The Noon Project Revisited

By Tom Akashi

Introduction: 2200 years ago, Eratosthenes calculated the circumference of the Earth from the measurements of two shadows (in a well and from a pole). The Noon Project is an annual Internet event for schools to team up and make their own measurements. Using the reported 1995 shadow measurements, you can perform the calculations to determine the circumference of the Earth.

Prior Knowledge: You should have a knowledge of geometry and trig functions.

Grade Level: 8-12

Task: To determine the circumference of the Earth from the shadow measurements reported from the 1995 Noon Project.

Resources: Noon Project Revisited Worksheet and calculators with trig functions

Process:

1. **Anticipatory Set-** Introduce the lesson by stating the objective and/or giving the history on this lesson. For more information on Eratosthenes, go to http://yn.la.ca.us/eratosthenes/welcome.html
2. **Instruction -** Model calculating the Angle, the Distance, and the Circumference of the Earth using the data for AUS and CA, from the Noon Project Revisited Worksheet.

   d = distance between the two locations, using the formula,
   d = (L2 - L1)k
   A = 360 degrees, assumption of round earth
   a = the difference of the solar angles,
   a = angle1 - angle2 .
   D = circumference of the Earth.

3. **Guided Practice -** Allow for guided practice, using the data for AUS and WI. Check for understanding. Then have students continue to try to complete the rest of the worksheet.
4. **Closure and Independent Practice -** Remind students that just like Eratosthenes, they are trying to use math to calculate immeasurable objects. Students are to finish the worksheet at home.

Learning Advice: Teachers need to try out the calculations before having your class do them. Be sure to model each step in a clear and organized manner. Students should take notes which can be included with their own calculations and drawings. Students will need calculators with trig functions. An overhead transparency of the worksheet would be helpful.

Evaluation: Along with accurate calculations, students should show each step in a clear and organized manner. Drawings should be used, where they aid communication. Students should be encouraged to include comments.

Extensions:

- You could have students present their calculations and drawings, to the whole class.
- Create a diagram showing two shadows in the same hemisphere, and explain the reasoning behind subtracting the solar angles, to obtain the central angle.
- Try participating in the Noon Project, held each year during March or April. http://www.ed.uiuc.edu/coe/projects/noon-project/

Two schools with email accounts can exchange their noon shadow measurements and latitudes, for any one day, and can still get a close approximation of the circumference of the Earth.

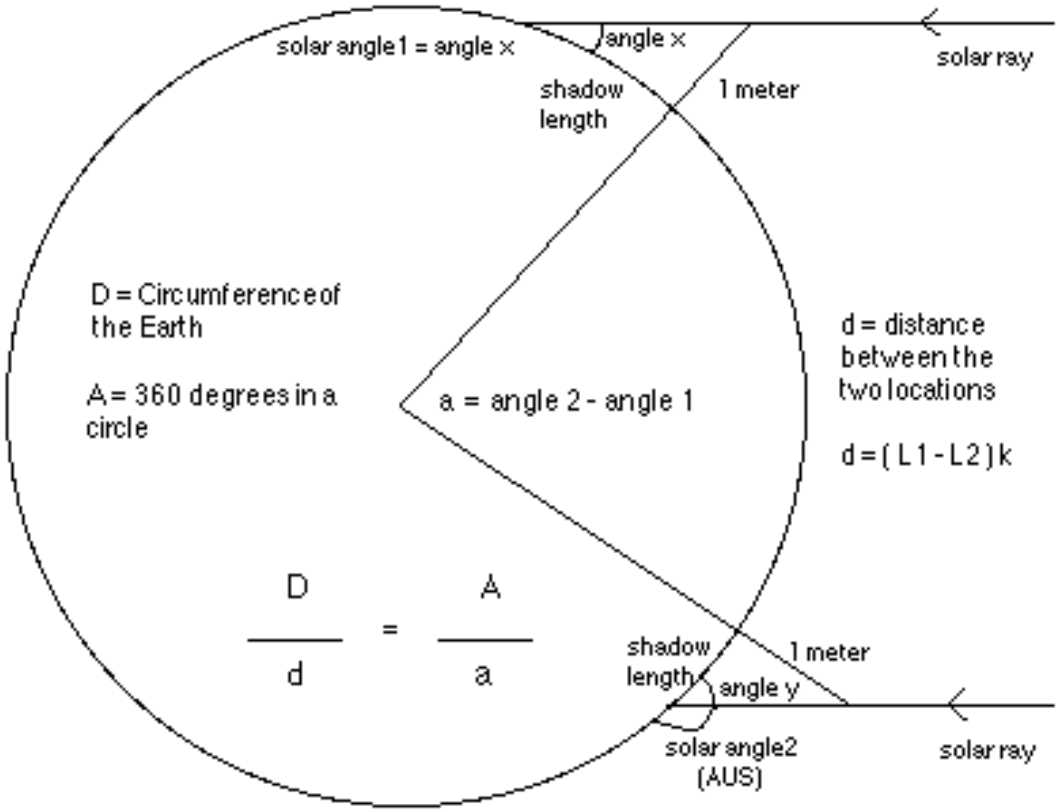
Conclusion: This project is a real world application of geometry and trigonometry. Hopefully, by doing such activities, students will begin to see the value and power of mathematics.

Names :

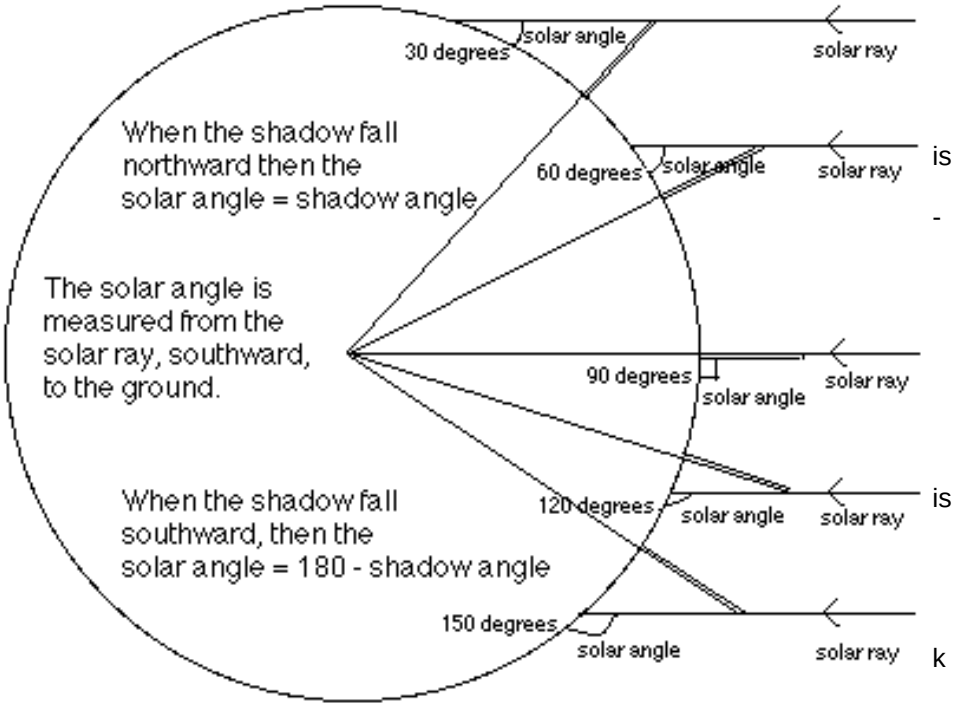
Directions:

- **Using the data supplied from the 1995 Noon Project, complete the table.**
- **The diagram is included for assistance.**
- **Australia is always used for pairing.**
- **Do your work in a clear and organized manner and attach it to this sheet.**
- **Include your comments or questions.**

Site	Latitude	Shadow (cm)	Solar Angle	N/S Distance	Circumference	%
AUS	-23.38	46.2	114.8	(km)	Estimated	Deviation
CA	34.13	65.14	56.92	6391	39751	-1
WI	43.17	91.5	47.54	7396	39586	-1
NY	42.93	90	48.01	7369		-1
CA	36.53	67		6658		2
NZ	-43.53	96.6			41959	5
IL	40.07	81.67				-1



This diagram demonstrates how the solar angle is measured. Notice that the solar angle is only equal to the interior shadow angle when the shadow falls northward. At more southern latitudes, the solar angle equal to the exterior angle. In this way, the solar angle ranges from 0 180 degrees.

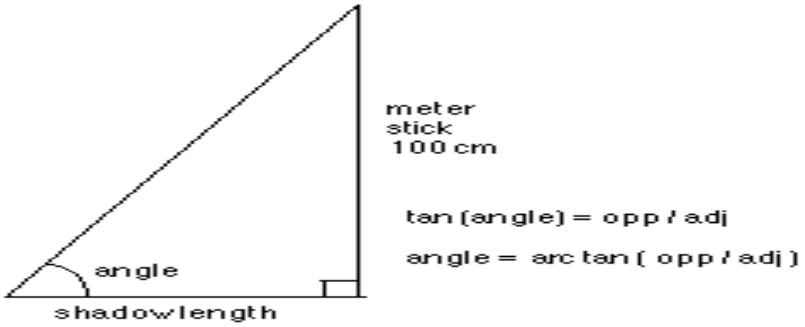


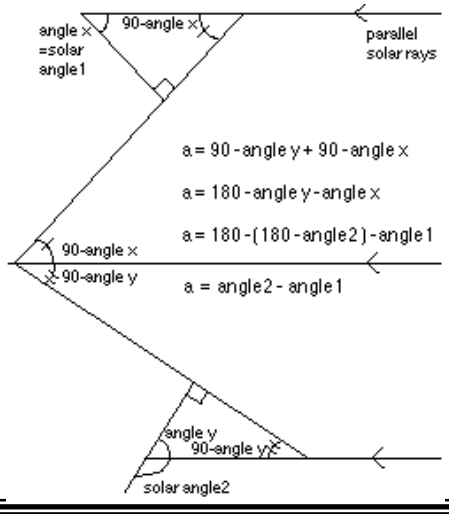
To calculate the Solar Angle, first calculate the interior shadow angle, using the rule below. Then, for this project, you can assume that for positive latitudes, the Solar Angle is equal to the interior angle. And for negative latitudes, the Solar Angle equal to 180 minus the interior angle.

To calculate the N/S Distance, you can use the rule, d = (L2 - L1) , where d is the N/S Distance, L1 and L2 are the latitudes of the two locations, and k is the latitude constant (in kilometers). Using the supplied data, you can first find the latitude constant, k. After that, you can calculate the N/S Distance, using the latitude data.

To calculate the Circumference, use the proportion, D/d = A/a , where D is the circumference of the Earth (in kilometers), d is the N/S Distance between the two locations, A is 360 degrees (since the Earth is like a circle), and a is the difference of the two solar angles (a = angle2 - angle1).

This diagram shows the trigonometric rule for calculating the interior angle of a right triangle





This diagram is a geometric proof of why the central angle a, is equal to the difference of the two solar angles.