



# LESSON 3: MY ANGLE ON COOLING EFFECT OF DISTANCE AND INCLINATION

## LESSON OVERVIEW

### LESSON SUMMARY

In this lesson, students discover that one way to cool an object in the presence of a heat source is to increase the distance from it or change the angle at which it is faced. The students perform an experiment that measures how the heat experienced by a test subject changes as the distance or the viewing angle changes. The students learn to distinguish which effect is more important for determining the seasons on Earth. They learn how the MESSENGER mission to Mercury takes advantage of these passive cooling methods to keep the spacecraft comfortable in a high-temperature environment.



Figure 1. MESSENGER spacecraft with its solar panels angled toward the Sun for safe power generation.

Picture credit: [http://messenger.jhuapl.edu/press/the\\_mission\\_artistimpression/orbitwithsun\\_br.html](http://messenger.jhuapl.edu/press/the_mission_artistimpression/orbitwithsun_br.html)

### OBJECTIVES

Students will be able to:

- ▲ Set up an experiment to test the effect of distance and inclination.
- ▲ Explain how distance and inclination affect heat.
- ▲ Graph their data.
- ▲ Identify situations where these concepts apply, such as the seasons on Earth and the MESSENGER mission.

GRADE LEVEL  
5 - 8

DURATION  
1-2 45-minute periods

ESSENTIAL QUESTION  
  
How do distance and inclination affect the amount of heat received from a heat source?



### CONCEPTS

- ▲ Sunlight can be felt as heat when it interacts with matter.
  
- ▲ The intensity of light decreases as the distance from the light source increases.
  
- ▲ The angle at which a light source is viewed affects the intensity of light to which the object is exposed and therefore the amount of heat generated in the object.
  
- ▲ Seasons on Earth are caused by the (23.5°) tilt of the Earth's rotational axis, and by the resulting changes in the angle of sunlight arriving in different parts of the world at different times on the year.

### MESSENGER MISSION CONNECTION

Because Mercury is much closer to the Sun than the Earth, a spacecraft studying the planet is exposed to more sunlight than objects on Earth. Two cooling methods used by the MESSENGER mission are making sure the solar panels do not view the Sun face-on, and keeping the distance from the sunlit areas of Mercury's surface large enough to limit the amount of radiation received from the surface.





## STANDARDS & BENCHMARKS

### NATIONAL SCIENCE EDUCATION STANDARDS

#### Standard D3 Earth in the solar system

- ▲ The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface due to the tilt of the earth's rotation on its axis and the length of the day.

#### *Related Standards*

#### Standard B3 Transfer of energy

- ▲ The sun is a major source of energy for changes on the earth's surface. The sun loses energy by emitting light. A tiny fraction of that light reaches the earth, transferring energy from the sun to the earth. The sun's energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation.

#### Standard G2 Nature of science

- ▲ Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.

### AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, PROJECT 2061

Benchmark 12C3: Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, and temperature, and choose appropriate units for reporting various magnitudes.

