Distance and Inclination

Your group will perform two experiments.
The first experiment will measure how distance from a light source (in this case, a light bulb) can affect the amount of heat that an object receives.
The second experiment will measure how the angle (or inclination) at which the light source is viewed (in this case, the Sun) can affect the amount of heat received by an object.

Part 1: Effect of distance

For Part 1, you will have three members in your group. When making the measurements, you will perform different functions:

- "Time Keeper" will operate the stopwatch.
- "Temperature Monitor" will read temperatures in the thermometers.
- "Recorder" will record the results.

Your group will need the following materials for Part 1:

- 2 thermometers
- Desk lamp or flood lamp (without lampshade)
- 2 meter sticks
- Masking tape
- Stopwatch

WARNING

Do *not* look directly at the Sun!
Looking for even a few seconds can cause permanent damage to the eyes!
Note that sunglasses do *not* provide an adequate safeguard against looking directly at the Sun.

So remember to ***never*** look directly at the Sun!

Procedures:

1. Place each meter stick on a table. Place the tables side-by-side so that there is enough space between them to put the lamp, and so that the 0 end of the meter sticks are next to each other. (See Figure S1.)

2. Place the lamp between the tables, as close to the tables as possible. Move the meter sticks so that each 0 cm mark is next is next to the lamp (see Figure S1). Leave the lamp off.

3. Measure 10 cm out from the lamp on one table and tape a thermometer there so that the bulb of the thermometer is facing the lamp. Tape another thermometer at the 50 cm mark on the other table.

4. Record the temperatures of the thermometers to the nearest degree at the "0 minute" line in Chart 1 of this worksheet on Page 5.

5. Turn on the lamp and start the stopwatch. The Time Keeper keeps track of the time and tells the Temperature Monitor when it is time to check the temperature (see Chart 1 on Page 5). The Recorder writes the result in the chart on Page 5.

6. Record your results as indicated on the chart, for 10 minutes.

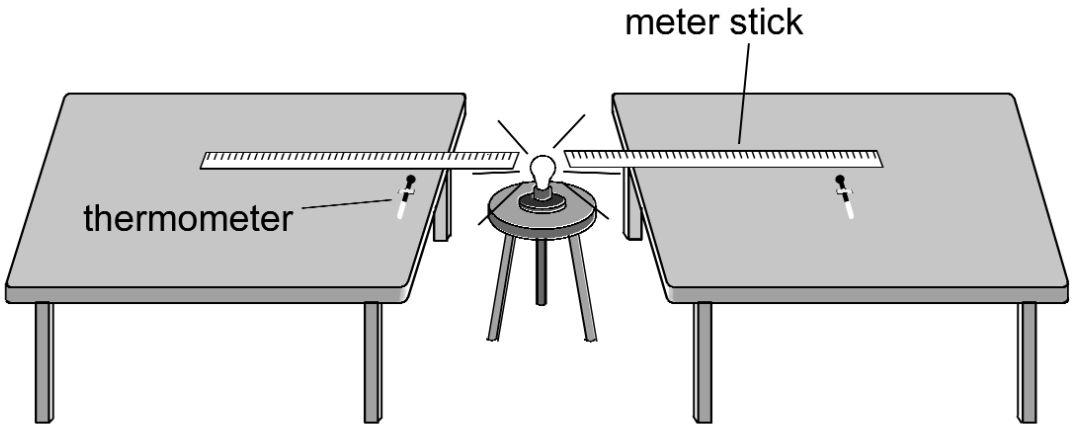

Figure S1. Setup for measuring the effect of distance from a light source.

Part 2: Effect of inclination

For Part 2, you will have five members in your group. One of you will be the Time Keeper for the entire group.

You will need the following materials:

Per student:

- Thermometer
- 1 sheet of black construction paper
- 1 piece of cardboard the same size as the construction paper
- Bricks or blocks to prop up cardboard
- Graphing paper
- Meter stick

Per group:

- Scissors or knife (to cut slit in paper)
- Masking Tape
- Stopwatch
- Colored pencils

Procedures:

1. Cut an inch-wide slit in the middle of the piece of black construction paper. Tape the paper to the cardboard. Place the thermometer into the slit in the construction paper so that the bulb is between the board and the paper, and the scale can be read without removing the thermometer. Tape the thermometer in place, making sure that you can still read the temperature. (See Figure S2, which shows the entire setup for the experiment.)

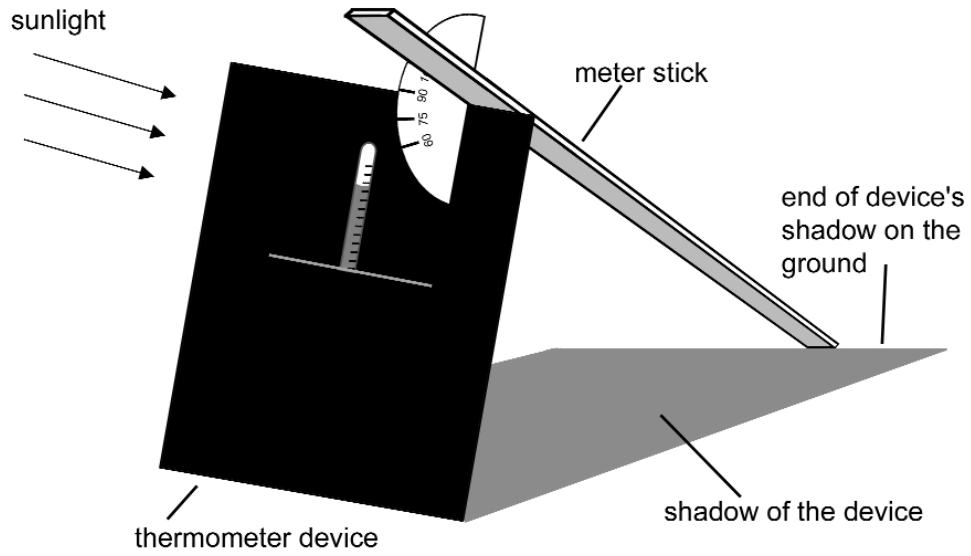

Figure S2: Setup for thermometer device.

2. Cut out the protractor provided for you on Page 8 of the worksheet and fold it along the dotted line. Place the protractor on top of the thermometer device (see Figure S2), and tape the flap down on the construction paper.

3. Bring the thermometer device, meter stick, Student Worksheet 1 and pencil out to the experiment site. Place the thermometer devices in the shade for five minutes so that they read the outside temperature.

4. Set the device on the ground facing the general direction of the Sun so that the slit in the black paper is horizontal with respect to the ground. Place the meter stick so that one end is resting on top of the thermometer device and the other end is at the edge of the device's shadow. The number on the protractor that the meter stick crosses is the angle between the thermometer device and the Sun. This means that when the meter stick crosses 90°, the device is at a 90° angle (face-on) toward the Sun. (See Figure S2.)

5. Each student in your group has been assigned an angle at which to monitor the temperature. Adjust the meter stick and thermometer device so that you are measuring the correct Sun angle. (See Figure S2.) *Remember to keep the end of the meter stick at the very edge of the cardboard's shadow.*

6. Use blocks or bricks to prop the cardboard and keep it at the correct angle.

7. Start the stopwatch. The Time Keeper keeps track of the time and tells each student in the group when to check his or her thermometer (every two minutes). Write the result in Chart 2.

8. After 10 minutes, return to your classroom and share your data among your group so that you can fill in the entire Chart 2.

9. Graph your data. Your x-axis should be labeled "Time" and your y-axis should be labeled "Temperature." Pick a color from your pencils to use for marking your own measurements from Chart 2. Once you have plotted your data points, connect them with a line. Repeat plotting for all angles in your group using different colors for each angle.

Chart 1 (Distance):

Time	Temperature of thermometer 1 at 10 cm (˚C)	Temperature of thermometer 2 at 50 cm (˚C)
0 minutes		
1 minute		
3 minutes		
5 minutes		
10 minutes		
Total change:		

Chart 2 (Time):

Time	60°	75°	90° (facing Sun directly)	105°	120°
0 minutes					
2 minutes					
4 minutes					
6 minutes					
8 minutes					
10 minutes					
Difference of angle from facing the Sun directly					

Part 1 – Refer to Chart 1

1. Which thermometer recorded the higher temperature? By how much?

2. Are the results what you expected? Why or why not?

3. How does the amount of heat you feel from a hot object depend on your distance?

4. Think of examples where the distance to a hot object is important.

Part 2 – Refer to Chart 2

1. a) At which angle was the greatest temperature recorded?

   b) What do you notice about the relationship in general between the temperature and the angle between the device and the Sun?

2. Is this what you would expect? Why or why not?

3. How does the amount of heat you feel from a hot object depend on the angle at which you are facing it?

4. Look at the graph you made. What are your observations of the temperatures at different angles? How does this graph tell you that inclination to the heat source is important?

5. Think of examples where your inclination to a hot object is important.

Putting it together

1. Which of these effects (distance or inclination) do you think is more important? Why? Is it always more important?

2. If you had to cool down something that was close to a heat source (like a light bulb, a fire, or the Sun), how would you do it? Based on this experiment, think of two different ways.

3. If you wanted to heat something up very quickly, how would you do it? Based on this experiment, think of two different ways.

Use this protractor to measure the angle between arriving sunlight and the thermometer device.