

Division Of Geological Survey

HANDS ON

EARTH SCIENCE

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HOW TO DETERMINE TRUE NORTH

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Can you mark on the ground a true north-south line? Is the Sun directly overhead at noon? Does midday coincide with noon? Such questions can form the basis of an excellent inquiry-based experiment for students ranging from fifth graders through college undergraduates. Although this activity is simple enough to use with middle-school students, it is also worthwhile to pursue with high-school and college students because the vast majority of such students have not made, or even considered, these fundamental determinations.

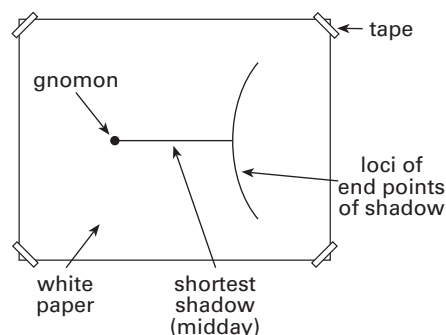
A straightforward method to lay out a north-south line is to first determine midday. Midday is simply that time halfway between the times of sunrise and sunset, which can be ascertained by calling the local television station or watching the local evening news. The times given will be accurate to within a couple of minutes, depending on your location with respect to the station.

The class can be divided into small groups. Each group will need two large sheets of white paper, masking tape, a standard laboratory support stand with rod (the vertical rod serves as the shadow-casting object, or gnomon), a meter stick, a watch, and a sharp pencil. You should also have available a scout or army-type compass and a large protractor.

Take the class outside on a sunny day about a half hour before your calculated value of midday. They will need a horizontal surface, such as a sidewalk, on which to work. Place the support stand on the level surface and arrange the large sheet of paper so that the shadow of the tip of the rod falls on the paper. Tape the paper to the level surface. (Remember, the shadow is going to move; that is why we have an extra sheet of paper.) The position of the base of the stand should be outlined by pencil on the paper so that if the stand gets bumped, it can be returned to its original position.

To add a worthwhile flair to this experiment, the instructor can set up a similar apparatus in the morning and mark positions of the tip of the shadow every half hour. Record the times on the paper near the appropriate mark. The teacher can then connect these points with a smooth curve, providing a dramatic representation of how far the shadow (or "Sun") moves in just a couple of hours.

Students should begin their measurements at least 20 minutes before the calculated value for midday and should measure the length of the shadow every 2 minutes for approximately 40 minutes. They should mark the position of the tip of the rod's shadow and note the time beside each mark. Measurements should continue until the length of the shadow begins to noticeably increase. Midday is when the length of the rod's shadow is shortest. A line drawn on the paper between the mark representing the tip of the minimum shadow and the center of the base of the support rod provides a true north-south line.



Bird's-eye view of set up for determining midday.

What the students are witnessing is empirical evidence that the Earth is rotating about its axis. They are watching the Earth spin. One should keep in mind, though, that this is evidence, not proof. A stationary Earth about which the Sun makes a daily orbit provides an alternative explanation. A field trip to a local science museum where a Foucault pendulum is on display would provide more direct evidence that the Earth is rotating.

With the aid of the compass and the protractor, students can now determine the angle of deviation between the direction the compass needle points and the line they have drawn on the paper. They should compare this angle with the accepted value for the angle of magnetic declination given on a U.S. Geological Survey topographic map of their area. If this experiment is done with moderate care, the students will be pleased with the comparison.

Further questions and experiments come immediately to mind. How did the measured value for midday compare with the computed value? Why wasn't midday at noon? What were sources of error in this experiment and how might they be minimized? For any given time, will the length of the shadow change from day to day? If so, why? On what date will shadows be shortest? Longest?

These questions can best be answered by further shadow measurements. Students can calculate the latitude of their school. This experiment is best done at midday on either the vernal or autumnal equinox. The shadow measurement of midday provides a straightforward technique. All the class needs in order to determine their latitude is either a knowledge of elementary trigonometry or an accurate and large scale drawing of the length of the support rod (from ground to tip) and the length of its shadow. Then simply measure the appropriate angle.

Shadow experiments demonstrate that excellent science can be done with simple apparatus. After all, the old Greeks did remarkably well with what nature provided: a stick, the Sun, and some human ingenuity!

FURTHER READING

McClure, Bruce, 1987, Watching the Earth move with the shadow clock: *Astronomy*, v. 15, no. 8, p. 32-35.

(This article originally appeared in *The Physics Teacher*, 1995, v. 33, p. 116-117.)