# Robogals Science Challenge

**Minor Challenge Set #1**

**STEM Field:** Astronomy
**Level:** Senior
**Challenge Name:** Measure the Size of the Sun with a Pinhole Camera
**Project cost:** 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 8.5x11 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:**

- This challenge is split into three parts, they can be completed all together or over the period of a few weeks if that is more convenient.
- The first section “Build your camera” will take 1 -2 hours
- The second section “Measure the Sun’s size” will take about 1 hour
- The third section “Calculate the size of the Sun” will take 1 -2 hours

# Introduction:

As you may know, looking directly at the Sun is dangerous. This is because too much UV light from the Sun will damage your eyes. A pinhole camera allows us to look at just a little bit of light which allows us to see the image of interest (eg. the Sun) without damaging our eyes!

The pinhole acts like a lens and the light is focused (see Figure 1) as it passes through the small hole. When you point your pinhole camera at an image (like a tree) each point on the tree reflects light. Each point of light passes through the pinhole and  creates a point on the screen on the other side of the pinhole (in this case the graph paper will be our screen). As every point on the tree will reflect the light at the same time, the entire image will be recreated on the screen, so  we are able to see a smaller image of the object on the screen.

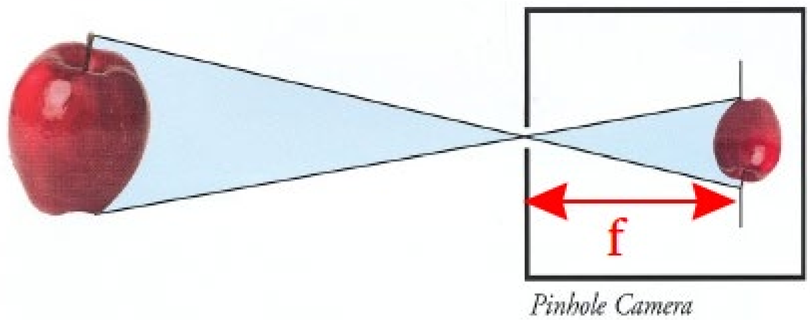


*Figure 1: Light from an image through a small hole*

We can use this image to find the true size of the original object (the Sun in this case) along with a little bit of math! The ratio of the size of the real object to the distance the light travels from the object to reach the observer is the same as the ratio of the size of the image of that object to the distance the light from the image takes to reach you. If you know this you can use your pinhole camera to calculate the size of the Sun. This is shown in Figure 1 above. However, if it doesn't make sense, don't worry about it! The instructions for this activity will help!

# Instructions:

**Build your camera (Figure 2 illustrates this):**

1. About half an inch (1 cm) from the end of the tube cut out a hole. The hole should be large enough so that you can see most of the opening at the end of the tube from the inside.

2. Cut a circle of graph paper that is just the right size to fit inside one opening of the tube and tape it over the side closest to the hole you cut in step 1.

3. Cut a piece of aluminum foil that is large enough to cover the other end of the tube. Place it over this end and tape it down so it is smooth and taut.

4. Use a sharp pin (or something similar) to poke a single hole in the centre of the tin foil.

5. Your pinhole camera is complete! Now it's time to measure the Sun's size (diameter).

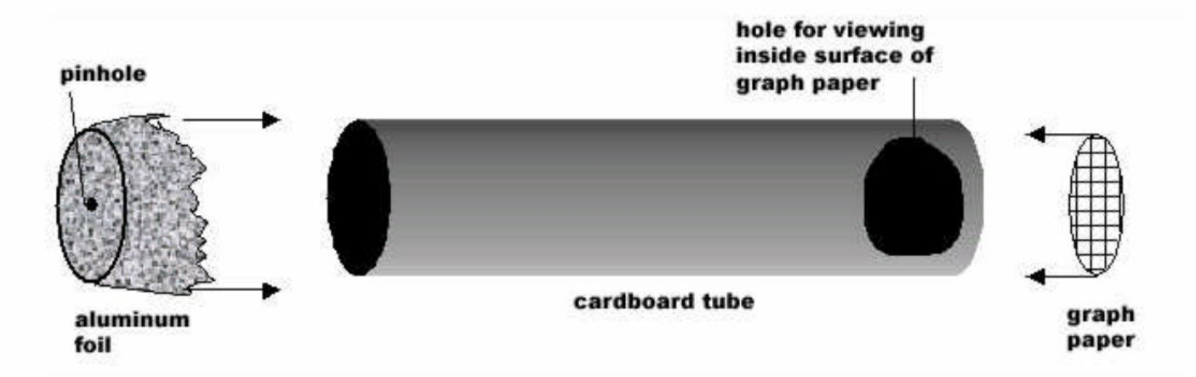


*Figure 2: How the camera comes together*

**Measure the Sun's size:**

6. On a sunny day, take your camera outside with you and stand facing away from the Sun.

7. Lift the hole you cut in the tube (the viewer hold) to your eye and point the tube over your shoulder in the direction of the Sun

8. Look for the Sun's image (a spot of light) on the graph paper, if you can't find this your camera isn't pointed quite right. Try to adjust where it is pointing until you see the Sun's image on the paper. One trick is to take a look at the shadow that your pinhole camera tube casts on the ground. Try to move the camera so that its shadow is as small as possible. When the camera is pointed directly at the Sun, its shadow will be at its smallest.

9. When you find the Sun's image, count the number of lines on the paper from the top of the image to the bottom and from side to side. This is key to the measurement so try to do this as carefully as possible.
    a. If the Sun's image is moving too much for you to measure the Sun's size try resting the camera on a solid object.

10. Record your measurements carefully.

11. To get the best measurement possible, take each measurement 3 times, then average your measurements. This will help to minimize any small mistakes made in a single measurement.

## Calculate the size of the Sun:

12. Measure the length of your camera. Try to be accurate within 0.1cm or 0.04in.

13. Convert the length of your camera into meters by dividing the centimeter measurement by 100.

14. Convert your measurements of the Sun to meters. You measured the Sun in millimeters using the graph paper so you must divide by 1000 to convert to meters.

15. For a pinhole camera, the relationship between the object size, the object distance, and the length of the camera is:

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

The "size of the Sun's image" is the average value you calculated in step 14. The "length of the camera tube" is the value you found in step 13. The "distance to the Sun" is about $1.496 \times 10^{11}$ meters.

This means the "actual size of the Sun" (in meters) can be found by rearranging the above equation to:

$$Actual\ size\ of\ the\ Sun = \frac{The\ size\ of\ the\ Sun's\ image}{The\ length\ of\ the\ camera\ tube} \times 1.496 \times 10^{11}$$

Congratulations! You've measured the size of the Sun!

**Extension:**

What happens to the measured size of the Sun if you make the pinhole larger?

What happens to the sharpness of the Sun's image as you make the pinhole larger?

# Reflection Questions:

- Are there any improvements you would make to this challenge?
- What real world application/s can you apply this challenge to?
- What are the key science and engineering concepts that relate to this challenge?

- How accurate do you think your measurement was? If you compare your calculated Sun size to the real Sun size (you may Google what this is) do you find good agreement?

# Submission Guidelines:

- Submit a photo of your camera construction and include your calculations for determining the size of the sun. Include a short summary that addresses the reflection questions.

> Note: Remember, if you want to upload pictures of your Minor Challenge that also include you, please check if it is OK with your mentor first.

- The submission form is on the Minor Challenges page: https://sciencechallenge.org.au/index.php/minor_-challenges/ Fill out the details and make sure you upload your submission.

# Learn More! Resources:

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

# Bibliography:


- (2021). Retrieved 28 November 2021, from All the Sun through the eye of a pinhole
- 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