4. Time and the Earth Moon Sun Cycles (Part 2 - Determining Longitude)

Edexcel GCSE Astronomy Course

4.19 Be able to use shadow-stick data and the Equation of Time to determine longitude

The use of shadow sticks to find local noon has already been discussed in the Topic 4 Part 1 presentation. This is a good opportunity to do Unaided Observing Task A9 if you can, although it will depend on the weather of course.

The background theory and basic method are described in this presentation:
https://www.abingdonsciencepartnership.org/wp-content/uploads/2020/04/A9-Longitude-from-a-Shadow-Stick-2.pdf
Workbooks to help you plan, analyse and evaluate observing tasks can be found here:
https://www.abingdonsciencepartnership.org/gcse-astronomy/

(To get a really accurate value for your longitude you will need to correct the shadow stick time of local noon using the value of the Equation of Time (EOT) for the date on which you made your observations. The EOT was also discussed in Topic 4 Part 1).

4.20 Understand the principles of astronomical methods for the determination of longitude, including lunar distance method

The simple shadow stick method for determining longitude can be very accurate provided you know the time at Greenwich. Now that we have extremely accurate clocks and instantaneous, global communication this is not a problem. However, before long distance communication was possible this was a huge problem for surveyors and navigators trying to map the world and travel over it.

This was the main reason that astronomers and observatories were very important and very well funded in many wealthy cultures, such as Europe, Arabic nations and China. Their prosperity depended on navigation.

Astronomers developed ways to use natural, astronomical clocks to solve the problem of finding longitude, for instance the orbital period of the Moon. This was called the **lunar distance method** and was developed into a practical method for use on ships at sea by the British Astronomer Royal, Nevil Maskelyne, in the late 1700s.

The next slide gives a basic outline of the method.

The Lunar Distance Method For Finding Longitude

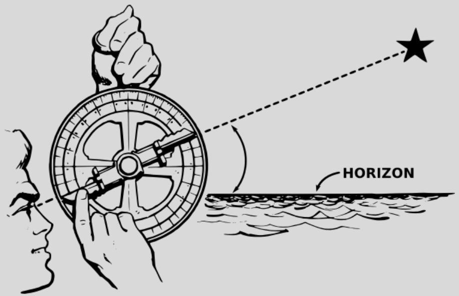
The Moon moves across sky by approximately 13.1^0 per day or 0.5^0 per hour or 0.01^0 per min and is therefore a pretty regular, natural clock.
Angles between the Moon and other objects, such as the Sun and bright stars, are measured at Greenwich and published in a big book called a Nautical Almanac.
Using a sextant, navigators can then measure the angle between the Moon and the chosen object at their own location.
If this location is not at Greenwich, the angle will be different from the one shown in the Almanac and this difference will depend on the time difference at the navigator's longitude.
Knowing the time difference between the navigator's observation and the time at Greenwich from the almanac allows the navigator to calculate their longitude.

E.g. 2.5^0 difference in lunar distance from Greenwich means 2.5/0.5 = 5 hours difference = 5x15 = 75 deg difference in longitude.

If you are really interested in this, look at this link for more detail https://astronavigationdemystified.com/lunar-distance/

4.21 Understand the principle of the horological method for the determination of longitude (Harrison's marine chronometer) (knowledge of internal working of chronometers not required)

The lunar distance method takes a lot of skill and knowledge of some quite complicated maths, including spherical trigonometry, to find a really accurate longitude. It shows how skilled and highly trained ship's navigators were in the 18th and 19th centuries when they perfected this method. They had to make accurate measurements on moving decks, in all weathers and then spend a long time doing the calculations by hand without calculators or computers.

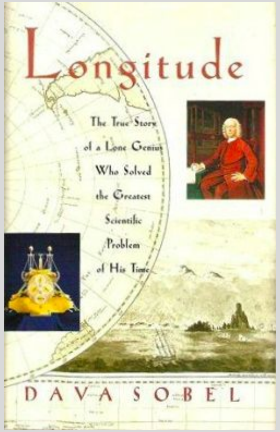


Another option was to carry accurate clocks on board a ship, one set to Greenwich time and one adjusted every day to read local time. Then all you needed to do was calculate the time difference and use the 15^0 per hour rule to calculate longitude. The problem here was to make mechanical clocks that kept their time and could withstand the motion, temperature changes and salt water on a ship.

By about the 19th century navigators were using both methods, correcting their clocks with lunar distance measurements to keep the clocks measuring accurately on long voyages.

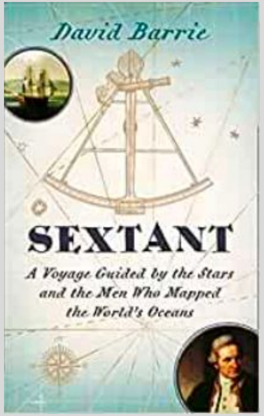
Further reading:

If you are interested in the history of astronomy and navigation then books like these are very readable stories of how the methods developed:



http://www.davasobel.com/books-by-dava-sobel/longitude

https://geographical.co.uk/reviews/books/item/300-sextant-by-david-barrie



Or visit the Royal Greenwich Observatory:

https://www.rmg.co.uk/collections/our-collections-timekeeping