Ship navigation

Keywords: plane geometry, geometry, circumferential angle

Since the 15th century, navigators have been equipped with mechanical aids that allowed them to measure the angular distance between two objects (such as stars, the Sun, and the horizon, or significant points on a distant land). Among such aids, we mention here the Jacob's staff, the astrolabe, or the marine sextant.[1] It is interesting to note that despite its age, the sextant, in particular, still has its place as a backup in case of a sudden loss of GPS signal and is even being tested for its potential emergency use in space. [2] Among other mechanical navigation tools, let us mention the station pointer, whose role will be explained in the note after the solution of the first exercise.

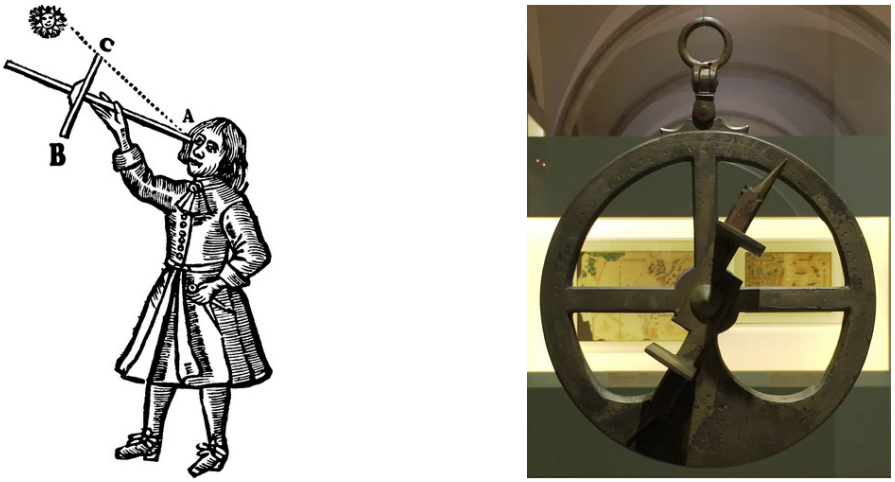

Figure 1: Jacob's staff (left) and astrolabe (right)

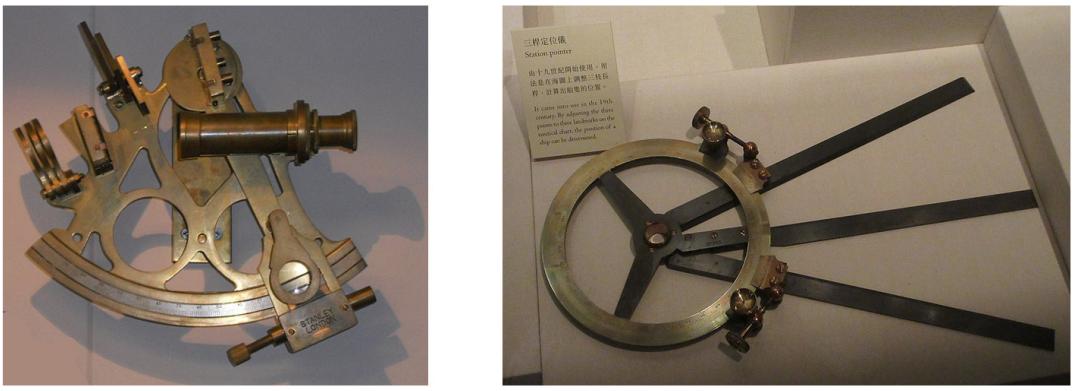

Figure 2: Sextant (left) and station pointer (right).

[1] For more information about navigation, see Vondrák (2013).
[2] Gaskill (2018).

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Exercises

The following two exercises involve a map that students will need to draw on. Therefore, we provide the assignments also in the form of a printable worksheets.

Exercise 1. On the map, the positions of three lighthouses near the town of Bonifacio on Corsica are marked. The captain of a ship at sea has measured two angular distances, denoted θ, between two pairs of lighthouses as follows:

- $\theta(2,3) = 52°$
- $\theta(1,3) = 35°$

Construct a point on the map indicating the position of the ship at the time of measurement. Assume that the measurements were taken in rapid succession, i.e., the ship's position practically did not change.

Note. The tool that freed navigators from this construction is the station pointer (also called the three-armed protractor) we already mentioned. Its three arms were set on the map in such a way that they passed through positions of the three salient points and formed angles of the measured sizes. The intersection of the arms then determined the position of the ship on the map.

Exercise 2. On the map of the strait between the islands of Mallorca and Menorca, two prominent points on the mainland and the position of the ship L are marked. Additionally, two areas of dangerous waters, containing underwater obstacles, are indicated. Find a way for the ship to navigate through the dangerous waters to the port of Cala Agulla. Utilize the ship captain's ability to measure the angular distance between the two mentioned points at any given moment.

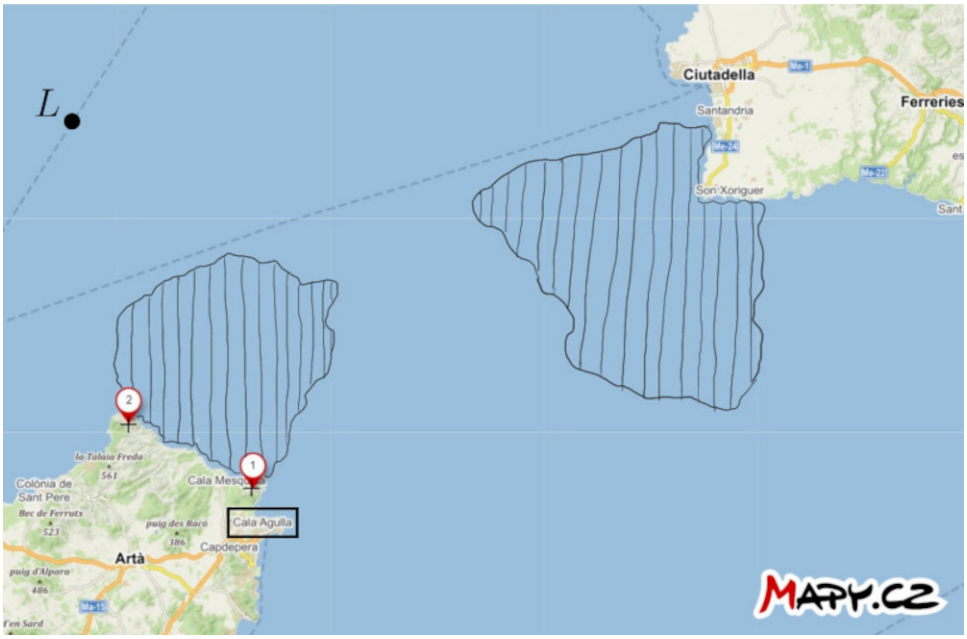

Figure 3: Problem 2

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References and literature

Literature

- Vondrák J. (2013). History of navigation - from quadrant to GNSS. * Advances of mathematics, physics and astronomy, 58 (1)*, 11-20.
- Gaskill M. (2018). *Deep Space Navigation: Tool Tested as Emergency Navigation Device*. NASA. https://www.nasa.gov/mission_pages/station/research/news/Sextant_ISS

Image Sources

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- astrolabe
  https://upload.wikimedia.org/wikipedia/commons/thumb/9/91/Astrolabio_Aveiro_Lisboa_ca1600.jpg/800px-Astrolabio_Aveiro_Lisboa_ca1600.jpg
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