



ANSWER KEY

Student Worksheet 1

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Charts will vary according to the students' measurements. Generally, the ending temperature of Thermometer 1 should be higher than that of Thermometer 2 in Chart 1, and the ending temperature at 90° angle should be the highest in Chart 2.

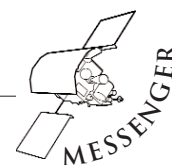
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Part 1

1. Answers may vary, however Thermometer 1 (the one closer to the light bulb) should have changed more (i.e., have a higher temperature).
2. Answers will vary depending on the students' expectations.
3. The closer you are to a heat source, the more heat you feel.
4. Answers will vary. Examples may include being close to fire, stoves, etc. A wrong answer would be distance from the Sun at various locations on Earth. A correct answer with regards to the Sun would be the distances of different planets from the Sun.

Part 2

1. a) The 90° angle should have the highest temperature rise.
b) The highest temperature rise occurs when the Sun is viewed face-on. The temperature rise becomes smaller when the difference of the angle from the face-on direction becomes larger.
2. Answers will vary depending on the students' expectations.
3. If you are facing a heat source directly, you will feel more heat than if you are inclined with respect to that source.
4. At all angles, the temperatures rise from their initial value. The temperature at 90° should reach the highest value in the end, the temperatures at 60° and 120° the lowest (but similar to each





other), and the temperatures at 75° and 105° angle should be in between the other values (but, again, similar to each other.) This should tell the students that inclination is a good way to keep the temperatures at a desired level, either cooler (inclined away) or warmer (faced toward the heat source) than they would be otherwise.

5. Answers will vary. Examples may include leaving objects in sunlight, avoiding sunburn, etc.

Putting it together

1. Answers will vary. It depends on the situation as to which is more important. For example, distance is more important if the change in distance is large (as with distances of planets from the Sun) but inclination is more important if the change in distance is small (as with Earth's seasons).

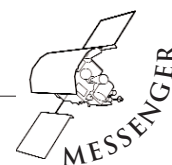
2. Answers may vary. However, the two ways demonstrated in this lesson are to move the object far away from the heat, and to incline the object with respect to the heat source.

3. Answers may vary. However, the two ways demonstrated in this lesson are to bring the object as close to a heat source as possible, and to angle the object so that it is directly facing a heat source.

Student Worksheet 2

Answers given below are based on the solutions used by the MESSENGER mission. The students may come up with other solutions—some of them may not work, but some might work quite well!

1. Mercury is so close to the Sun that the spacecraft will be exposed to much more sunlight than it would on Earth. This creates a high-temperature environment which can be dangerous to the spacecraft.





2. Answers may include: MESSENGER's orbit around Mercury is designed so that it is never very close to the hottest part of the planet's surface and so that it flies over the sunlit regions quickly. The solar panels are inclined when they face the Sun so that they don't heat up too much. (Note that you cannot change the distance from the Sun in this case effectively.) The solar panels are also partially covered with mirrors, but this is not discussed in the lesson, so the students will probably not know this. These are mentioned in the MESSENGER Information sheet, so the crucial point is in how well the students can explain the reasoning. The Information Sheet also mentions the sunshade—but it does not use the concept of cooling by distance or inclination, so it is not a correct answer to this question.

3. a) The Sun appears to be directly overhead at noon each day.

b) At the poles, the sunlight always arrives at a grazing angle—the Sun just appears to crawl around the horizon all day, every day, all year round.

4. The low angle at which sunlight arrives at the poles means that there are craters on the surface whose bottoms have never seen sunlight. It is possible water ice could exist in these regions even if the temperatures in sunlit areas are high.

