

## 3.1 Triangulation

Triangulation is the technique of determining the location of a point by using the known points of a triangle. The applications of triangulation include land surveying, ocean and space navigation, and astronomy.

### Land Surveying

Land surveying is the scientific measurement of land. Its applications include making maps and defining boundaries for land development. An important tool used in land surveying is a theodolite, also called a total station, which is an optical instrument that finds the angles and distances by analyzing the slope between itself and a specific point. To survey land, a land surveyor visualizes and imposes various triangles across an area. Using a total station, the sides and angles of the three survey control points of any triangles can be calculated. Each of the calculated distances becomes one side of another triangle. The calculations are performed until the measurements of all triangles are found. These measurements combined give the surveyor a more concrete idea of what the land is like. The more triangles are measured, the greater the accuracy and effectiveness of the land survey.

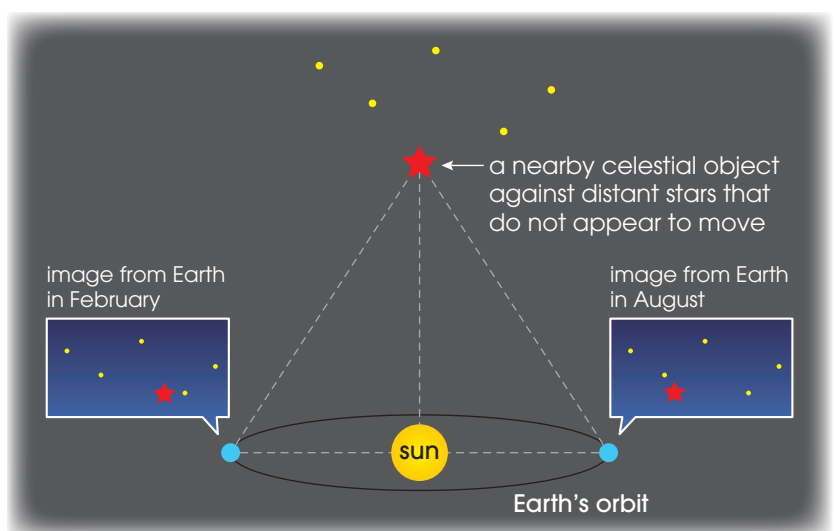
### Ocean Navigation

For hundreds of years, sailors have been using different measuring tools to determine their locations. The most popular tool used was the sextant, which measures the relative distance between different things, including stars (often the sun) and other celestial objects or the horizon. A sextant is built with mirrors and a telescope, allowing a navigator to measure the angle between two objects. A navigator then uses the measurements obtained and triangulation to perform celestial navigation – locating the exact position he or she is on Earth. Nowadays, navigation relies on satellites to measure distances using trilateration, a technique similar to triangulation, to chart positions and courses.

### Astronomy

To determine the positions and distances of stars and planets in space, triangulation plays an important role. A deep space telescope pointing toward a celestial object can determine its trajectory through triangulation.

As Earth orbits the sun, our viewpoint of stars changes. It works similarly as holding your finger in front of you; when alternating with either eye open, your finger appears to have moved; this “shift” due to the change in viewpoints is called parallax. In addition, for the same distance travelled, near objects will seem to move more than distant objects. This effect can be used to measure distances in space.



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To find the distances, telescopes are used to take two images when Earth is on opposing points in its orbit around the sun. An imaginary triangle (see diagram) is formed using the diameter of Earth's orbit around the sun and the celestial object to be measured. The two images taken will show a "shift" of the celestial object, or parallax, against distant stars that do not appear to move. Since the object is far away from Earth, the parallax is very small. Therefore, precise instruments are needed to determine the most accurate measurements. This information can then be used to calculate the distance of the celestial object to the sun.