ACTIVITY 03 - Investigating Similar Triangles associated with the Earth, Moon and Sun.

Year Level: Years 7–12 (typically from 12 to 18 years of age)

Background: The apparent size of the Sun and the Moon as seen from Earth has mystified and amazed humans throughout the ages whenever an eclipse has occurred. In ancient times eclipses were viewed with all the emotions humans could espouse from wonder to terror and the impact eclipses had on the religious beliefs of people was significant. The understanding of the relationship between the distance to the Moon and the Sun in relation to similar triangles has been known since an Ancient Greek called Aristarchus estimated the distance to the Moon over 2 200 years ago, using a solar eclipse. This lesson allows students to explore the characteristics of similar triangles and apply what they discover to the concept of eclipses.

Aim: Students will explore what happens during a solar eclipse as they learn about similar triangles.

References:

- Section 2, 6 and 7 of the AAQ/STAQ teacher booklet.
- PowerPoint presentation PP02 “How Eclipses Occur”

Safe Observing Message:

When discussing a solar eclipse students should be reminded that it is not safe to look directly at the Sun at any time and that safe viewing methods must be used to observe a solar eclipse.

Shape of the Australian Curriculum: Science strands on focus areas.

Content descriptors: Years 7 and 10

Science Understanding	Science as a Human Endeavour	Science Inquiry Skills
Yr 7 **Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the Sun, Earth and the Moon (ACSSU115)**	**Yr 7** **Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people’s understanding of the world (ACSHE119)**	**Yr 7** **Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)**

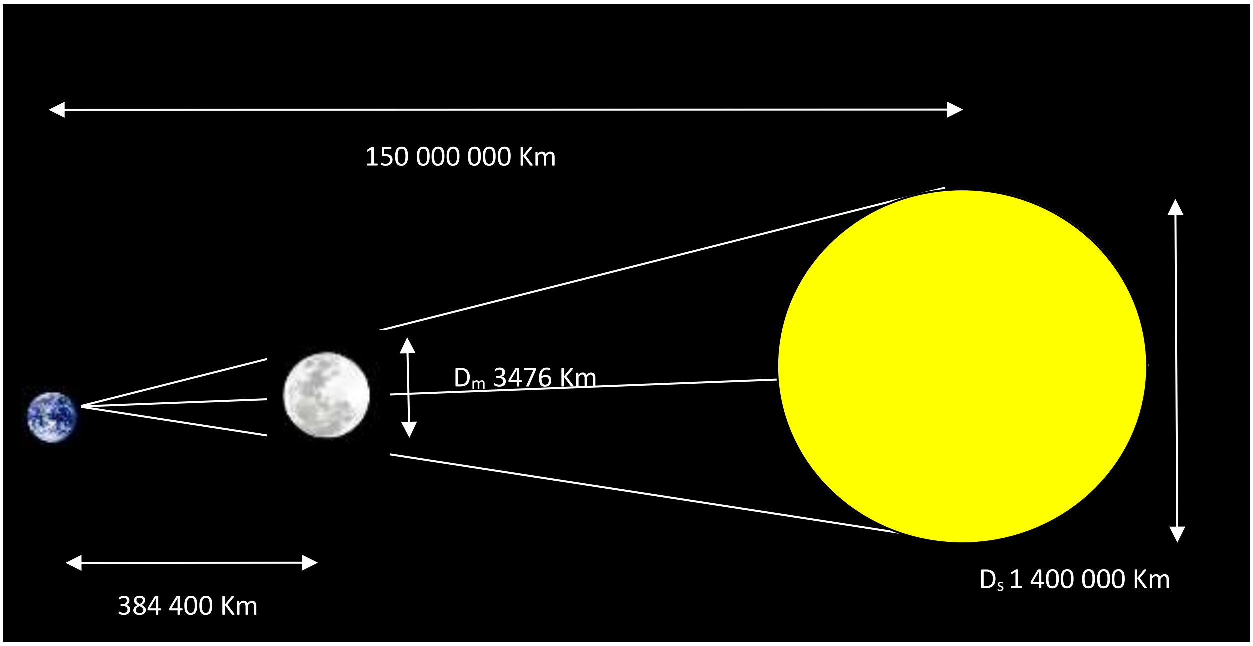
		Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125) In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (ACSIS126) Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (ACSIS131) Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate (ACSIS133)
Yr 10 **The universe contains features including galaxies, stars and solar systems and the Big Bang theory can be used to explain the origin the universe (ACSSU188)**	**Yr 10** **Scientific understanding, including models and theories, are contestable and are refined over time through a process of review by the scientific community (ACSHE191)** **Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE192)** **People can use scientific knowledge to evaluate whether they should accept claims, explanations or predictions (ACSHE194)**	**Yr 10** **Plan, select and use appropriate investigation methods, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199)** **Select and use appropriate equipment, including digital technologies, to systematically and accurately collect and record data (ACSIS200)** **Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)** **Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208)**

Investigating Similar Triangles associated with the Earth, Moon and Sun.

As the Moon gradually passes across in front of the Sun during a total solar eclipse the apparent same size of both these objects becomes obvious at the point of totality. However this is the result of the ratio of distance to the Moon and the Sun and the ratio of the diameter of the Moon and the Sun being almost the exact same value. This was not always the case as the distance from the Earth to the Moon has gradually been increasing over millions of years. You can read about this at the following link http://curious.astro.cornell.edu/question.php?number=124 or 365 Days of Astronomy Podcast March 28th 2009 "What if the Moon did not exist" found at http://365daysofastronomy.org/2009/03/28/march-28th/ .

The average distance between the Earth and Moon is 384 400 kilometres whereas the distance to the Sun from the Earth is about 150 000 000 kilometres. The diameters of the Moon and Sun are 3476 and 1 400 000 kilometres respectively. Using ratios of the distance from the Earth to Sun compared with the distance from the Earth to the Moon we obtain a value, using the above figures, of approximately 400. This compares to the ratio of the diameters being also approximately 400. This almost identical ratio leads to the spectacular phenomenon of Total Solar Eclipses when the Moon is just large enough to briefly cover the Sun.

Students can investigate these similar ratios in the following activities.



EQUIPMENT PER GROUP

- 1 tennis ball (represents the Sun)
- 1 basket ball
- 1 ping pong ball (represents the Moon)
- 1 30cm ruler
- 1 m ruler
- 1 small marble

STUDENT ACTIVITY Part A

1. Students work in groups of two.

2. Have students decide which object is largest to smallest and get them to measure the diameter of each of the tennis, ping pong and basket balls (in centimetres). Record their results on the handout sheet Student Worksheet: Part A.

3. One student is to hold the Ping Pong ball (Moon) at approximately 25cm from their eye (which represents the Earth). The same student, with one eye closed, holds the Tennis ball, in their other hand, at a distance so that the Ping Pong ball appears to be the same size as the Tennis ball.

4. The second member of the group uses the metre ruler to measure the distance from the person's eye (Earth), remembering to be careful, to the Ping Pong ball. Record this distance on the Student Worksheet: Part A (in Centimetres).

5. The second person then measures the distance from the person's eye to the Tennis ball and that distance is recorded.

6. Complete the calculations on Student Worksheet Part A.

7. Once students have completed the worksheet for Part A they can go further with an alternative method of calculating the size of the Earth and Moon at the CSIRO website listed using similar triangles.

http://www.csiro.au/helix/mathsbyemail/activity/sunmoon.html

8. Extension activities are also provided for students to complete.

STUDENT WORKSHEET : Part A

Diameter of the Ping Pong ball - ___________________ cm

Diameter of the Tennis ball - ___________________ cm

Diameter of the Basketball - ___________________ cm

Distance Eye to Ping Pong ball - ___________________cm

Distance Eye to Tennis ball - ___________________cm

CALCULATE THE FOLLOWING RATIO'S (only to one decimal place)

1. $\dfrac{\textbf{Diameter of the Tennis ball}}{\textbf{Diameter of the Ping Pong ball}}$ **=** ____________

2. $\dfrac{\textbf{Distance Eye to Tennis ball}}{\textbf{Distance Eye to Ping Pong ball}}$ = ____________

What do you notice about the values of the ratio's you have calculated in the two situations above?

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Do you think the following equation is true? Explain your answer.

$$\frac{\textbf{Diameter of the Tennis ball}}{\textbf{Diameter of the Ping Pong ball}} = \frac{\textbf{Distance Eye to Tennis ball}}{\textbf{Distance Eye to Ping Pong ball}}$$

Determine how far from the person representing the Earth the Basketball would need to be placed, given you know the Basketballs diameter, so that they both appear to be the same size. Work with your group to come up with an equation that would allow you to determine the distance without actually carrying out the experiment.

How close were your calculations to the actual value the Basketball was located at from the Earth person?

Why must the person representing the Earth be the same person in both situations?

Extension Activity

A.

1. Using the small marble and the information provided about the size of the Moon and Sun in relation to diameter and distance from the Earth, work with your team to mathematically determine the size of an object that would represent the Sun if the Moon was represented by the marble.

2. Determine how far from the marble the object representing the Sun would need to be placed if to represent a scaled down version of the Earth, Moon and Sun system.

3. What would be the problem with trying to make the Sun using cardboard. Work out how you could represent the situation you have just calculated and go to the oval to represent this system of Solar System objects. You may need to modify the size of the marble and use something smaller.

B.

1 More than 2 200 years ago, the Greek mathematician Eratosthenes used similar triangles to estimate the circumference of the Earth. He got the idea when he observed that at noon on the day of the summer solstice, the Sun shone straight down to the bottom of the well in the town of Syene (which is called Aswan, Egypt today).

   a) Find out how Eratosthenes solved the problem and explain why his solution was a valid way to estimate the size of the Earth.

   b) List some limitations of his method.

C.

Using the information in the podcast "What if the Moon did not exist" determine how long it will be until the Moon only covers 75% of the Sun's disc.

http://365daysofastronomy.org/2009/03/28/march-28th/