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Equatorial Sundials in the Ancient World: Construction and Applications

Alyssa Stark
Wright State University - Main Campus

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INTRODUCTION

Time is an easy concept on the surface. Most people comprehend the idea of a year, month, week, day, and second. This was not the case for the ancient populations who lived before us. One of the earliest methods for determining time throughout the day was utilizing shadows which were cast from objects. Tall trees, due to their sedentariness, were great tools in early time telling. Ancient people would have observed these shadows much earlier than we have record for. However, the idea of time telling using shadows continued long past the ancient world.

Sundials are the tool created to better use the shadows created by the sun rotating around the earth. Trigonometry in ancient Greece established the math to create much more sophisticated sundials. This poster will explore trigonometry in relationship to sundials.

HISTORY & USES

Ancient people would have noticed the shadows from various objects changing throughout the day. They would have also recognized that the length of the shadow changed seasonally as well. This information would have proved to be valuable for people all over the world. The first tool used in this capacity was likely sticks placed in the ground. However, it is not possible to determine the actual date these were first used.

The earliest sundial recorded dates to around 1500 B. C. and it is a stone fragment of a sundial. Thus, it can be concluded that simple sundials have been around for a long time. These early tools would have been used to tell the general time of the day such as morning, afternoon, and evening. The mathematics to determine hour lines had not yet been discovered. These early sundials would have also been used to determine shifts in the seasons.

Greek trigonometry developed around 300 B. C. provided the necessary math to create sophisticated sundials. The markings that were created using this new idea likely resembled modern sundials. However, it is worth noting that not all ancient people had sundials or were concerned with precise time. This was a habit of the wealthy and used by the government to track time.

MATH

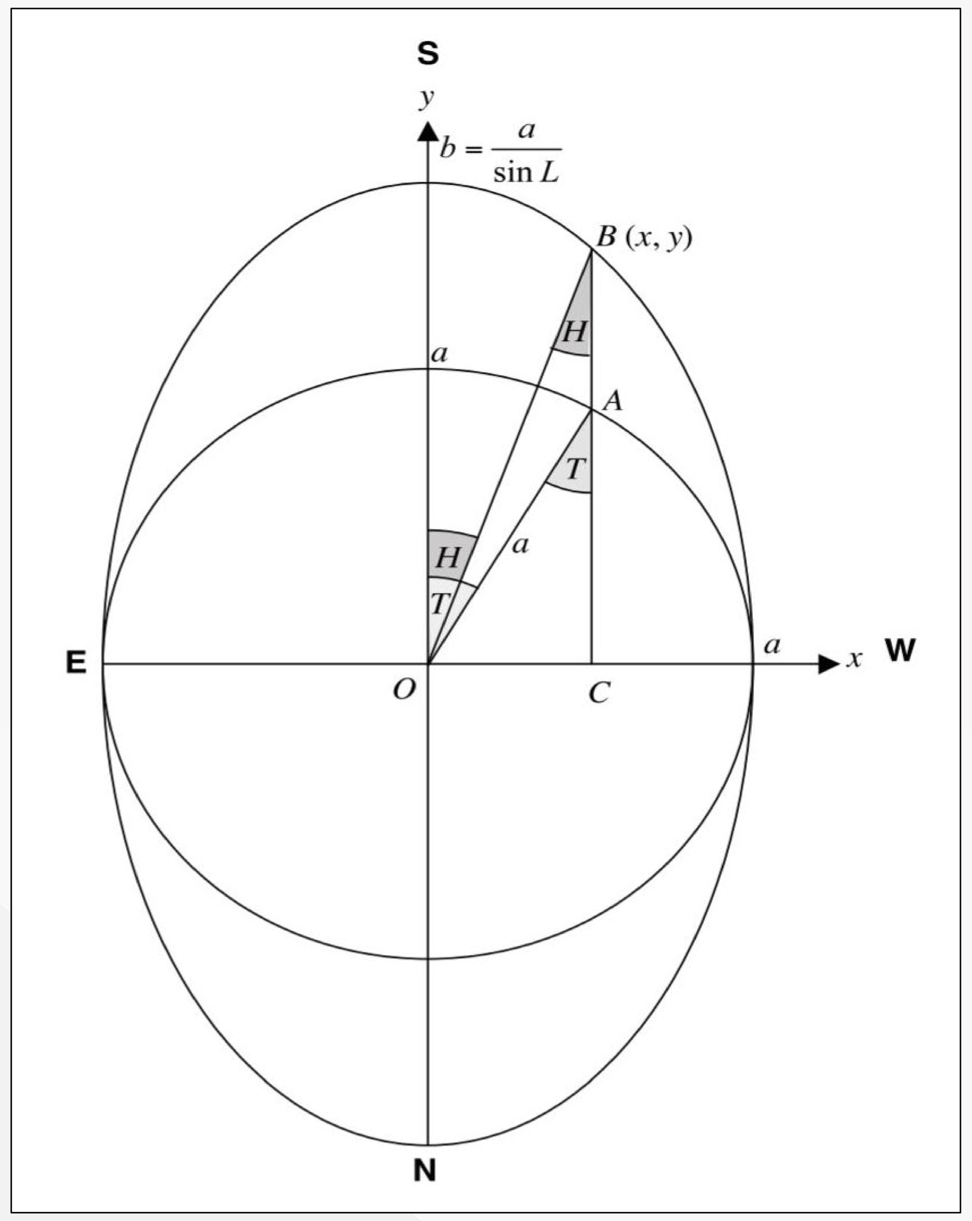
First, we must determine the latitude of the desired location. In Dayton, Ohio, our latitude is 39° 45' 34" N. That must be converted to a decimal for the equations which translate to 39.76° N.** This number will be deemed "L" for our equation. Then the arbitrary "a" must be establish which is the radius of the circle inclined at 39.76°. In our case, "a" will equal nine inches to accommodate for the piece of wood the dial will be constructed from. The "b" in the equation is calculated by a/sinL or 9/sin(39.76) which equals 10.2 inches. This number becomes the major NS axis and "a" is the minor EW axis of the ellipse dial. The points "a" and "b" create a right angle from the center the of dial. The foci points must be determined to finish the ellipse shape. To locate the foci points the formula $c^2 = b^2 - a^2$ or $c = \sqrt{(10.2^2 - 9^2)}$ was used which yields c=4.8 inches. Drawing the foci, it is determined that the dial will measure 20.4 inches in length and 18 inches in width.

A string, wrapped one length completely around the board, was used to trace the ellipse on the board and cut it out. After cutting, the hour markings could be created on the dial face. The only hours that need to be equated are 1-5 because any hour divisible by 6 land on one of the 90° of the dial. 12 pm is set default to the north line. The next variables to determine are "x", "y", "T", and "H". The "a" that was utilized earlier is also needed. "T" equals the angle of the time on an evenly distributed 24-hour circle with 12 pm as the 0° on the north line. 1 pm would then be T=15°. 9 am would be 270°. "X" is calculated as "a"*sinT and "y" is computed as "a" times cosT divided by sinL. "H" is the arctan of tanT*sinL. This results in 1 pm being the arctan of tan(15°)*sin(39.76) which equals 9.72°. 2 pm = 20.27°, 3 pm = 32.60°, 4 pm = 47.93°, and 5 pm is 67.27°N. 6 pm is at the east intercept, 12 am is to the south, and 6 am is the west intercept. The gnomon is cut at an angle of 39.76° and extends 10.2" from the south point to the center of the sundial. The other 3 quadrants of the sundial are filled in with the reflections of the first quadrant to determine the time.

**The conversion was created by dividing 45 minutes by 60, the 34 seconds by 3,600 and add the results to the 39 degrees. 39+0.75+0.00944= 39.75944 or 39.76°N.

CONSTRUCTION

Trigonometry diagram used to create the modern sundial. The design and mathematical formula was modeled from Dr. Jill Vincent from Melbourne, Australia. Thus, the diagram and math had to be adjusted and flipped for northern hemisphere use.



The construct sundial for this project outside at 5:00 pm natural time. This picture was taken at 6:00 pm Daylight Savings Time.

CONCLUSION

Overall, we must conclude that the trigonometry used in this project may not be comparable to math used in the ancient world. Modern tools such as Microsoft Excel and advanced calculators were used in the making of the sundial for this project. The sundials that are recorded from the ancient world also do not convey the best methods and mathematics to use to recreate the type in question. However, the end results and function of the sundial are likely comparable.

Several things that were not accounted for did affect the end results. The major one that must be mentioned is Daylight Savings Time used in the United States. All our results are off one hour due to time being artificially moved forward one hour. Nonetheless, the gnomon relayed accurate time onto the dial.

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Contact

Alyssa Stark

Stark.26@wright.edu