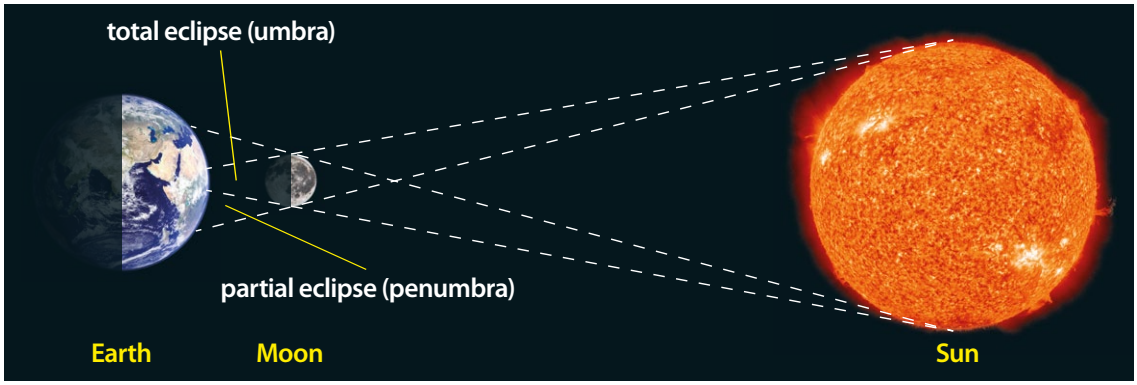
The mathematics of a total solar eclipse (Years 10–11)



1 Introduction

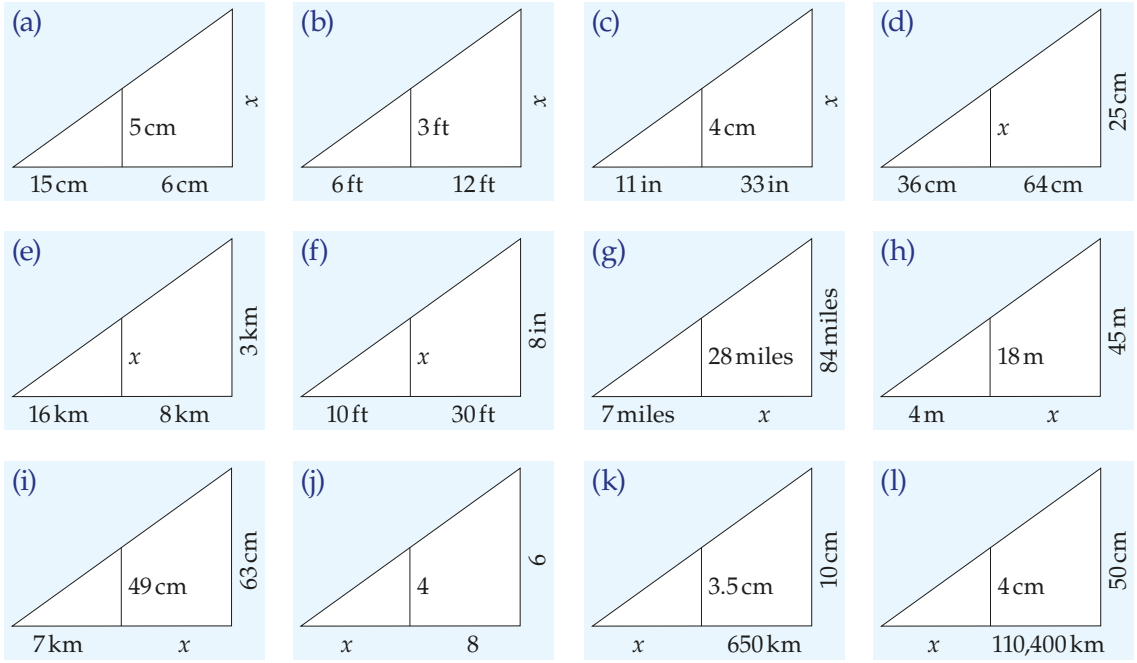
A solar eclipse occurs when the Moon passes between the Earth and the Sun. (Note that the diagram above is not to scale!) A *total* solar eclipse occurs when the path of the Moon produces a relatively small area of shadow on the Earth known as the "umbra", where it completely covers the face of the Sun. The view of a solar eclipse from this area is quite spectacular.

The Moon completely covers the face of the Sun as its distance and size just happens to be in the same proportions as that of the Sun. This brings about an interesting mathematical situation involving similar triangles concerning the sizes of and distances to the Sun and the Moon. But first, some practice…

Advancing Astronomy and Geophysics

This worksheet was produced by the RAS to mark the solar eclipse of 20 March 2015 – visible as a partial eclipse from the UK. It is available free – along with other eclipse resources – online from www.ras.org.uk

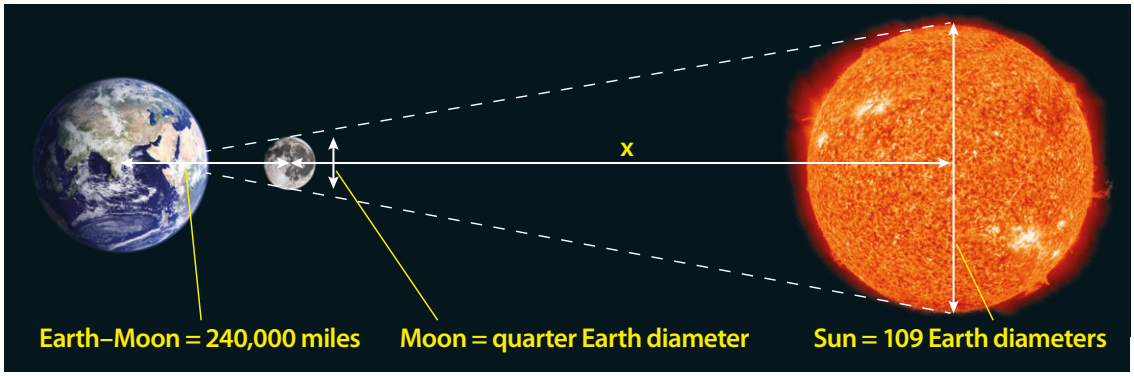
2 Task 1: find the missing sides in each figure



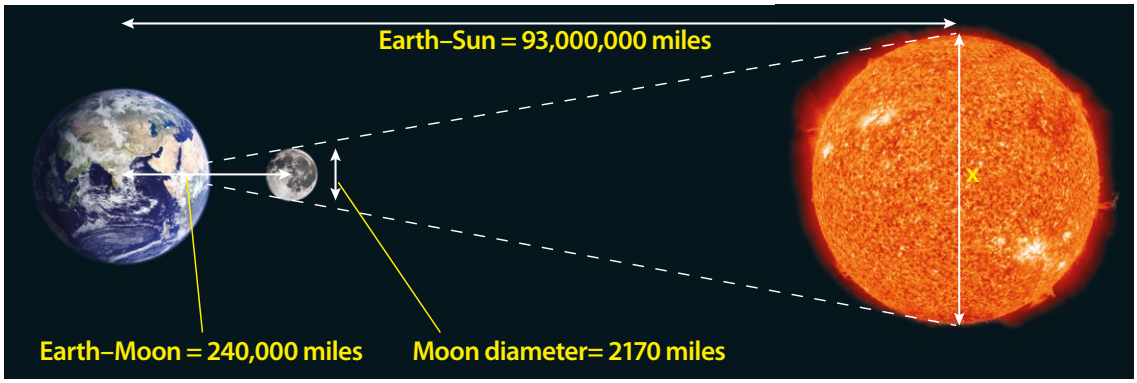
3 Task 2: the total solar eclipse

If we know three of our Sun/Moon, size/distance figures then we can find the fourth.

(a) Use the figures in the diagram below to show how to find the distance between the Earth and the Sun, and hence distance to the Sun, during a total solar eclipse.



(b) Use the figures in the diagram below to find the diameter of the Sun, and hence the diameter of the Earth.



(c) Using a pinhole camera with a distance of 1 metre between the "camera" and "projection screen", how large would you expect the image of the Sun to be?

4 The mathematics of a total solar eclipse: answers

Task 1

(a) $x = 7$ cm (b) $x = 9$ ft (c) $x = 16$ cm (d) $x = 9$ cm (e) $x = 2$ km (f) $x = 2$ in

(g) $x = 14$ miles (h) $x = 6$ m (i) $x = 2$ km (j) $x = 16$ cm (k) $x = 350$ km (l) $x = 9600$ km

Task 2

(a) $x = 103{,}440{,}000$ miles Distance to Sun = 103,464,000 miles

Actual distance to Sun is 93,500,000 miles, 10.7% error. Our answer is different as figures were rounded in the question. Actual figures: Moon's diameter = 0.27 Earth, distance to Moon = 240,249 miles.

(b) $x = 840{,}875 \approx 841{,}000$ miles Using Sun = 109 Earths, Earth diameter ≈ 7,700 miles

Actual diameter of Sun is 870,000 miles, 3.5% error. Actual Earth diameter is 8000 miles, 3.3% error.

(c) Image around 9 mm diameter. This is calculated using proportional figures of part (b).