	
Mars	25	
Jupiter	10	
Saturn	11	
Uranus	17	
Neptune	16	

The Earth takes 365 days to complete one revolution around the Sun, this is known as a year.

2. Complete the table below to compare the length of one year on other planets. Some examples have been done for you.

Planet	Orbital period (Earth days)	Orbital period (Earth years)
Earth	365	
Mercury	88	
Venus	225	
Mars	687	
Jupiter	4331	
Saturn	10,747	
Uranus	30,589	
Neptune	59,800	

3. Do you notice any relationship between the length of day on a planet and the distance from the Sun?

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4. Do you notice any relationship between the length of year (orbital period) and the distance from the Sun?

_____

5. If you made a model orrery and it took the Earth one minute to revolve around the Sun, how long would it take each of the other planets?

Planet	Time taken to revolve around Sun (min)
Earth	1
Mercury	
Venus	
Mars	
Jupiter	
Saturn	
Uranus	
Neptune	

6. What would be the downside of this model?

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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.

Step 1. Research some designs for orreries and discuss their strengths and weaknesses. Consider factors such as ease to build, materials used, time taken to revolve and scale.

Website	Strengths	Weaknesses

Step 2. Draw two 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 both 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.

Design	Materials	Strengths	Weaknesses

Step 4. Provide a list of materials required to build your orrery.

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_____

_____

_____

_____

_____

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.

Method steps	Hazards	Precautions
1		
2		
3		
4		
5		
6		
7		

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?

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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.

Method steps	Hazards	Precautions
1		
2		
3		
4		
5		
6		
7		

c) What are the strengths and weaknesses of your final model?

Strengths	Weaknesses

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?

Changes	Why would this improve the model?