

Name: _____

30.1

Cycles on Earth



Question: How do we keep track of time?

1

Building a sundial

Follow the procedures in your Investigation guide to build your sundial. Record the angle of your latitude (from your teacher) below:

a. Do you see a shadow on the sundial? Where is it located?

b. What will happen to the shadow as the day progresses? Explain your answer.

c. Can you tell the time by looking at the location of the shadow on the sundial? What do you need to do in order to be able to tell the time?

2**Calibrating the sundial**

Follow the procedures in your Investigation guide for this step. Record your data in the table below.

Afternoon hour	Angle from noon line	Corresponding morning hour
1:00 pm		11:00 am
2:00 pm		10:00 am
3:00 pm		9:00 am
4:00 pm		8:00 am
5:00 pm		7:00 am
6:00 pm		6:00 am









- a. Can you use your sundial to tell the time? How accurate is your sundial?
- _____
- _____
- b. How could you improve the accuracy of your sundial so you could tell the time within fifteen minutes?
- _____
- _____
- c. What variables affect the accuracy of your sundial? List as many variables as you can think of.
- _____
- _____
- _____
- d. What effect do you think that the time of year will have on the accuracy of your sundial? Explain your answer.
- _____
- _____
- _____
- e. How do you think Daylight Savings Time will affect the accuracy of your sundial? How could you adjust the sundial for this?
- _____
- _____
- _____

3

Modeling the lunar cycle

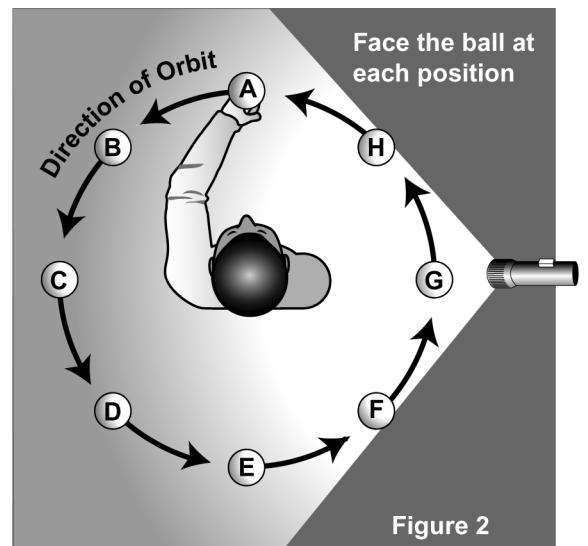
Follow the procedures in your Investigation guide. Record your results in the table below.

 **Your teacher will turn out the classroom lights once you have gathered your materials and are ready to begin.**

Position	Appearance	Position	Appearance
A		E	
B		F	
C		G	
D		H	

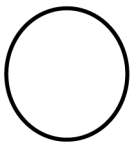
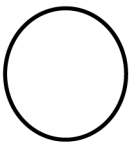
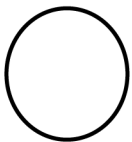
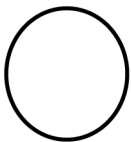
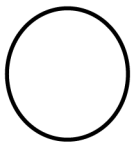
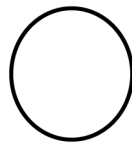
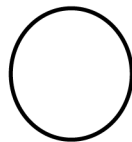
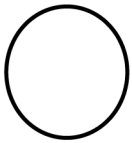
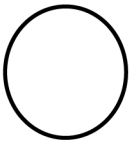
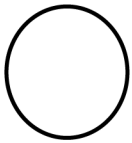
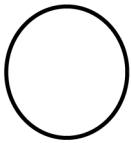
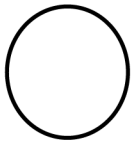
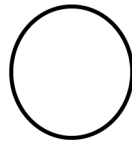
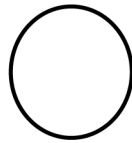
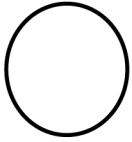
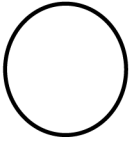
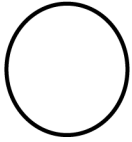
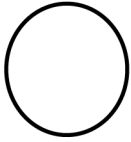
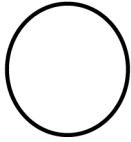
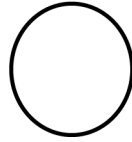
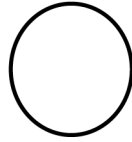
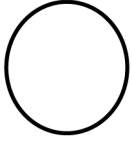
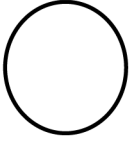
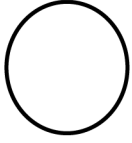
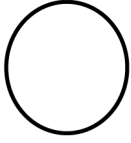
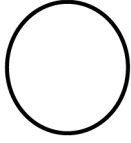
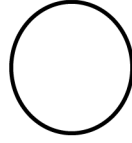
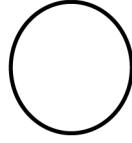
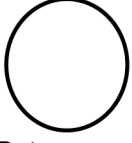
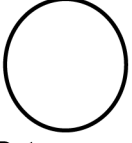
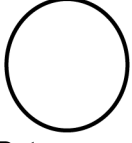
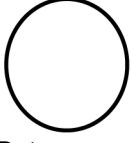
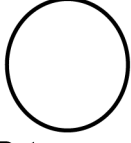
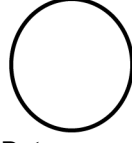
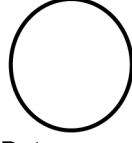
- a. Compare your observations to the diagram of the moon phases in the reading, *Cycles on Earth*. Based on your observations, what do the terms **waning** and **waxing** mean?

- b. During what position on Figure 2 would a solar eclipse occur? During what position on Figure 2 would a lunar eclipse occur?



Long-term project: Constructing a lunar calendar

Now, you will track time by following the phases of the moon. In the chart below, draw the moon as it appears in the sky each night for 28 nights. Record the date of your observation, the time, and illustrate the shape of the moon for each night. Identify the phase of the moon for each night. Refer to *Cycles on Earth* in your student text for a graphic that shows each phase. Use the following two-letter symbols to represent each phase: new moon (NM), waxing crescent (XC), first quarter (FQ), waxing gibbous (XG), full moon (FM), waning gibbous (NG), third quarter (TQ), waning crescent (NC).

SUN	MON	TUE	WED	THUR	FRI	SAT
 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____
 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____
 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____
 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____
 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____	 Date ____ Time ____ Phase ____

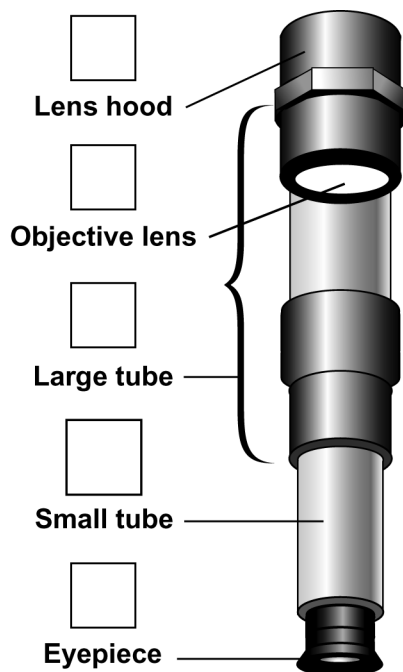


Question: How does a telescope work?

1

Learning the parts of a refracting telescope

For this Investigation you will use a small **refracting** telescope. This type of telescope uses a lens to gather light into a focal point, and another lens to magnify the image. Use the diagram below to identify the parts of your telescope. You may take your telescope apart and reassemble it to learn the parts. The function of each part is listed next to the diagram. Place the letter of each function next to the correct part.



- A. Moves in or out to focus image
- B. Magnifies image
- C. Reduces glare
- D. Holds the light-gathering lens
- E. Gathers light

2

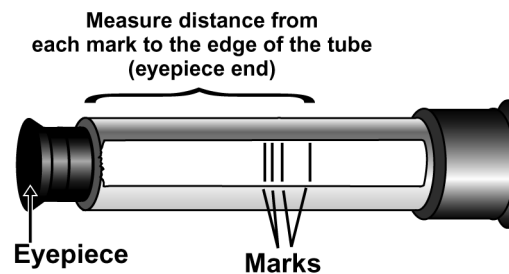
Focusing a telescope

⚠ Safety Tip: Never look at the sun or a bright object through your telescope! You will cause damage to your eye.

Follow the procedures in your Investigation guide.

Be sure to measure the distance from each mark you make to the edge of the short tube as shown in the diagram to the right.

Record your data and observations in the table below.



Distance from card (m)	Observations	Length of small tube (mm)
10		
9		
8		
7		
6		
5		
4		
3		
2		
1		

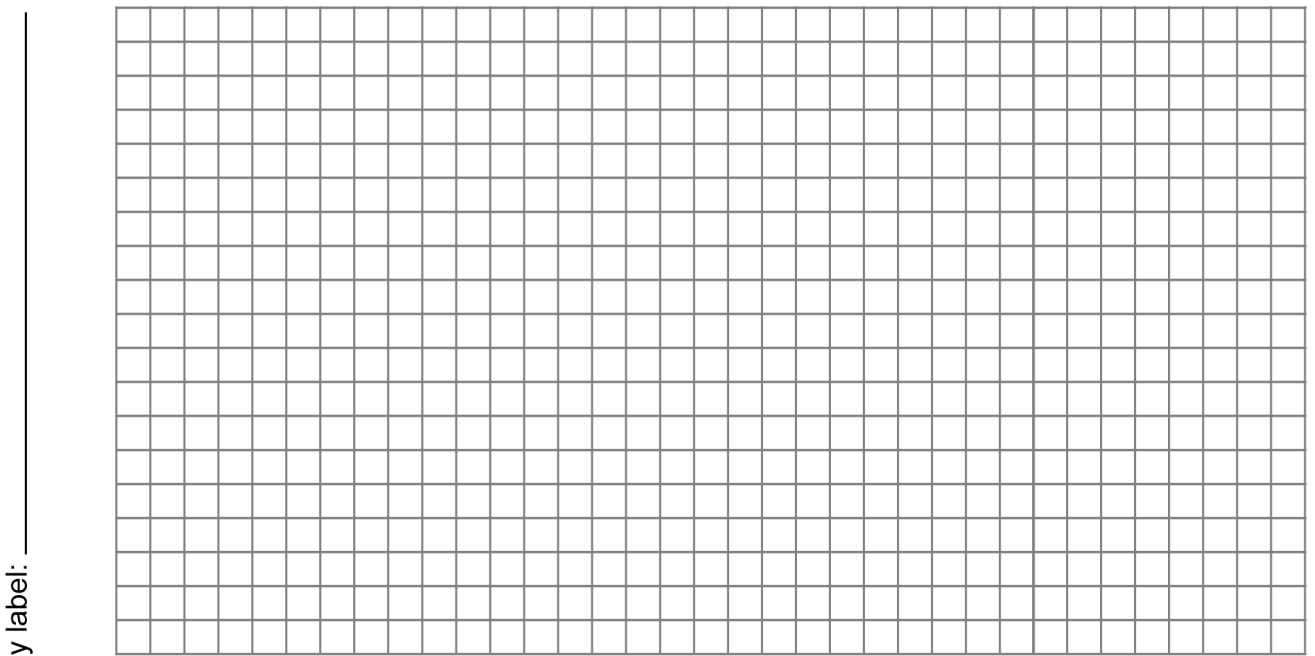
a. In general, as you move closer to an object, how should you adjust the small tube?

b. When you view the letter “e” through your telescope, why does the image appear upside down? (HINT: Trace the light rays coming from the penny in the picture at the top of page one.)

c. Make a graph of distance versus length of the small tube. Would you describe the relationship as direct or inverse? Explain your answer.



Title: _____



x label: _____

$\frac{a}{b}$ Determining the magnification of a telescope

Popular focal lengths for eyepieces are 10 millimeters and 25 millimeters. Suppose your telescope has an objective lens with a focal length of 200 mm and an eyepiece with a focal length of 25 mm. What is the magnification of your telescope?

$$\text{magnification} = \frac{200 \text{ mm}}{25 \text{ mm}} = 8x$$

- a. If you wanted to increase the magnification of the telescope in the problem above, which eyepiece would you choose—10 mm or 40 mm? Explain your answer and show your solution to the problem.

- b. Calculate the magnification of the following telescopes:

Objective lens	Eyepiece	Magnification
1200 mm	10 mm	
1200 mm	25 mm	
800 mm	20 mm	

- c. A telescope with an 800 mm objective lens can gather more light than a telescope with a 200 mm objective lens. Does this mean that the 800 mm telescope has greater magnification than the 200 mm telescope? Explain your answer.

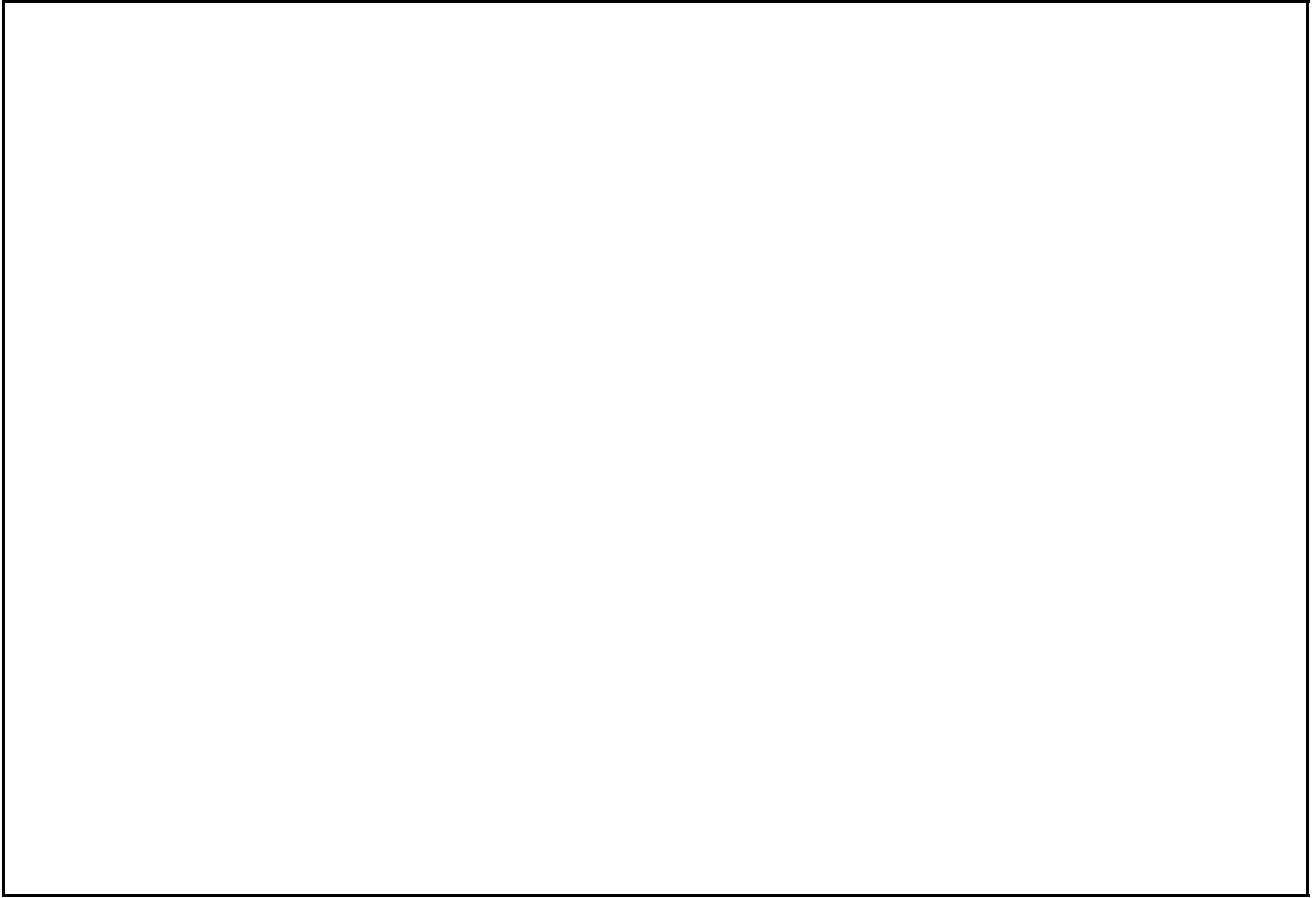
- d. The focal lengths of two telescopes are shown below. Which telescope would have the greater magnification? Through which telescope would you expect to see a brighter image? Explain your answers.

Telescope A: 800 mm objective lens; 20 mm eyepiece

Telescope B: 200 mm objective lens; 5 mm eyepiece

4**Observing the moon**

Follow the instructions for observing the moon in your Investigation guide. Make sketches of your observations in the space below, then answer the questions.



- a.** How many craters can you see? Do they overlap? What do you believe this tells you about their age? Make sure you can locate Tycho, an 85-kilometer-wide crater on the lower part of the moon that is the hub of a system of bright streaks.

- b.** How many maria (Latin for seas, remember?) can you see?

5**CHALLENGE! Observing Jupiter and its moons**

When it is visible, Jupiter is the third brightest object in the night sky—after the moon and Venus. Though you will not be able to see any of Jupiter’s features through your telescope, you may be able to see four of its moons.

- a.** Find out when Jupiter is visible in the night sky and the best time for viewing. Good resources include your local newspaper (the weather page) and the Internet.

- b.** Use a telescope to view Jupiter. How many moons do you see?

- c.** Why is Jupiter visible from Earth only during certain periods of time?

31.1

Earth and the Moon



Question: What does the length of a year have to do with Earth's distance from the sun?

1 Setting up



Safety Tip: Make sure that others stay out of the path of the ball's orbit.

- a. What forces keep the ball in orbit? How are these forces similar to those that keep a planet in orbit?

- b. What would happen to the ball if you cut the string while it was in orbit?

- c. What information would you need to determine the orbital speed of the ball?

2 Doing the experiment

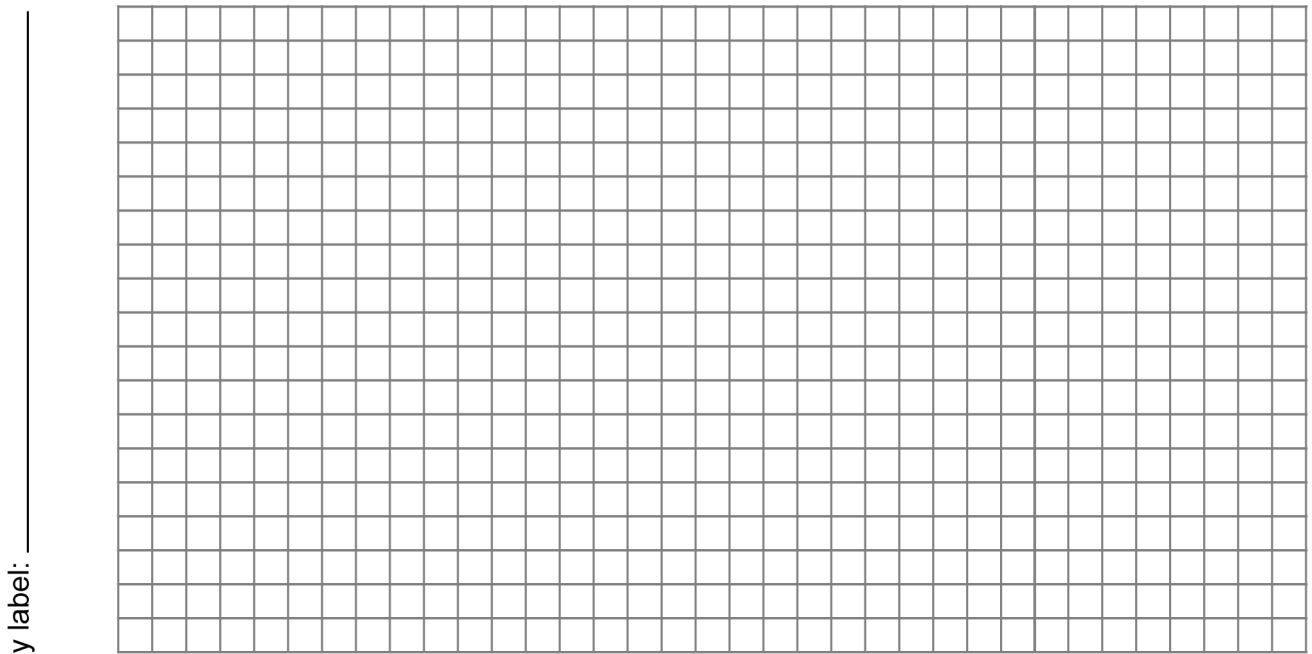
Distance (m)	Revolutions	Orbital speed (m/sec)
0.10		
0.20		
0.30		
0.40		
0.50		

Distance (m)	Revolutions	Orbital speed (m/sec)
0.60		
0.70		
0.80		
0.90		
1.00		

3**Analyzing the results**

- a. Make a graph of distance versus orbital speed.

Title: _____



What does the curve of the graph reveal about the relationship between these two variables?

- b. According to the equation of universal gravitation, the gravitational force between two objects decreases inversely with the distance between them. How would you state the mathematical relationship between orbital speed and distance?

- c. Explain why the relationship between orbital speed and distance is the same as that between gravity and distance.

4 Applying your knowledge

- a. How do the results from this experiment compare with the orbital speeds of the planets?

- b. The **orbital period** of a planet is the amount of time (in Earth years) it takes to make a complete revolution around the sun. Based on the results of your experiment, which planet has the shortest orbital period? Which has the longest orbital period?

31.2

The Solar System



Question: How big is the solar system?

1

$\frac{a}{b}$ Using proportions to determine scale distances

Pluto is an average distance of 5.9 billion kilometers from the sun. We can use a *proportion* to determine a scale distance for our model. Assume the largest distance you can measure is 100 meters. The length of a soccer field is usually between 90 and 120 meters long. For this Investigation, we will use 100 meters as the scale distance between the sun and Pluto.

$$100 \text{ m} = 5,900,000,000 \text{ km}$$

If the distance from the sun to Pluto equals 100 meters, where would you find the other planets? You can answer this question by setting up the following proportion where x is the distance from the sun to any planet, in meters:

$$\frac{x}{\text{Distance from the sun to planet}} = \frac{100 \text{ m}}{5,900,000,000 \text{ km}}$$

Mercury is 58,000,000 kilometers from the sun. Using our proportion, we can find the scale distance:

$$\frac{x}{58,000,000 \text{ km}} = \frac{100 \text{ m}}{5,900,000,000 \text{ km}}$$

Cross-multiply and rearrange the variables to solve for x :

$$x = \frac{100 \text{ m}}{5,900,000,000 \text{ km}} \times 58,000,000 \text{ km} = 0.98 \text{ m}$$

Mercury is 0.98 meters from the sun using this scale.

2

Determining scale distances for the other planets

Based on the example in Part 1, you would place Mercury 0.98 meters or 98 centimeters from the sun in your 100-meter scale model. Use this example to help you calculate the placement of the other planets. Write the distance in meters for each planet in Table 1.

Table 1: Distance from the sun

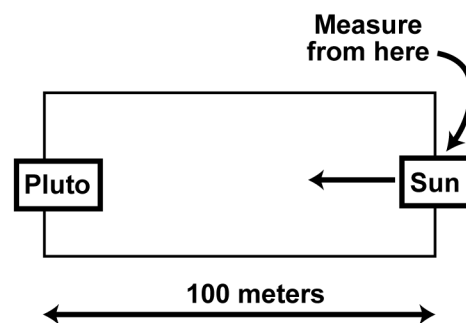
Planet	Actual distance to sun (km)	Proportional distance from the sun (m)
Mercury	58,000,000	0.98
Venus	108,000,000	
Earth	150,000,000	
Mars	228,000,000	
Jupiter	778,000,000	
Saturn	1,430,000,000	
Uranus	2,870,000,000	

Table 1: Distance from the sun

Planet	Actual distance to sun (km)	Proportional distance from the sun (m)
Neptune	4,500,000,000	
Pluto	5,900,000,000	

3 Setting up the scale model

- To begin, make signs for each of the planets and one for the sun. In your scale model, a student in your class will hold the sign at each position of the planet.
- In an area that is at least 100-meters long, identify the location of the sun. A student will stand in this position with a sign that says “Sun.”
- Measure 100 meters from the position of the sun. At the 100-meter mark, a student will stand with a sign that says “Pluto.” In this model, 100 meters is the scale distance from the sun to Pluto.
- Now, use the scale distances from Table 1 to find the locations of each planet. At the location of each planet, a student will stand with the appropriate sign. Then, answer the questions.



- After constructing a model of it, what is your impression of our solar system?
- Describe some disadvantages and advantages to this model of the solar system.
- Alpha Centauri is the closest star to Earth at 274,332 AU. One astronomical unit is equal to 150 million kilometers. Where would you place this star in the 100-meter scale model?
- The diameter of the Milky Way galaxy is known to be about 100,000 light years. One light year is 63,000 AU. How does the Milky Way compare with the size of the model solar system?

4 Determining scale sizes of the planets

What would the planets look like in this scale model of the solar system? For example, Mercury has a diameter of 4,880 kilometers. How big would Mercury be in your 100-meter scale model? You can use the same method to determine the scale diameter of Mercury that you used in Part 2:

$$\frac{x}{4,880 \text{ km}} = \frac{100 \text{ m}}{5,900,000,000 \text{ km}}$$

Cross-multiply and rearrange the variables to solve for x :

$$x = \frac{100 \text{ m}}{5,900,000,000 \text{ km}} \times 4,880 \text{ km} = 0.000078 \text{ m}$$

Based on the example above, the diameter of Mercury in a 100-meter scale solar system would be 0.000078 meters or 0.078 millimeters. For comparison purposes, a single human hair is about 0.1 millimeters in diameter or one-tenth of a millimeter.

Use the above proportion to calculate the diameters of the other planets as well as the sun and Earth's moon. Write these values in units of meters in the third column of Table 2. Then answer the questions that follow the table.

Table 2: Diameters of the planets, our moon, and sun

Planet	Actual diameter (km)	Scale diameter (m)	Scale diameter (mm)
Sun	1,391,980		
Mercury	4,880	0.000078	
Venus	12,100		
Earth	12,800		
Moon	3,475		
Mars	6,800		
Jupiter	142,000		
Saturn	120,000		
Uranus	51,800		
Neptune	49,500		
Pluto	2,300		

- How big is the sun in this model in units of centimeters?
- How much larger is the sun's diameter compared with Earth's? How much larger is Earth's diameter compared with the moon's?
- The smallest object that the human eye can see without magnification is 0.100 millimeters. Given this information, which planets would be visible to the human eye? Would you be able to see the sun or the moon on this 100-meter scale model of the solar system?
- What is your impression of how the size of the planets and the sun compare with the size of the solar system?

Extension: Making a larger scale model of the solar system

In this part of the Investigation, you will use common objects to compare the diameters of planets, the sun, and Earth's moon in our solar system. For example, we could use an Earth globe to represent the scale size of Earth. The diameter of the globe we will use is 30 centimeters.

1. If an Earth globe is used to represent the size of Earth, what would the sizes of the sun and the other planets be? How big would the moon be? Use what you have learned in this Investigation to calculate the scale diameters of the other planets, the moon, and the sun. Fill in the third column of Table 3 with these values.
2. What objects could be used to represent each of the planets, the moon, and the sun? Fill in the fourth column of Table 3 with your answers to this question.
3. Answer the questions that follow the table.

Table 3: A scale model of the solar system

Planet	Actual diameter of planet (km)	Scale diameter of sun or planet (cm)	Representative object and its diameter or length (cm)
Sun	1,391,980		
Mercury	4,880		
Venus	12,100		
Earth	12,800	30 cm	Earth globe, 30 cm
Moon	3,475		
Mars	6,800		
Jupiter	142,000		
Saturn	120,000		
Uranus	51,800		
Neptune	49,500		
Pluto	2,300		

- d. How many times bigger is 24 centimeters than 0.20 millimeters? These are the diameters of Earth for the two scale models you created.
- e. Using your answer to question 5a, what would be the distance between the sun and Pluto on this larger scale? Come up with a way to explain or model this distance.
- f. Why is it challenging to make a scale model of the solar system that includes the distances between planets and the sun and the sizes of the planets?



Question: How can we use energy from the sun to generate electricity?

In this Investigation, you will:

1. Measure the power output of a photovoltaic cell.
2. Determine the efficiency of a photovoltaic cell.

You have learned that the sun produces 3.9×10^{26} watts of energy every second. Of that amount, 1,386 watts fall on a square meter of Earth's atmosphere and even less reaches Earth's surface. This energy can be used to generate electricity without producing pollution or dangerous wastes. Photovoltaic (PV) cells convert sunlight *directly* into electricity and are used to run small appliances such as calculators and outdoor light fixtures. Many PV cells can be wired together to form *panels* that can be used to run larger devices such as irrigation pumps, radar stations, and even refrigerators. How much power does a PV cell produce? How efficient is a PV cell at converting the sun's energy into power?

1**Setting up**

Follow the instructions in your Investigation manual to set up the experiment.

Measure the length and width, in centimeters, of your PV cell and calculate the area. Record your measurements and calculation here:

length: _____ × width: _____ = area: _____ cm²

- a. How does changing the angle of the PV cell affect the speed of the fan?

- b. At which angle is the fan's speed the fastest?

- c. Why do you think the angle of the PV cell affects the speed of the fan?

2**Measuring electrical quantities in the circuit**

Follow the instructions in your Investigation manual to perform the measurements. Record your results below.

Record the **voltage**:

Record the **current**:

3**How efficient is your photovoltaic cell?**

In this part of the Investigation, you will determine how much of the energy that is reaching your PV cell is being converted into **power**. To do this, you will use your data from Parts 1 and 2.

- a. $\frac{a}{b}$ Use the formula below to calculate the **power output** of your PV cell in watts/cm².

$$\frac{\text{voltage} \times \text{current}}{\text{area}} = \text{watts/cm}^2$$

Record your result.

- b. Multiply your result by 10,000 to convert the value to watts/m². Record your result.

- c. Calculate the efficiency of your photovoltaic cell using the formula below (*NOTE: Use the formula below, not the formula in your Investigation guide*).

$$\% \text{ efficiency} = \left(\frac{\text{power output of your PV cell}}{\text{power input from the sun}} \right) \times 100$$

Record your result.

- d. Most PV cells have efficiencies between 5 and 20 percent. How does yours compare?

4**Applying your knowledge**

- a. Besides angle, what other factors do you think will affect the energy output of your PV cell?
- b. PV cells are found on satellites, space probes, and the space shuttle. Do you think the power output of your PV cell would be greater or less just beyond Earth's atmosphere? Explain your answer.
- c. With your group, design and conduct an experiment that addresses one of the questions below. Prepare a lab report that explains your hypothesis, procedure, data analysis, and conclusions. Use additional paper or your lab notebook to record your experimental design and results.
- How does the *distance from a light source* affect the power output of a PV cell?
 - How does the *color of light* affect the power output of a PV cell?
 - How does *temperature* affect the power output and efficiency of a PV cell?



Question: What are stars made of?

1 Using the spectrometer

 **Safety Tip: Never look directly into any light source—especially the sun!**

- a. While looking through the eyepiece, point the slit of the spectrometer directly at an incandescent bulb. Use colored pencils to show where the different colors of light appear in on the spectrometer scale.



- b. Blue light has the highest energy and red light the lowest. Based on your observations with the spectrometer, what is the relationship between wavelength and amount of energy?

2 Using a spectrometer to identify elements in a fluorescent light

3. Use colored pencils to sketch the lines you observe. Be very precise in your sketch by placing the lines you see in the *exact* positions on the scale below.



4. Identify the wavelength of each spectral line, from left to right, then fill in Table 1.

Table 1: Spectral lines produced by a fluorescent light






Line number	Spectral line color	Spectral line wavelength (nm)
1		
1		
1		
1		

a. The light produced by the fluorescent tube you observed contains only one element. Compare the spectral lines you observed with the ones shown in the diagram above. Which element does it contain?

b. Fluorescent tubes have special instructions for disposal and must not end up in a landfill. Based on your spectral analysis of the gas inside the tube, why is this so?

c. Stars are made up of more than one type of element. When astronomers use a spectrometer to analyze the light produced by stars, they observe the combined spectral lines of all of the elements present in the star. What specific information would an astronomer need to know in order to determine which elements are present in a star?

Table 2: Spectral lines produced by different light sources

Light source	Spectrometer scale (nm)	Position of each vertical line (nm)	Elements present
			
			
			
			
			

a. If one light source displays more spectral lines than another, does that mean that it contains more elements? Explain your answer.

b. Which light source contains the greatest variety of elements?

c. Which light sources contain only one element?

4**Analyzing the light from a star**

Safety Tip: Do not point the spectrometer directly at the sun. Point it only at reflected sunlight. NEVER look directly at the sun!

Table 3: Analyzing light from the sun

Spectral line color	Spectral line wavelength (nm)	Element present

a. Explain why the sun’s light produces more spectral lines than the light sources you observed in Parts 2 and 3.

b. Where do elements in the sun’s atmosphere come from? Explain your answer in detail.

c. The sun is a main sequence star. If you could analyze the light from a much older star, what would you expect to see? Justify your answer using your knowledge of the star life cycle.

32.2

Galaxies and the Universe



Question: How do we measure the distance to stars and galaxies?

1 Setting up the experiment

- a. Does this experiment measure the *absolute brightness* or the *apparent brightness* of the light source? Explain your answer.

- b. Is the power rating of the light source (100 watts) a measure of the light bulb's *absolute brightness* or *apparent brightness*? Explain your answer.

- c. What effect do you think increasing the distance will have on your measurements of brightness?

2 Doing the experiment

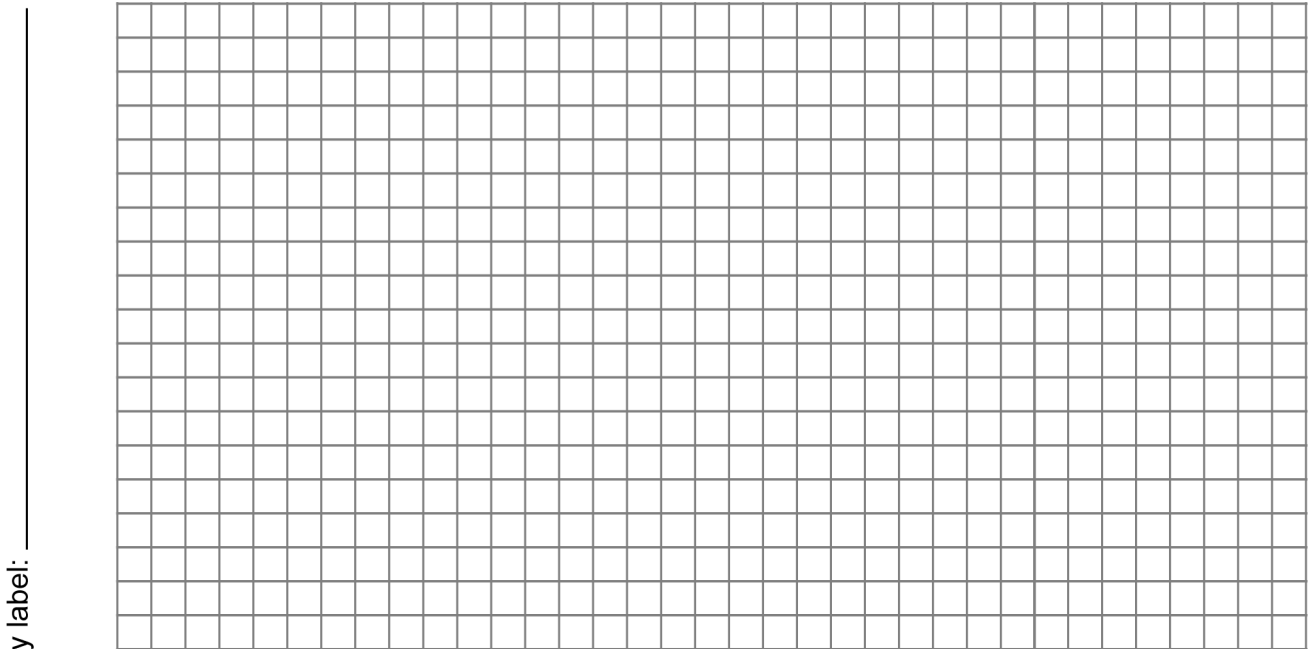
Table 1: Brightness and distance data

Distance (cm)	10	20	30	40	50	60	70	80	90	100
Brightness (mA)										

Analyzing your data

Make a graph of brightness versus distance. Plot brightness on the y -axis and distance on the x -axis.

Title: _____



x label: _____

a. Is your graph increasing or decreasing from left to right?

b. Describe the shape of the curve on your graph. Have you seen a curve like this before?

c. Is there a mathematical relationship between brightness and distance from your graph? Explain your answer.

4

$\frac{a}{b}$ Inverse relationships

- a. What does the third equation state?
- _____
- _____
- _____
- b. Assuming that the correct equation is one of the three above, how could you figure out which is the correct one?
- _____
- _____
- _____
- c. Which equation do you think is the correct one? Explain your reasoning.
- _____
- _____
- _____

5

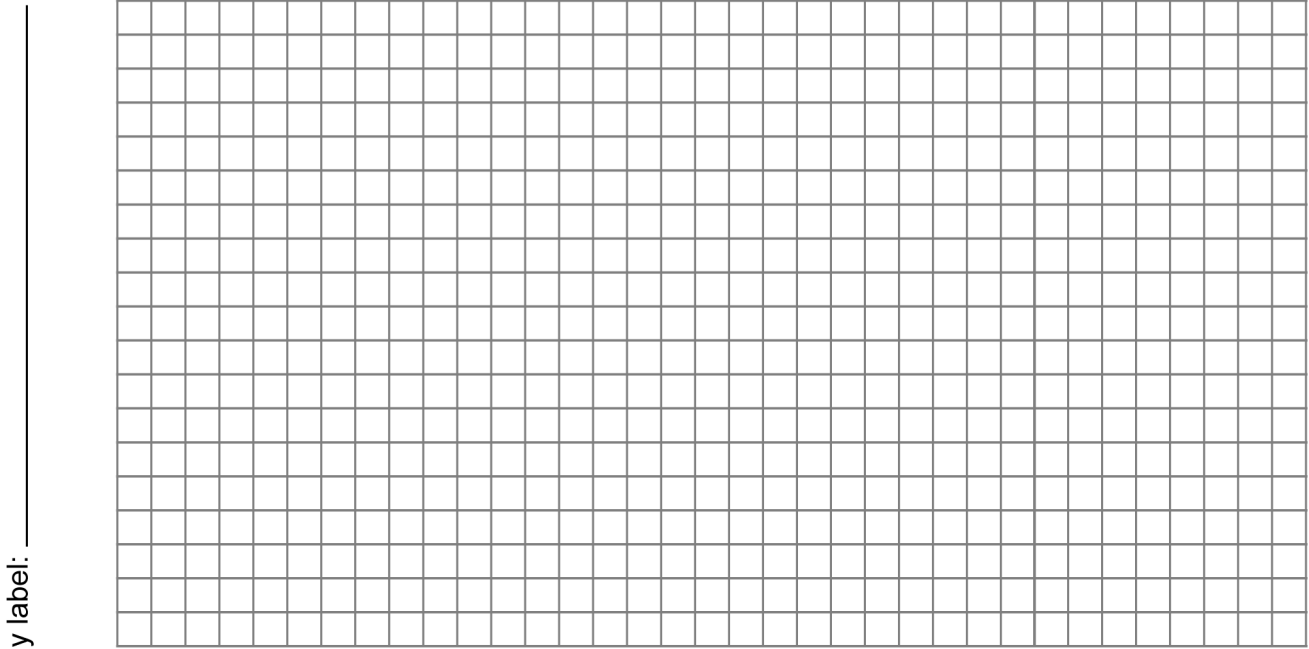
Identifying the correct inverse relationship

Table 2: Analyzing your distance and brightness data

Distance (cm)	10	20	30	40	50	60	70	80	90	100
Distance (m)	0.10	0.20								
1/D	10	5								
1/D ²	100	25								
1/D ³										
Brightness (mA)										

Graph 1:

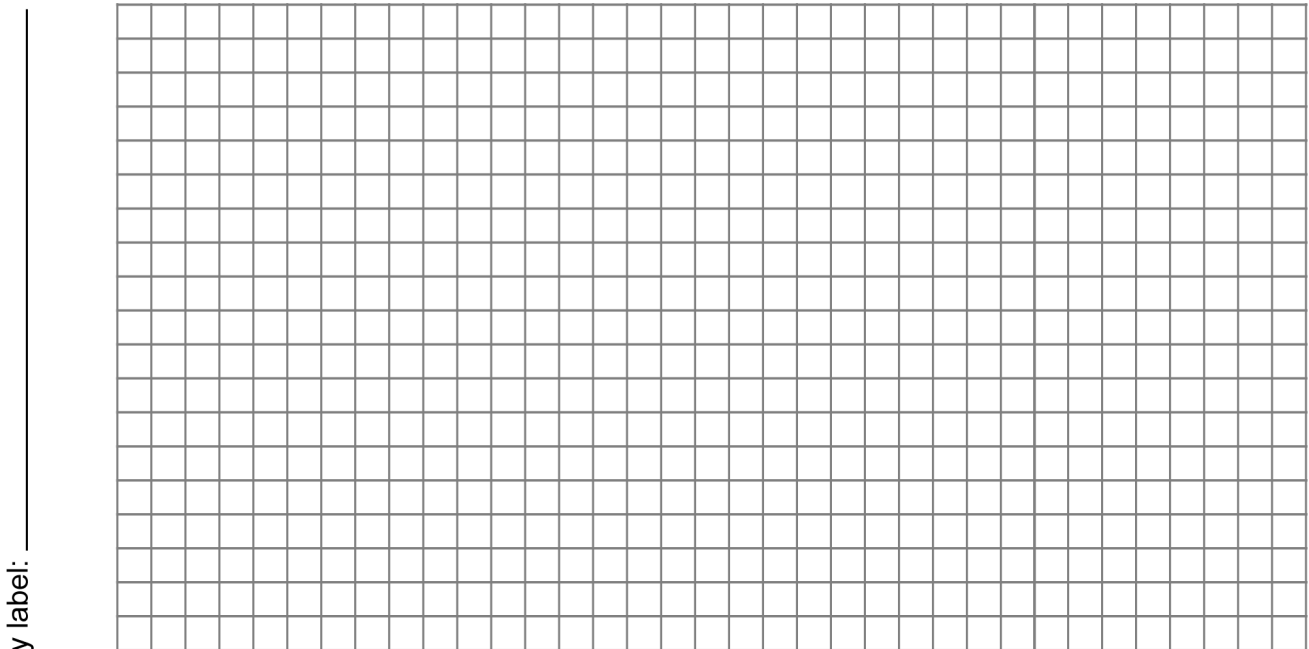
Title: _____



x label: _____

Graph 2:

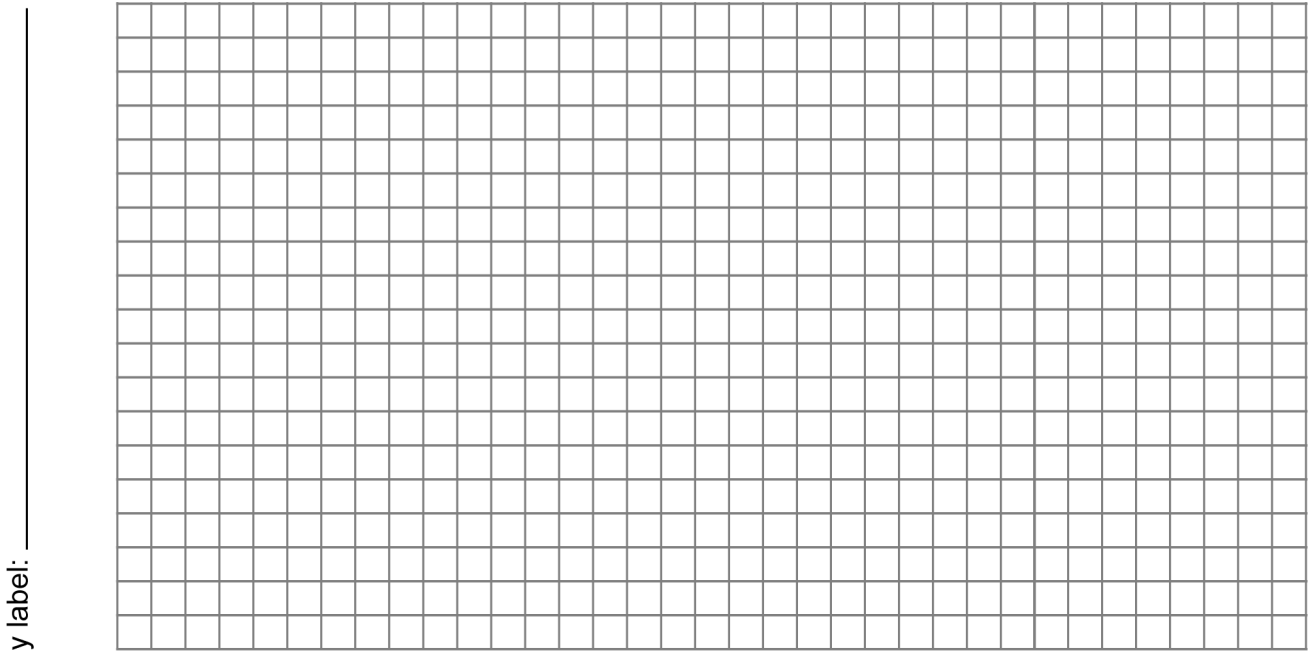
Title: _____



x label: _____

Graph 3:

Title: _____



x label: _____

6 Reaching a conclusion

a. Which graph identifies the correct inverse relationship between brightness and distance? Explain your choice.

b. Write down the correct formula for the relationship between brightness and distance.

c. Test your formula and write down your results here:

- d. Your actual brightness should be fairly close to your predicted brightness. What are some possible reasons for differences between predictions and measurements in this experiment?

7

Applying your knowledge: How bright would the sun appear on Pluto?

Use what you have learned in this Investigation to complete Table 3 below.

Table 3: Apparent brightness of the sun from the planets

Planet	Average distance from the sun (AU)	Apparent brightness (SBU)
Mercury	0.37	
Venus	0.72	
Earth	1.0	1.0
Mars	1.5	
Jupiter	5.2	
Saturn	9.5	
Uranus	19.2	
Neptune	30.0	
Pluto	39.5	

a. How much brighter is the sun viewed from Mercury compared with its brightness viewed from Earth?

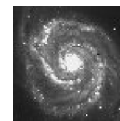
b. How much fainter is the sun viewed from Pluto compared with its brightness viewed from Earth?

c. CHALLENGE! Alpha Centurai is 4.1×10^{13} km from Earth. How bright would the sun appear in SBU from Alpha Centurai? (Hint: You must first convert kilometers to astronomical units.)

8 Using light to measure distances to stars and galaxies

a. Which variables would an astronomer need to know in order to determine the distance to a faraway galaxy or star? Describe how an astronomer could determine each variable.

b. In the diagram to the right, which galaxy is the farthest from Earth? Explain your reasoning.



Galaxy A

B = 3.0
L = 18.0



Galaxy B

B = 6.0
L = 9.0
