CALIFORNIA STATE SCIENCE FAIR
2012 PROJECT SUMMARY

Name(s)

Caleb Clements; Chase Clements

Project Number

J1405

Project Title

Creating a Global Positioning System: Determining Latitude and Longitude Based Upon Solar Azimuth and Elevation

Abstract

Objectives/Goals

Our project was to create a global positioning system (GPS) by building a device to measure the azimuth and elevation of the Sun and creating an algorithm to calculate the latitude and longitude of the observer.

Methods/Materials

We built a device similar to a horizontal sundial to measure the azimuth and elevation of the Sun based upon the length and direction of the shadow cast by the gnomon. We also developed an algorithm to calculate the latitude and longitude based upon the date, time, solar azimuth, and solar elevation.

The algorithm had to account for Earth's orbital mechanics, including but not limited to: eccentricity of orbit, uneven days in year, axial rotation, and variable speed of orbit (Kepler's second law).

In order to test our hypothesis, we measured the solar azimuth and elevation for 10 different dates and times in our backyard and used our algorithm to estimate our latitude and longitude. We also obtained date, time, solar azimuth, and solar elevation data for 30 significant events in world history in the last 1,000 years and used our algorithm to estimate the latitude and longitude of the event.

Results

For the 10 tests performed in our back yard our errors ranged from 16.5KM to 143.8KM, with an average of 40.2KM. For the 30 worldwide events we were given for our experiment, our errors ranged from 0.4KM to 92.1KM, with an average error of 24.2KM.

Conclusions/Discussion

Our conclusion is that we can create a GPS by noting the date and time, measuring the azimuth and elevation of the Sun and calculating our latitude and longitude on Earth. This project greatly increased our knowledge of Earth's orbital mechanics.

Summary Statement

We created a global positioning system by building a device to measure the azimuth and elevation of the Sun and developing an algorithm to calculate the latitude and longitude based upon the date, time, solar azimuth, and solar elevation.

Help Received

Mother helped us prepare the board; Father operated the drill press during the construction of our device; Dr. Fiona Vincent (astronomer at St. Andrews University) and Dr. Robert Kellog (with the North American Sundial Society) both answered questions and explained certain concepts.