Solar Eclipse Activities/Resources

TSAAPT/TSAPS Fall Meeting 2023

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Arts and Crafts Resources/Materials Links

Eclipse Chalk Art

NASA Resource -
https://science.nasa.gov/resource/eclipse-chalk-art/

PDF Instructions - https://science.nasa.gov/wp-content/uploads/2023/09/Eclipse-Chalk-Art-Activity-1.pdf

UV Bead Bracelets

UV Beads on Amazon - LINK

Make Your Own Sundial

Simple Sundial Instructions - https://www.generationgenius.com/activities/earths-orbit-and-rotation-activity-for-kids/

Sundial Template - https://www.generationgenius.com/wp-content/uploads/2018/03/GG-Simple-Sundial-v2.pdf

Moon Phase Modeling

Nasa Resource - https://www.jpl.nasa.gov/edu/teach/activity/moon-phases/

DIY Pinhole Camera

Plenty of video tutorials or use these written instructions.

Sun Funnel

Nasa Resource - https://eclipse2017.nasa.gov/make-sun-funnel

Measuring the Temperature of the Sun

Purpose: In this lab you will measure the solar flux, the amount of energy per unit area per unit time that reaches the Earth from the Sun. From this, you will calculate the temperature of the surface of the sun.

Equipment: Insulated cup, water, ink, thermometer, watch (timer), meter stick, scale, graph paper, and calculator

Introduction

Flux is defined as the amount of energy delivered per unit of area and per unit of time (measured in units of joules per square meter per second). We can use the flux to find out how much energy is delivered by the Sun using the following equation:

$$Energy\ delivered\ by\ Sun = Flux * Area * \Delta t$$

The energy delivered by the sun to the water will cause the water to increase in temperature. There is also a relationship between the amount of energy absorbed and the temperature increase of water given by the following equation:

$$Energy\ absorbed\ from\ the\ Sun = mass * specific\ heat * \Delta Temp$$

Where the specific heat of water is equal to 4186 J/(kg°C).

Setting the two equations equal to each other we can derive an expression to find the Flux.

$$Flux * Area * \ \Delta t = mass * specific\ heat * \Delta T$$

$$Flux = \frac{mass * specific\ heat}{Area}\ \frac{\Delta T}{\Delta t}$$

Part 1: Gathering Data

From the above equation, it is clear to see that in order to find flux, we will need to measure the mass of the water, area of the cup that sunlight will be falling on, change in temperature, and change in time.

1. Measure the diameter of the cup and divide it by 2 to find the radius:

   Radius = ______________________m

2. Calculate the area of the cup opening:

   Area = _________________________m^2

3. Measure the mass of your empty cup:

   Mass = ________________________kg

4. Obtain some water from a cold source and then measure the mass of your cup with water in it:

   Mass of water & Cup = _______________________kg

   Mass of water inside cup = _____________________kg

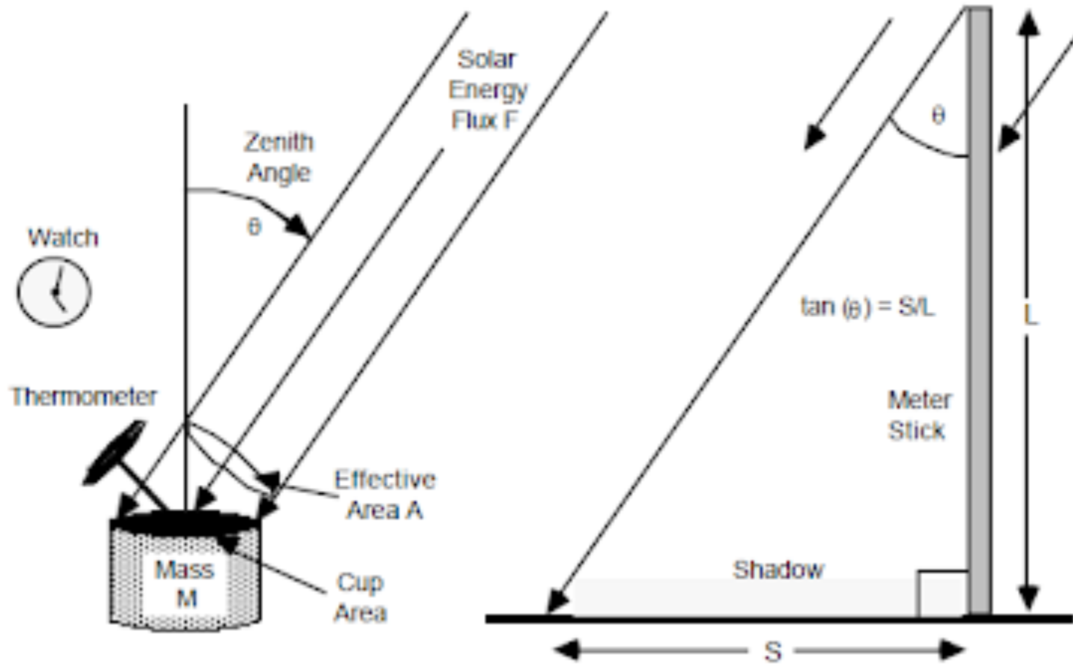
Place a few drops of dark food coloring in the water and mix it up to help the water absorb as much sunlight as possible. You will now take your set up outside.

When ready, place the thermometer in the water and record the temperature of the water at set time intervals for approximately 25-30 min. Record your data in a table similar to the one below.

Data Table: Time and Temperature	
Time (s)	Temperature (°C)
0	
120	

When you have all of your data for temperature and time, graph it on the plot at the back of this lab.

While outside, you may notice that the sun is not directly overhead. This means that the sunlight is not falling on the complete area of the cup but only a portion of it. In order to find the correct area of the cup, you will need to measure the angle the sun is away from Zenith. The easiest way to do this is to measure the shadow length of a specific item like a meter stick.



From the image above, you can see that the zenith angle is related to the length of the meter stick (L) and the shadow length (S) by the following relationship:

$$tan\, tan\,(\theta)\ =\ \frac{S}{L}$$

Calculate the zenith angle by using:

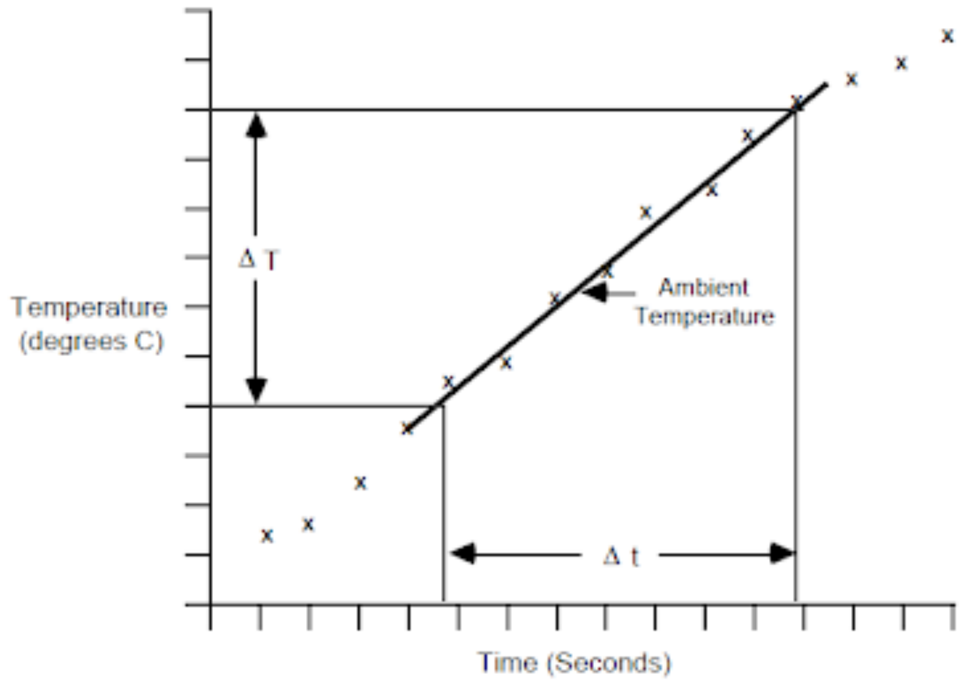
$$\theta\ =\ tan^{-1}\left(\frac{S}{L}\right) = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\ ^{\circ}$$

Calculate the correct area by using:

$$A\ =\ A_{cup} * cos\ cos\ (\theta)\ =\ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\ m^2$$

Data Analysis

Time to head back inside and analyze your data to find the solar flux. Your graph should come out to be relatively linear; an example is shown below.



For the part that looks the most linear, you can find the change in temperature and the change in time. Record those values below.

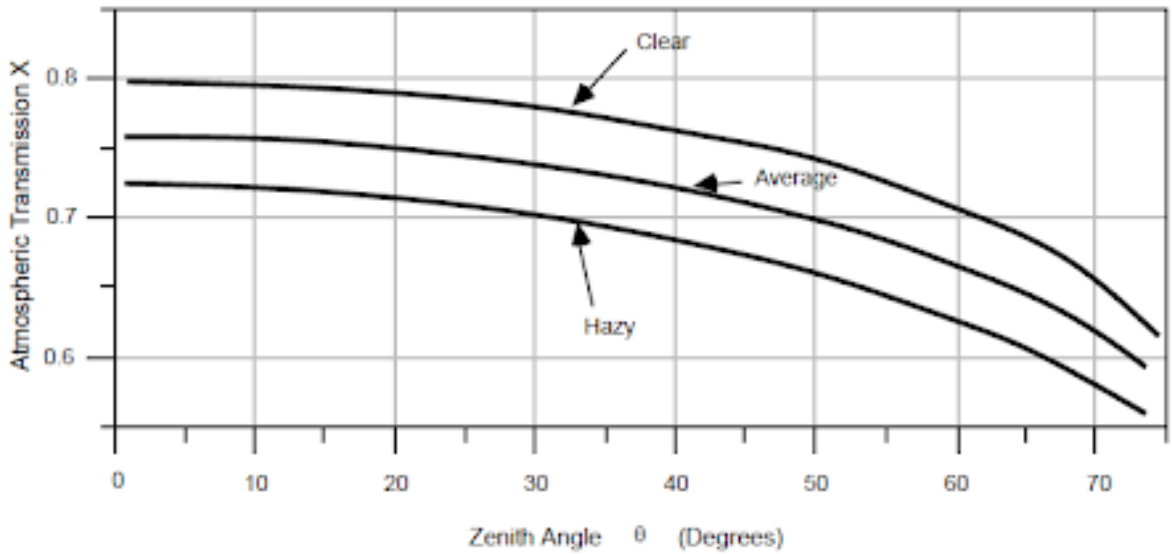
Change in Temperature = _______________________°C

Change in time = ___________________________s

You are now ready to find the solar flux. Use the equation for flux listed in the Introduction section on page 1 and record your value below.

Flux = ___________________________ J/m^2s

Just like the water heats up from the Sun, so does the atmosphere. We will have to adjust the above number using the following graph.



Find the Atmospheric Transmission value on the above graph by first locating your Zenith angle and deciding whether your skies outside or especially clear, average, or hazy. Then use that number to find the Solar Flux here on Earth by following

$$Solar\ Flux = \frac{calculated\ Flux}{X}$$

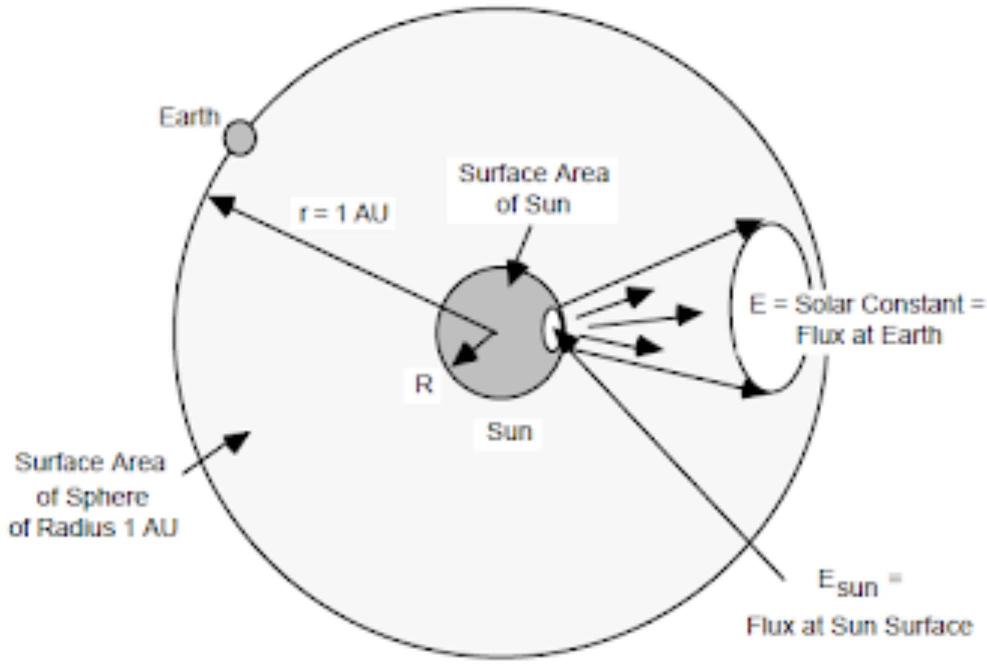
Record your Solar Flux value here: ________________________J/m^{2}s

Compare your calculated value for the Solar Flux with the generally accepted value of 1360 J/m^{2}s (that's equivalent to nearly fourteen 100-W lightbulbs shining onto an area 3 feet by 3 feet!).

Finding the Temperature of the Sun

Your calculated value of the solar flux measured the number of watts striking *one* square meter of surface at a distance of one astronomical unit (1AU = 1.5 x 10^{11}m) from the Sun. If you multiply the energy hitting one square meter of the Earth by the total number of square meters on a sphere of radius 1 AU you obtain the **luminosity**, or total power output of the SUN!

$$Luminosity = Solar\ Flux * 4\pi(1.5x10^{11}m)^2$$



Now that you know how much *total* energy the Sun puts out, you can also determine how much energy E_{sun} is emitted by each square meter of the solar photosphere. Since the radius of the Sun is about 7.0 x 10^8 m, we divide the total energy output by its surface area:

$$E_{sun} = \frac{Luminosity}{4\pi(7.0x10^8m)^2}$$

The Sun radiates energy according to the Stefan-Boltzmann law: the power radiated per unit area (E_{sun}) is proportional to the fourth power of its absolute temperature T measured in degrees K:

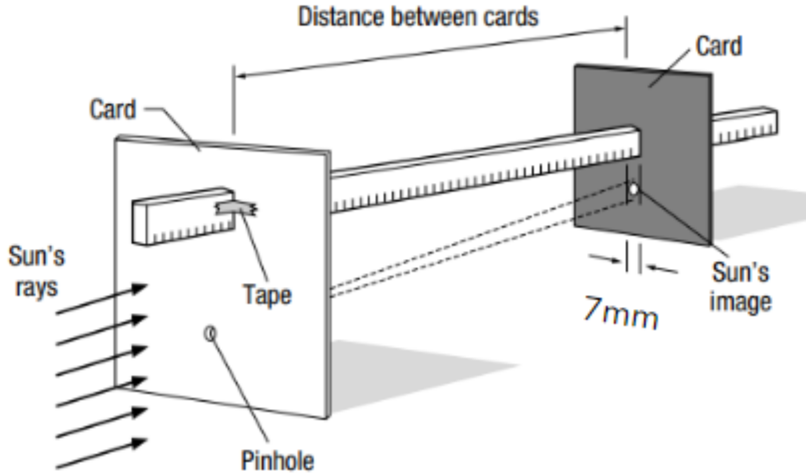
$$E_{sun} = \sigma T^4$$

Where σ (called the Stefan-Boltzmann constant is known from experiments to be 5.69 x 10^{-8} W/m^2K^4). Calculate the temperature of the photosphere using:

$$T = (\frac{E_{sun}}{\sigma})^{1/4}$$

Record the Temperature of the Sun here _______________________________K

Measuring the Diameter of the Sun



Move the cards on the meterstick until you create an image of the Sun that is exactly 7 mm wide. Fill in the data table below.

Scaled Diameter of Sun Image	7 mm (0.7 cm)
Actual Distance Between Sun and Earth	1.5×10^{8} km
Scaled Distance Between Sun and Earth	

$$\frac{diameter\ of\ Sun\ (km)}{distance\ to\ Sun\ (km)} = \frac{diameter\ of\ Sun's\ Image\ (cm)}{distance\ to\ Sun's\ Image\ (cm)}$$

Using your measurements and the ratio equation above, determine the diameter of the Sun in kilometers.

Adapted from https://www.fusd1.org/cms/lib/AZ01001113/Centricity/Domain/883/eslb24.pdf