Celestial Navigation

Outcomes:

1. Describe the science underlying particular technologies designed to explore natural phenomena, extend human capabilities, or solve practical problems. (111-5)
2. Relate personal activities and various scientific and technological endeavours to specific science disciplines and interdisciplinary study areas. (109-11)

Introduction

In May, 1497 an Italian captain, John Cabot set sail from Bristol, England with a crew of English sailors on a voyage of exploration and discovery. He first sighted a "new-found-land" on June 24th (Prowse, 1895). Cabot returned to Bristol with news of his discovery in August of the same year. How was Cabot able to navigate over 3000 kilometres across the ocean from Europe to the island of Newfoundland and then successfully return to Bristol?

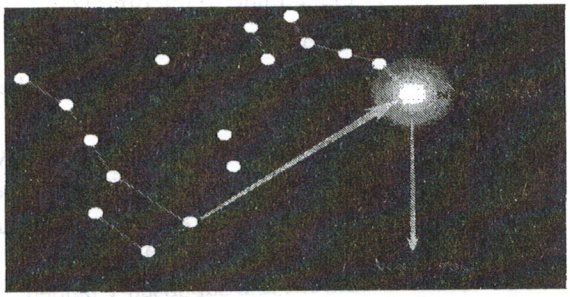

Figure 1: Using the Big Dipper to find the Little Dipper is easy using this method. Photo courtesy of http://www.m4040.com/Survival/Skills/Navigation/Navigation.htm.

Figure 2: This time lapse photo shows Polaris at the center; note that while the other stars show movement, Polaris is stationary. Photo courtesy of http://zimmer.csufresno.edu/~fringwal/courtright.html.

Celestial Navigation

On a clear night in the northern hemisphere we can see thousands of stars. Ursa Major is a constellation that includes seven stars that make up the Big Dipper. Once you have found the Big Dipper it is easy to locate the Little Dipper. Simply connect the last star at the bottom of the big dipper to the adjacent star at the brim and extend it as shown in the diagram below. The extended line points directly towards the Little Dipper. The last star on the handle of the Little Dipper is known as the North Star, the Pole Star or Polaris.

Polaris is positioned directly over our north pole, the axis of rotation of Earth. Therefore, as Earth spins, Polaris never changes its position in our

night sky. If Polaris is directly overhead at the north pole it must disappear into the horizon as we move toward the equator. As you move from zero degrees latitude at the equator and move north, Polaris begins to rise so that when you move to 10 degrees north latitude Polaris now appears 10 degrees above the horizon. Early naval explorers realized this and used this information as they navigated vast distances across oceans. Celestial navigation, or using a celestial object such as the moon, planets or stars to navigate, has been used by people for thousands of years. But why was knowing latitude so important?

For ancient explorers like Cabot it would be valuable information to know the latitude at their home port. To do this they would measure the angle that Polaris made with the horizon. If they knew that their destination was a similar latitude they would try to keep Polaris at the same altitude in the sky as they sailed. Cabot left Bristol which is 51°N latitude and supposedly landed in Bonavista which is 48°N latitude. A possible explanation to the question as to how he was able to successfully return to Bristol in such a short time could be that he kept the North Star at the same altitude in the sky as he sailed all the way back across the Atlantic Ocean.

Knowing your position on our planet enables you to draw a map. Navigators of the fifteenth century quickly produced maps that depicted our modern view of the Americas.

Celestial Navigation Technology

Many ingenious inventions were created to measure the altitude of the North Star. Early Arabian explorers used a kamal to measure latitude. A kamal consists of a small rectangular wooden block measuring approximately 2.5 cm by 5 cm (Wikipedia). The navigator would thread a line through the center of this block and hold the line between their front teeth. The line would

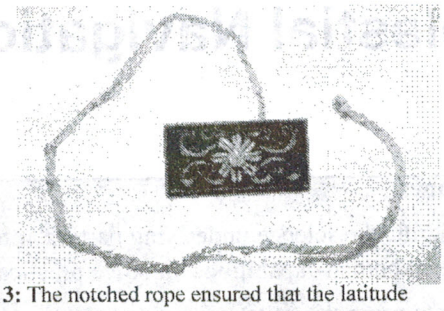

Figure 3: The notched rope ensured that the latitude measurements provided by users of this kamal were consistent.

then be pulled through the kamal until the navigator aligned the horizon with the bottom short edge and the North Star with the top edge. When this was accomplished a knot would be tied in the line to record the position of the North Pole relative to the navigator's home port. This would essentially be a record of their home port latitude. When returning to their home ports, navigators would attempt to realign their kamal by steering their ships north or south to find their original latitude.

Figure 4: Astrolabe dating back to the 11th century.

A shipwreck at Red Bay Labrador dating back to the 1600's contained an astrolabe used by early Basque whalers to determine their latitude. The Astrolabe allowed the mariner to sight celestial bodies including the moon, the sun and stars. Noting the time of the year, the time of day and measuring the altitude of the body using the astrolabe enabled them to find their latitude.

Other navigational devices soon followed. Quadrants, sextants and other devices that relied on celestial bodies to make navigation at sea possible have been salvaged from shipwrecks all around our province. Many shipwrecks occurred because although sailors could easily calculate their latitude from celestial bodies, determination of longitude, or their east to west position, was more difficult to find. It wasn't until the use of an accurate chronometer, in the 1772 voyage of HMS Resolution, that longitude

could be accurately measured. Before this early navigators had difficulty judging their distance from shore resulting in many marine disasters.

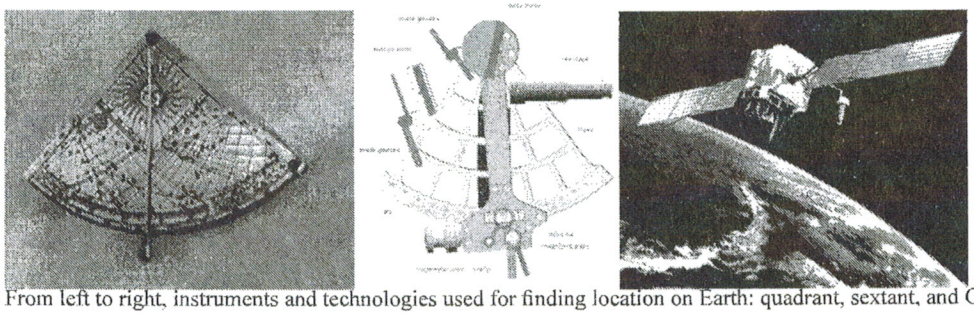

Figure 5: From left to right, instruments and technologies used for finding location on Earth: quadrant, sextant, and GPS using satellite technology.

Conclusion

Today we rely on Global Positioning Systems (GPS), LORAN and Radar to accurately find our position while navigating at sea. These advanced technologies rely on our ability to send and receive signals. But what happens if these signals are interfered with or the devices malfunction? For thousands of years sailors have been sailing by the stars without any advanced electronic equipment. Current technology allows for much more accurate determination of where you are on Earth, the older technologies discussed in this module could still be used for more general approximations. In fact, many outdoor's people prefer to navigate by the stars.

Questions

1. Explain why a sailor would be unable to use celestial navigation all the time.
2. What alternatives do we have to celestial navigation today?
3. Why is it important to know how to use a variety of navigation techniques?
4. Are there any other uses for celestial navigation than just navigation at sea?

References

Ifland, P. (2000). *The history of the sextant.* Available: http://www.mat.uc.pt/~helios/Mestre/Novemb00/H61iflan.htm

Kamal. Available: http://en.wikipedia.org/wiki/Kamal

Prowse, D.W. A History of Newfoundland. London: Macmillian, 1895.

Tyson, P. (2000). Secrets of ancient navigation. Available: http://www.pbs.org/wgbh/nova/longitude/secrets.html

Activity

Constructing and Using a Kamal

Purpose: To construct and use a Kamal.

Materials:
- 1 technical eraser - typically 2 cm by 6 cm
- 1 metre of twine/thread
- 1 heavy duty threading needle
- 1 metre stick
- 1 sticky star (0.5 cm diameter)