A model of the Earth and Moon

Background Information

This activity demonstrates the relative sizes of the Earth and Moon and the distance between them. The Moon is our nearest neighbour. It orbits the Earth following an elliptical path and therefore the distance between the Moon and the Earth varies from about 350 000 km to 400 000 km. On average the Moon is 385 000 km away. This seems like a large distance; however, the Moon is close compared to the planets in our Solar System.

The diameter of the Moon is about 3500 km which means that the face of the Moon is roughly the same width as Australia. The Earth has a diameter of approximately 12 800 km. The Moon is a little less than a quarter the diameter and is approximately one-fiftieth the volume of the Earth.

What you need

- Handful of modelling clay, plasticine or playdough
- Ruler
- Calculator

What to do

Part A - Estimating the relative size of the Earth and the Moon

1. Give each student or group of students a handful of clay.
2. Allow about 5 minutes to divide the clay into two balls or spheres so that one represents what they consider to be the size of the Earth (when compared to the size of the Moon) and the other represents the size of the Moon.
3. Comment on the differences demonstrated by the models made by each group or student.
4. Tell them to re-combine their 2 balls or spheres into one lump of clay again.
5. Ask them to divide the lump of clay into 50 pieces of approximately equal size.
6. Have them choose one piece then re-combine the other 49 into a single chunk.
7. Ask them to roll each piece into the shape of a ball so that they end up with two spheres. Explain to them that they now have a scale model of the Earth and the Moon, with the small ball (made of 1 piece) representing the Moon and the large ball (made of 49 pieces) representing the Earth.

Part B - Estimating the ratio of the Earth's diameter to that of the Moon

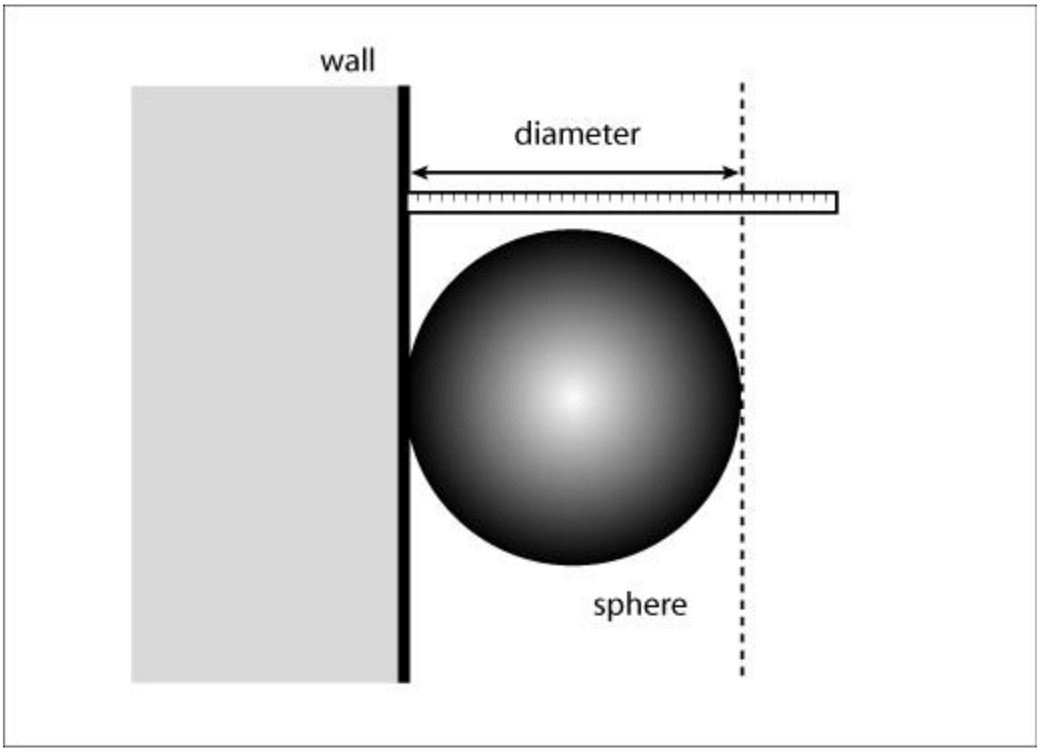
8. Ask the students to predict the ratio of the Earth's diameter to that of the Moon.
9. Their predictions can be checked by measuring the diameters of both objects.
   (Students can measure the diameter of the ball of clay by putting the ball against a wall and placing a ruler gently alongside it. The distance from the wall to the outer edge of the ball of clay should approximate the diameter. Refer to the diagram on the next page).
10. Take an average of the class results and you should obtain a ratio of approximately 4:1. (The size of the Earth's diameter is approximately 4 x the diameter of the Moon. More precisely, the ratio of the Earth's diameter to that of the Moon is 3.7:1.

Part C - Estimating the distance between the Earth and the Moon

11. Ask the students to predict how far apart their model Moon and Earth should be to represent the Moon-Earth distance (according to the scale of the models they have made).
12. Encourage them to hold the Moon up to the Earth and try to visualise how far away the Moon should be. Each group should reach a consensus, then measure their distance.
13. Explain to the students that the actual Moon-Earth separation is about 30 Earth diameters.
14. Students then calculate how long this distance would be in their model and ask them to now place their Moon at that distance.

Optional

- Ask the students to determine the accuracy of their prediction by dividing their predicted distance by the actual distance. A score of one is perfect.
- Ask each group of students to trace the shape (circumferences) of their models on A3 poster paper. Attach A3 sheets of poster paper together so the distance between the Moon and the Earth can also be shown (approximately) to scale. The posters can be labelled, coloured and stuck around the room.
- Students are generally amazed at how far apart the Earth and the Moon are in their model. Ask them what the next closest object in space to Earth is. The answer is Venus. At its closest approach it is 3000 Earth diameters away! That's one hundred times further than the Moon. Have them calculate where to place a model of Venus on the same scale.
- Ratio exercise – see below



A model of the Earth and Moon worksheet

Introduction

The Earth's diameter is about 4 times as big as the Moon's diameter. If we multiply the Earth's diameter by 30, the distance would approximate how far away the Moon is from the Earth.

Part A: The diameters of the Moon and Earth

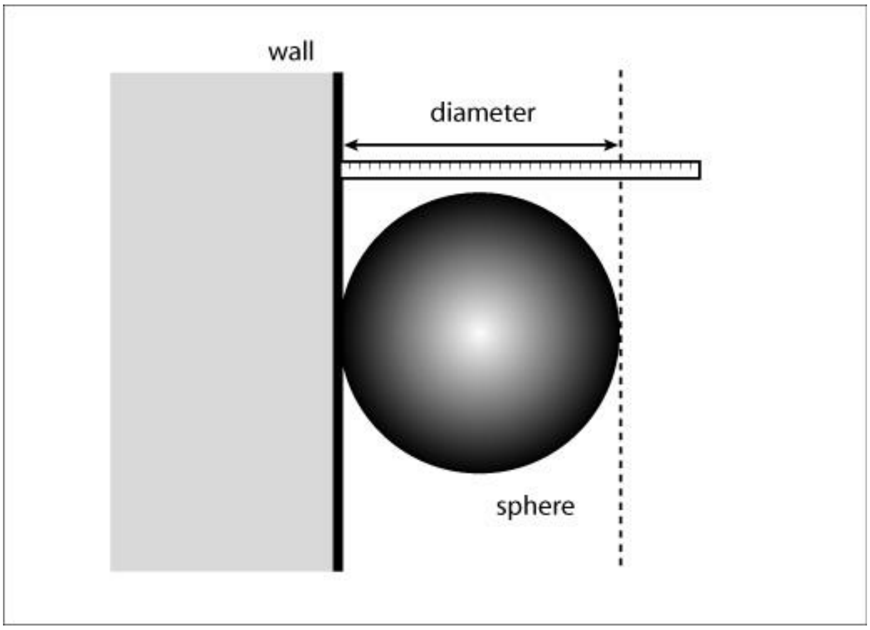
What you need

- About 10 different types of balls (eg. basket balls, tennis balls, soccer balls)
- Graph paper
- Calculator

What to do

The balls will represent the size of Earth.

1. Choose one ball and measure the diameter by putting it against a wall and placing a ruler lightly over the top. The distance from the wall to the edge of the ball will approximate the diameter. (Refer to the diagram below.)



2. Record the type of ball and the measured diameter in the table provided.
3. Calculate the diameter of the Moon if this ball represents Earth. Record this value in the table.
4. Repeat steps 1-4 for the different balls.

Part B - The distance from the Earth to the Moon

1. Calculate how far away the Moon would be if the size of Earth was represented by each of the balls.
2. Record these values in the table below.

Type of ball representing Earth	Measured diameter Earth (cm) D	Calculated Moon diameter (cm) D/4	Distance between the Earth and Moon (cm) D x 30

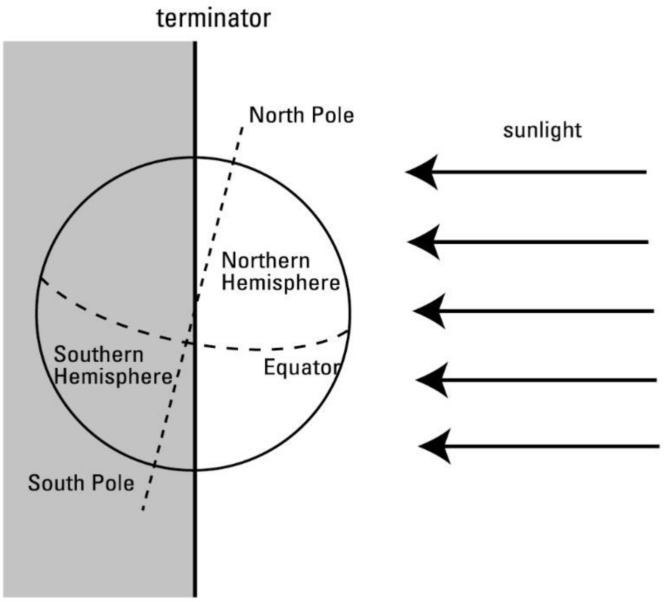
Questions:

1. How much smaller is the diameter of the Moon compared to the diameter of the Earth?
2. How far away is the Earth from the Moon (How many Earth diameters)?
3. Graph Earth diameter versus Moon diameter. What do you notice?
4. Graph Earth diameter versus distance. What do you notice?

Day and night on Earth

Background information

It takes the Earth approximately 24 hours to spin once on its axis. The Earth's axis can be thought of as an imaginary line that runs through the North and South Poles. The Earth's axis is tilted 23.5 degrees from the vertical. As the Earth turns, half the Earth faces the Sun and experiences daytime and half is in shadow and experiences night-time. The line that separates day and night is called the *terminator*. The imaginary line that separates the Northern Hemisphere and the Southern Hemisphere is called the Equator.



The time it takes for the Earth to spin around once with reference to a distant star is called a sidereal day and is always 23 hours, 56 minutes and four seconds long. This means that the star Sirius, for example, would return to the same position in our sky after 23 hours, 56 minutes and four seconds. The length of a solar day measures day length with reference to the Sun. It is about four minutes longer than a sidereal day. The Earth must turn a little more than one rotation to again face the Sun because, as the Earth turns on its axis, it also moves around the Sun.

During summer at the South Pole the Sun circles the sky and never sets. It is daytime continuously for (approximately) six months. During winter the Sun never rises, and it is constant night-time for (approximately) the next six months.

The following activity uses a model to simulate day and night as the Earth rotates on its axis. The questions help the students identify the terminator and understand how day occurs at different times depending on where you live on Earth. The activity follows a teacher demonstration using a globe of the Earth to help the students.

Teacher Demonstration

What you need

- Globe of the Earth
- Blu Tak
- Small cardboard figures
- Lamp without shade
- Access to a darkened space

What you do

1. In a darkened room turn on the shadeless lamp and illuminate the globe. Identify the lit and unlit sides of the globe.
2. Ask the students to point out the countries experiencing day and those experiencing night.
3. Using Blu Tak, attach three small cardboard figures to the globe – one on Australia, one on Greece and one on Malaysia for example. Ask the students to watch their shadows change as the Earth rotates. (i.e sunrise, noon, sunset and night). Ask the students to watch the Australian figure and to call out the part of the day it is experiencing as the Earth rotates. What is the Greek figure experiencing whilst the Australian is experiencing morning?
4. Identify the north, south, east and west directions on the globe.
5. Demonstrate the movement of the Earth from west to east.
6. Identify the 'terminator' – the imaginary line that separates day and night.
7. Model the rotation of the Earth to represent one solar day (24 hours).

Student Activity

What you need

- Polystyrene ball
- Ice-cream stick or skewer
- Torch
- Pen
- Globe

What you do

1. The polystyrene ball is used to represent the Earth. Mark the ball with a broken line dividing the ball in half. This line will represent the equator.
2. Mark in the position of Australia, Melbourne and Perth with a pen. (The globe can be used for reference.)
3. Identify north, south, east and west.
4. The skewer or the ice-cream stick should be pushed through the polystyrene ball to represent the imaginary axis running through the North and South Poles.
5. Get help to show the direction the Earth turns (from west to east) with the axis slightly tilted.
6. Switch the torch on while the room is darkened. Now simulate the Earth turning with your model and try to answer the following questions.

Questions

1. What happens to the shadow across Australia when the Earth turns once?
2. Find the *terminator*. What is it and how does it move?
3. Who experiences daytime first, Melbourne or Perth?

Optional

Ensure that the top of the model has a tilt towards the ‘Sun’ (torch).

4. Look down on your model from the North Pole and turn the Earth once. What do you notice about the daytime and night-time here?
5. Look up at your model from the South Pole and turn the Earth once. What do you notice about the daytime and night-time here?

Diurnal motion

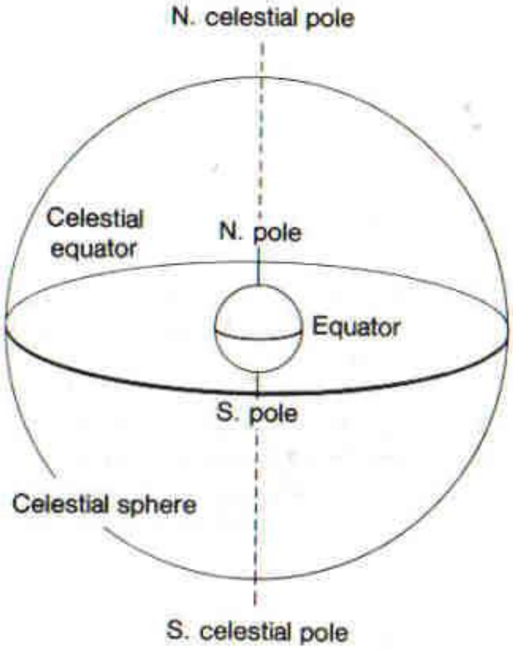
Background information

The Earth spins once every 24 hours resulting in day and night. This rotation causes the stars, (including the Sun), to appear to rise in the east and set in the west (diurnal motion). Stars in most parts of the sky travel in a large arc, then disappear below the horizon. However, for observers in the Southern Hemisphere, stars in the southern part of the sky never 'set' below the horizon, but trace circles above the South Pole.

Astronomers think of the Earth as being surrounded by an imaginary sphere (celestial sphere) dotted with stars. The North Pole of the Earth extends out to the North Pole of the celestial sphere and the South Pole of the Earth extends out to the South Pole of the celestial sphere. Likewise, the Earth's equator projects out to the equator of the celestial sphere. (The Equatorial Coordinate System is based on this representation of the sky.)

As the Earth turns, the stars seem to move across the sky. If you stood at the South Pole on Earth, the South Celestial Pole would be directly overhead, and the stars overhead would seem to be rotating clockwise around this point. In Melbourne, the South Celestial Pole is at an angle of (approximately) 38 degrees above the horizon – Melbourne's latitude. From southern Australia, stars like those that make up the Southern Cross never set but are always visible in our night sky and can be seen rotating around the South Celestial Pole.

Note that in the same way that Greenwich, England has been chosen by convention to be the origin of the prime meridian (0 degrees longitude) on Earth, the vernal equinox (the point at which the Sun crosses the celestial equator during March) has been chosen to be the starting point for Right Ascension (a star's equivalent of longitude).

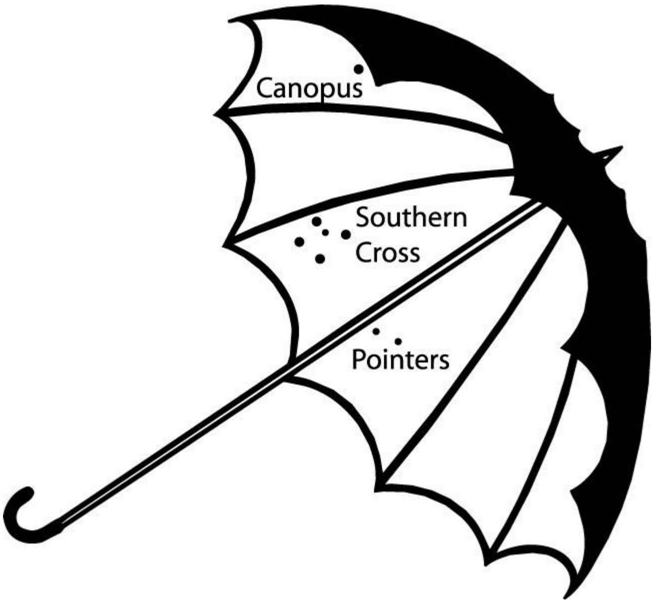


What you need

- Black umbrella
- White circular stickers

What you do

1. Open up a black umbrella.
2. On the inside of the umbrella, label or identify the centre or turning point of the umbrella (above the shaft) which will model the South Celestial Pole.
3. Stick the white circular stickers in the appropriate positions to represent the Southern Cross and the star Canopus as shown in the diagram below. These stars are always above the horizon in southern Australia.
4. Hold the umbrella at approximately 38 degrees above the horizontal (latitude of Melbourne) and slowly turn it once in a clockwise direction. This models diurnal motion (24 hours) as viewed from southern Australia.
   (You will need to find the latitude of other parts of Australia if you do not live in Melbourne.)
5. Hold the umbrella so that the South Celestial Pole is directly above your head. Turn the umbrella once slowly in a clockwise direction. The umbrella models diurnal motion of the overhead stars at the South Pole for one day (24 hours).



Questions

1. What is diurnal motion?
2. Do the stars really move?
3. Do the stars appear to move during the daytime? Why don’t we see them?
4. Explain how the stars would appear to move when looking at the night sky from Melbourne compared to looking up from the South Pole. Use your model to help you answer this question.
5. How would the stars seem to move if you were standing at the North Pole?
6. How would the stars seem to move if you were standing at the equator?
7. In what ways is the celestial sphere imaginary?