

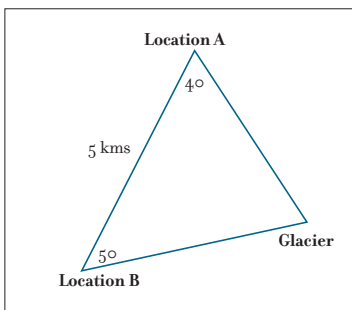
# THE INDIA SURVEY

HANDOUT 1

**ONE OF THE KEY TOOLS OF THE INDIA SURVEY** of the mid 1800s was a **theodolite** (thee-oh-duh-lite). Weighing more than 1,000 pounds, it required 12 men to move this enormous piece of equipment! A theodolite is a type of telescope mounted on a tripod, which surveyors use to view locations in the distance. The surveyor pivots the telescope and measures the angle between the two locations. The telescope also pivots up and down to measure the angle of a slope, or incline.

When marking a location, surveyors identify its **coordinates**, or the location's exact intersection of longitude and latitude. With the India surveys, surveyors began at one location and used huge chains or bars to measure and build a 12-kilometer baseline. Along that baseline, they established observation posts. From the observation posts they were able to observe, measure, and plot triangles across the land, then draw the land in the form of a basic map. A triangle is a helpful shape to the surveyor. Using triangles to identify and measure the land is called **triangulation**.

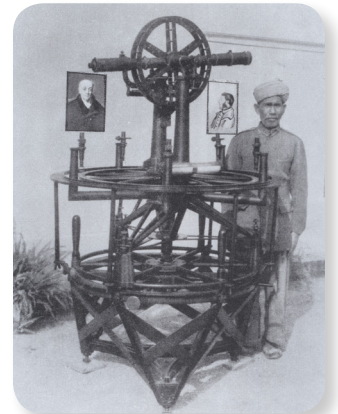
A surveyor can identify the location of an unknown point (such as the tip of a glacier) using two known locations (Location A and Location B) and the distance between them (5 kilometers). The surveyor goes to Location A, points the telescope of the theodolite to the tip of the glacier, and takes a reading. He then rotates it to known Location B, takes a reading, and records the angle of the difference ( $40^\circ$ ). Then the surveyor travels to Location B and repeats the process ( $50^\circ$ ). With the distance between the two known locations and the angle measurements, surveyors can use math processes called trigonometry to calculate the unknown distance to the tip of the glacier. They can then also determine the latitude and longitude at that third point.



In the early 1800s, the Andes Mountains of South America were thought to be the highest peaks in the world. As the India Survey extended their triangular measurements, it became clear that the distant peaks of Nepal were much higher than the peaks of the Andes. In 1848, James Nicolson of the India Survey team went to certain locations to take 36 theodolite readings of a summit known as peak b. He spent months traveling among six remote observation posts with the huge theodolite. James Nicolson contracted malaria and was transported home, but a team of surveyors led by Andrew

Waugh spent years using his data to calculate the elevation of the summit. In 1856, after years of work, Andrew Waugh wrote to his supervisor, "I am now in possession of the final values of the peak... it measures 29,002 feet."

The India surveyors used a very complex process of both vertical and horizontal readings to triangulate a distant elevation. To better understand triangulation we will try something simpler: measuring the height of a tree.



*George Everest used this theodolite in the 1830s and 1840s during the Great Trigonometrical Survey of India. This instrument weighed approximately half a ton.*