Robogals
Science Challenge

SCIENCE CHALLENGE

Minor Challenge - Activity Sheet

STEM Field	Astronomy
Challenge Name	Measure the Size of the Sun with a Pinhole Camera
Challenge Level	Senior
Project Cost (approx)	0 - 20 USD

Materials Required	• Cardboard tube (the longer the better but at least 75cm or 30in)
	  ◦ Consider tubes from wrapping paper
	  ◦ Taping together multiple shorter tubes
	  ◦ Or you can make a tube from stiff paper
	• Cardboard tube scraps
	• Aluminum foil
	• A sharp pin/needle
	• Tape
	• Graph paper (with millimeter grid)
	  ◦ you can print the grid paper linked here on A4 or 8.5 x 11 paper for this
	• Paper and pens/pencils

Safety	Adult supervision is advised when using the pin/needle and to ensure no one looks directly into the Sun!
Duration (approx)	This challenge is split into three parts: • Part 1: Build your camera ~ 1-2 hours • Part 2: Measure the Sun's size ~ 1 hour • Part 3: Calculate the size of the Sun ~ 1-2 hours

Introduction

Looking straight at the Sun can hurt your eyes because the Sun gives off a lot of strong UV light. A pinhole camera helps us see a tiny bit of that light, just enough to make an image of the Sun (or anything else) without harming our eyes.

The pinhole works kind of like a simple lens. Light goes through the tiny hole and gets focused on the other side. When you point your pinhole camera at something—like a tree—each spot on the tree bounces light toward the hole. That light goes through the pinhole and lands on the screen inside the camera (in our case, the graph paper). Because light from every part of the tree comes through the hole at the same time, the screen shows a small, upside-down picture of the whole tree.

Introduction

We can use the picture from the pinhole camera to figure out how big the real object is—in this case, the Sun—by doing a little bit of math! The idea is that the size of the real object compared to how far away it is works the same way as the size of the tiny image compared to the distance inside your pinhole camera. Because these ratios match, you can use the small image to calculate the Sun's actual size.

This is shown in Figure 1. But if it still feels confusing, don't worry! The activity instructions will walk you through it step by step.

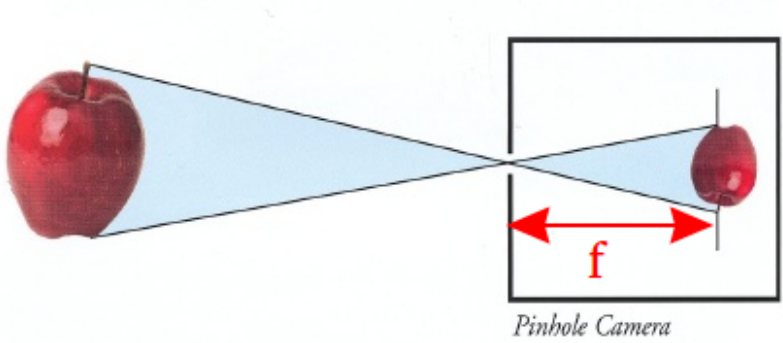

Figure 1: Light from an object traveling through a pinhole to create a picture

Instructions

Build your camera (Figure 2 shows what it looks like):

- About half an inch (1 cm) from one end of the tube, cut a small window. Make it big enough so you can see most of the tube's opening when you look through it from the inside.

- Cut a circle of graph paper so it fits snugly inside the tube. Tape it over the end of the tube that's closest to the window you just cut.

- Cut a piece of aluminum foil big enough to cover the other end of the tube. Stretch it across that end and tape it down so it's smooth and tight.

- Use a sharp pin to poke one tiny hole right in the center of the foil.

Now your pinhole camera is ready! Next, you'll use it to measure the Sun's size.

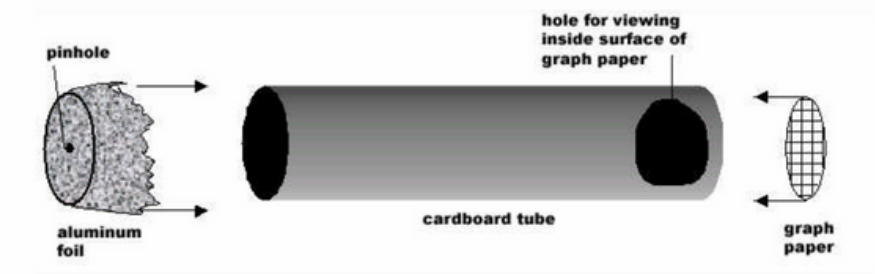

Figure 2: How the parts of the camera connect

Instructions

Measure the Sun's size:

- On a sunny day, take your pinhole camera outside and stand with your back facing the Sun.
- Hold the little window you cut in the tube up to your eye, then point the other end of the tube over your shoulder toward the Sun.
- Look for a small dot of light on the graph paper inside the camera—that's the Sun's image. If you don't see it, try moving the camera a little. A helpful trick is to look at the tube's shadow on the ground: make the shadow as small as you can. When the shadow is smallest, the camera is pointing right at the Sun.
- Once you see the Sun's image, count how many graph paper lines tall and wide the dot is. Be as careful as you can—this part is important!
- If the Sun's image is shaking or moving too much, try resting the camera on something solid to keep it steady.
- Write down your measurements neatly.
- To get the most accurate result, measure the Sun's image three times and then find the average. This helps fix small mistakes that might happen in just one measurement.

Instructions

Calculate the size of the Sun:

- Measure how long your pinhole camera is. Try to be as exact as you can—within about 0.1 cm (0.04 in).
- Change your camera length into meters by dividing the number of centimeters by 100.
- Change your Sun image measurement into meters too. Since you measured the image in millimeters on the graph paper, divide by 1000 to turn millimeters into meters.

A pinhole camera uses this idea:

$$\frac{\textit{Actual size of the Sun}}{\textit{The distance to the Sun}} = \frac{\textit{The size of the Sun's image}}{\textit{The length of the camera tube}}$$

The “size of the Sun’s image” is the average measurement you found. The “length of the camera” is the number you measured. The distance to the Sun is about 1.496×10^{11} meters.

To find the real size of the Sun, use this formula:

$$\textbf{Actual size of the Sun} = \frac{\textbf{Size of Sun's image}}{\textbf{Length of camera}} \times 1.496 \times 10^{11}$$

Congratulations—using your own pinhole camera and some math, you just measured the size of the Sun!

Instructions

Extension

- What happens to the size of the Sun's picture if you make the pinhole bigger?

- What happens to how clear or sharp the Sun's picture looks when you make the pinhole bigger?

Reflection Questions

- Is there anything you would change to make this activity better?
- Can you think of any real-life situations where people use ideas from this activity?
- What important science or engineering ideas did you use in this activity?
- How close do you think your measurement of the Sun's size was to the real size? If you look up the real size of the Sun, does your answer match it well?

Submission Guidelines

- Submit a photo of the pinhole camera you built.
- Include the calculations you used to figure out the Sun's size.
- Add a short summary where you answer the reflection questions.

The submission form is at the bottom of the following webpage: https://sciencechallenge.org.au/index.php/minor-challenges/

> **Note:** If you want to include yourself in the pictures of your Minor Challenge, make sure you ask your parent or guardian first to see if it's okay.

Learn More! Resources

To learn more about how a pinhole camera works check out the link below:
Pinhole camera facts for kids

Bibliography

- All the Sun through the eye of a pinhole (2021). Retrieved 28 November 2021
- Figure 1: Does 'focal length' mean something different with lenses and pinhole cameras? Retrieved 28 November 2021, from Does 'focal length' mean something different with lenses and pinhole cameras?
- Figure 2: (2021). Retrieved 28 November 2021, from All the Sun through the eye of a pinhole