Measuring the Diameter of the Sun

Introduction

The sun is approximately 150,000,000 km from Earth. To understand how far away this is, consider the fact that light travels approximately 300,000 km/s. At this speed, it takes the light from the sun a little more than eight minutes to reach Earth.

Even though the sun is extremely far away, it is still possible to make an approximate measurement of its size. The sun's diameter can be estimated by making two simple measurements and then solving a proportion problem.

$$\frac{\text{diameter of sun}}{\text{distance to sun}} = \frac{\text{diameter of sun's image}}{\text{distance between two cards}}$$

If you can determine three of the terms in the proportion problem, the fourth term, the diameter of the sun, can be solved mathematically.

In this investigation, you will construct a simple device and use it to collect data that will enable you to calculate the diameter of the sun.

Problem

What is the diameter of the sun and how can it be determined?

Pre-Lab Discussion

Read the entire investigation. Then work with a partner to answer the following questions.

1. Inferring What is the purpose of this investigation?

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2. Calculating To prepare for this calculation, solve for x in the following proportion problems.

a. $\frac{x}{5} = \frac{100{,}000}{20}$

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b. $\frac{x}{5} = \frac{200{,}000}{50}$

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3. Inferring Why is it important to never look directly at the sun?

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4. Applying Concepts How are the cards used in this investigation? How are the cards and the proportional relationships useful for determining the diameter of the sun?

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5. Predicting Do you think your calculation of the sun's diameter will be completely accurate? Explain your answer.

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Materials *(per group)*

2 index cards (10 cm × 15 cm)
metric ruler
drawing compass
tape
meter stick
scissors

Safety

Be careful when handling sharp instruments. **CAUTION:** *Never look directly at the sun.* Note all safety symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the symbol guide on page xiii.

Procedure

Part A: Measuring Distances and Calculating Ratios

1. Measure the base of each of the two triangles in Figure 1. Record your measurements in Data Table 1.
2. Measure the altitude (distance from tip to base) of each of the two triangles in Figure 1. Record your measurements in Data Table 1.
3. Determine the ratio between the base of the large triangle and the base of the small triangle. Record this ratio in Data Table 1.

4. Determine the ratio between the altitude of Triangle 1 and the altitude of Triangle 2. Record this ratio in Data Table 1.
5. Think about how these two ratios compare. In Part B of this lab, you will use a similar procedure to determine the diameter of the sun.
   - The base of Triangle 2 will represent the diameter of the image of the sun on a card.
   - The altitude of Triangle 2 will represent the distance between the two cards in the device you will construct.
   - The altitude of Triangle 1 will represent the distance from Earth to the sun.
   - The base of Triangle 1 will represent the diameter of the sun, which you will determine.

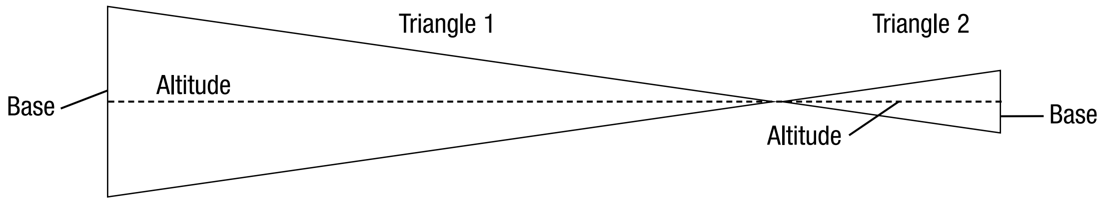

Figure 1

Part B: Determining the Diameter of the Sun

6. Using the scissors, cut I-shaped slits in each card in the positions shown in Figure 2. The meter stick should be able to slide through the slits, but the slits should be small enough so that the meter stick fits snugly. **CAUTION:** *Be careful when handling sharp instruments.*

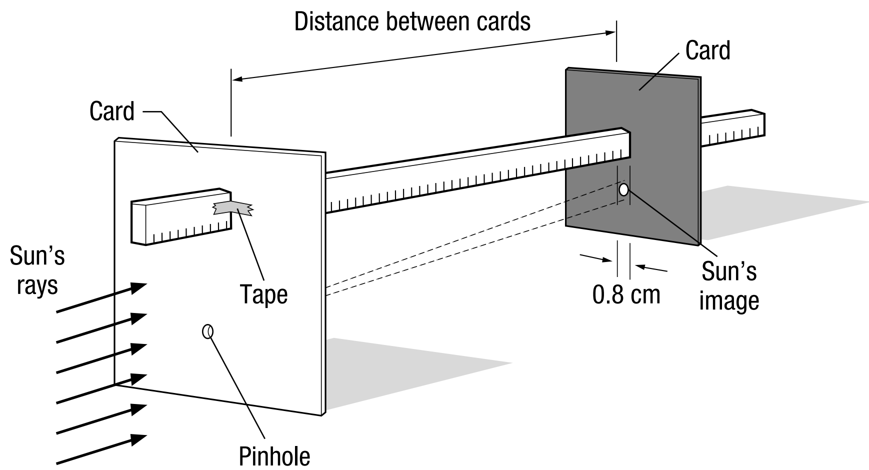

Figure 2

7. With the tip of the compass, punch a round pinhole in one of the cards in the position shown in Figure 2. Tape this card to the meter stick at the 5-cm mark so that it is perpendicular to the meter stick. **CAUTION:** *Be careful when handling sharp instruments.*

8. On the other card, draw two parallel lines exactly 0.8 cm (8 mm) apart directly below the slit, as shown in Figure 2. Slide this card onto the meter stick. Do not tape this card to the meter stick.
9. While outdoors on a sunny day, position the meter stick so that the taped card is directly facing the sun. Position the meter stick until it casts a shadow over the movable card. **CAUTION:** *Never look directly at the sun.*
10. You should be able to see a circle of light on the movable card caused by the sun's rays passing through the pinhole on the first card. If you do not see the circle of light, continue to adjust the position of the meter stick until you see the circle.
11. The circle of light on the second card is an image of the sun. Slide the movable card until the image of the sun fits exactly between the two parallel lines you drew earlier.
12. Make sure that both cards are perpendicular to the meter stick. You will know they are perpendicular when the circle of light, the sun's image, is brightest and sharpest and as close to a circle as possible. Tape the second card in place. Measure the distance between the two cards. Record your measurement in Data Table 2.

Observations

DATA TABLE 1

	Base	Altitude
Triangle 1 (large triangle)		
Triangle 2 (small triangle)		
Ratio (large:small)		

DATA TABLE 2

Distance between two cards	
Diameter of sun's image	

Analysis and Conclusions

1. **Calculating** Using the equation below, calculate the diameter of the sun. Use 150,000,000 km (or 1.5×10^8 km) as the distance to the sun. Show your work.

$$\frac{\text{diameter of sun (km)}}{\text{distance to sun (km)}} = \frac{\text{diameter of sun's image (cm)}}{\text{distance between two cards (cm)}}$$

Name ____________________ Class ________________ Date ____________

2. Calculating The actual diameter of the sun is 1,391,000 km. Using the equation below, determine the percentage error in your calculated value for the sun's diameter. Show your work.

$$\text{percentage error} = \frac{\text{difference between your value and the correct value}}{\text{correct value}} \times 100$$

3. Analyzing Data What could account for the difference in your calculation of the sun's diameter and the actual diameter of the sun?

4. Applying Concepts How might the technique used in this investigation be useful in making other astronomical measurements?

5. Relating Cause and Effect How might clouds in the sky affect the accuracy of your measurement in this investigation?

Name ____________________ Class ______________ Date __________

Go Further

A sunspot moves along the sun's equator. If the sunspot takes 12.5 days to move from one side of the sun to the other, use the steps below to calculate how fast the sunspot is moving.

1. Using the actual value for the diameter of the sun and the formula below, calculate the circumference of the sun. The value of π (pi) is approximately 3.14.

$$\text{circumference} = \pi \times \text{diameter}$$

2. The sunspot moved only halfway around the sun, so to calculate the distance it traveled in 12.5 days, divide the value for the circumference by 2.

3. To calculate the distance traveled by the sunspot in one day, divide the distance you calculated in Step 2 by 12.5.

4. Explain why this value is also the speed at which the sun's surface is moving at the equator.

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