Farnham Astronomical Society

Exercise: How far away is our Moon?
Difficulty: Basic

OBJECTIVE

The Greek philosopher Aristarchus of the isle of Samos – do you remember him? We came across Aristarchus in a previous exercise to calculate the diameter of our sun. Aristarchus was a bit of a whizz with trigonometry and was the first to use trigonometry to get the measure of our solar system. Aristarchus used a lunar eclipse to calculate the distance to the moon. We can use something a bit more pocketable – a coin!

In this exercise you will learn about angular diameters and will make some very basic equipment which you will use to measure and calculate the distance to the Moon.

EQUIPMENT

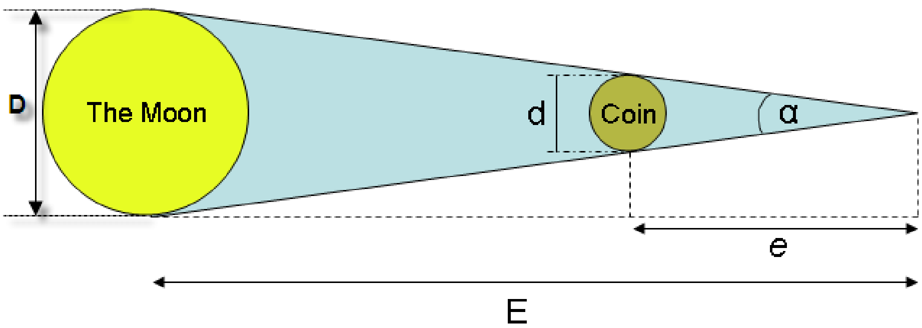
All you need to perform this experiment are:

- A selection of coins: 1p, 2p, 5p 10p, £1 (not a 20p or 50p, they are not circular);
- A metre rule;
- Blu-tack (or plasticine);
- A pencil and paper to record your results.

SOME BACKGROUND

Often astronomers don't know how big something is, but they do know how big it looks. They use a measure called the 'angular diameter' – in other words how big it appears to be (its 'apparent size' measured as an angle. For example, when held at an arms length, an adult finger is about 1 degree across.

We can use some simple rules to determine the size of the Moon. If we position a coin of known size at a short distance from our eye so that it appears to be exactly the same size of the Moon then the angular diameter of the coin and the Moon must be exactly the same.



We can estimate the angular diameter of the coin (α) because, for small angles, the angular diameter in *degrees*[1] is given by:

$$\alpha = 57.3 \times \frac{d}{e}$$

Given that the coin at distance *e* has exactly the same angular diameter as the Sun (α) and given that the angular diameter of the Moon in *degrees* is given by:

$$\alpha = 57.3 \times \frac{D}{E}$$

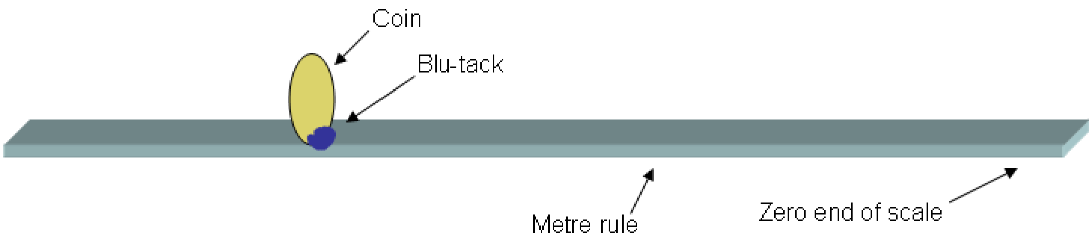
Then if we know the diameter of the Moon we can calculate its distance.

METHOD

This experiment can be performed night or day whenever the Moon is visible but it is best performed when there is full or near full moon.

Measure and make a note of the diameters of each of your coins. You will need this information later on in this exercise.

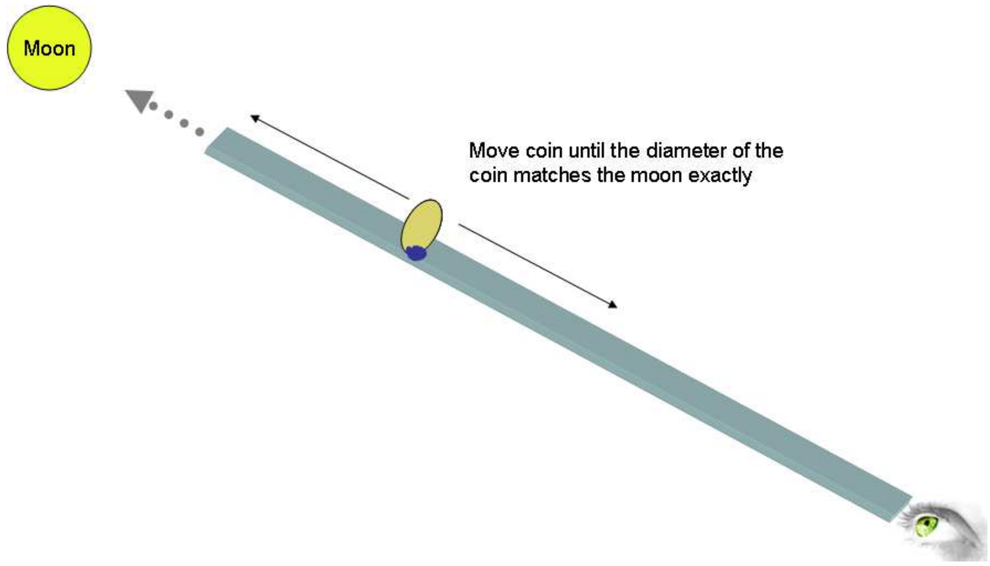
Using a small blob of Blu-tack or plasticine, fix a coin to the metre rule somewhere along its length so that it stands vertically (see below):

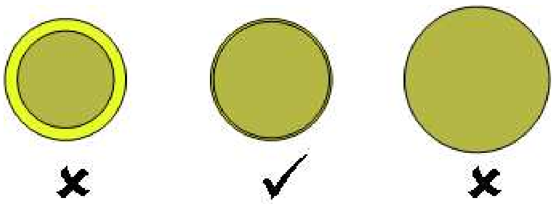


Now observe down the rule towards the Moon with your eye as close as possible to the 'zero' end of the rule (but be very careful not to get a poke in the eye!). To get a steady view you may need to balance one end of the rule on the back of the char or table.

If the coin fully eclipses the moon, move the coin further away from your eye and try again. If the coin appears smaller than the moon move the coin nearer to your eye. Find a position along the rule where the size of the coin matches exactly the size of the moon. This is easiest to determine with a full Moon (see diagram below).

[1] For small angles, tan(α) is approximately equal to α IN RADIANS. 1 radian is approximately 57.3 degrees.





When you have found this distance, read off the scale of the ruler the position of the coin. Try to measure this as accurately as possible. You can record your results on the logsheet at the end of this document.

Repeat the experiment for different sizes of coin.

Calculate the angular diameter of the coin using the formula below. Calculate the angular diameter (*α*).for each of the coin sizes and distances that you measured and take the average of these results to come up with yoyr final value.

$$\alpha = 57.3 \times \frac{d}{e}$$

We now know the angular diameter of the Moon (it is the same as the angular diameter of the coin). To calculate the distance to the Moon you need just one more piece of information – its actual diameter of the moon (*D*). We will save you the trouble of looking up – it is 3,475 kilometers. Now you have all of the information that you need.

Using the distance to the moon that you have just calculated (*E*), calculate the angular diameter of the Moon (α) using the formula below. This is the same formula we saw before but rearranged to give us the value *E*.

$$E = 57.3 \times \frac{D}{\alpha}$$

ANALYSIS OF YOUR RESULTS

Do your results look sensible? Look up the Moon's distance and angular diameter on the internet. How do they compare? If your result differs by a significant distance, why do you think that is?

Look up the angular diameter of some galaxies and nebular and compare these with your result. Compare the angular diameter of the Moon with the Andromeda Galaxy (M31):

1. How many times bigger does the Andromeda Galaxy appear to be than the Moon (remember, it is about 2.7 Million light years (or 24,330,000,000,000,000,000 kilometres if you prefer).

2. What does the angular diameter of the Andromeda Galaxy tell you about its actual size?

Logsheet

Coin	Diameter of Coin (mm)	Distance along rule (mm)	Angular diameter (degrees)
1p			
2p			
5p			
10p			
£1			
		Average	