

Teaching Sciences by Ocean Inquiry
SMS 491/ EDW 472
Spring 2008

HEAT AND TEMPERATURE: LAB I

Cooperative Learning: Group Teaching

In the following activities think about heat and how it is being transferred (heat flux). Is it radiative, convective, or conductive heat flux that takes place? Each group will be assigned one of the three activities below. After exploring the activity and the key concept(s) associated with it, members of each team will teach their classmates (other groups) the concepts associated with their assigned activity.

1. Conduction

Materials:

- 3 types of materials at room temperature: wood, metal, and cloth

Instructions:

- (a) All three materials on the desk have been at room temperature for quite a while. If you touch them, do you think they will all feel the same with respect to temperature? Predict whether some items will feel colder or warmer. Suggest possible explanations.
- (b) Briefly place your hand on each type of material. Does it match your expectations in (a)? How would you explain your observations given that all items have been at room temperature?
- (c) When and where do you think conduction comes in to play in the ocean?



Explanation for Conduction Activity:

Materials that are good conductors feel colder to the touch because heat is transferred away quickly keeping the area we touched from heating up. Poor conductors heat locally and thus feel warmer. In fluids, heat is transferred by direct collisions between molecules. Non-metal solids transfer heat by lattice vibration. Metals have higher thermal conductivity compared to non-metal solids. In metals not only do the bonded atoms vibrate faster when heated, but free electrons, which participate in electrical conduction also take part in the transfer of heat. For more details about conduction see “heat and temperature-background” handout.

2. Radiometer

Materials:

- Radiometer (Arbor Scientific)

Instructions:

(a) Observe the radiometer. Can you spin the vanes of the radiometer without touching it? How?

[DO NOT READ FURTHER: PLEASE THINK BEFORE PROCEEDING]

(b) Put it near a light source and observe it spin. Move the light source away from the radiometer and observe it slow down.

(c) Based on what you know about heat, heat absorption, and the relationship between gas volume, temperature and pressure, write an explanation for how a radiometer works.



Explanation for Radiometer Activity:

The radiometer is set in motion by heat energy. It consists of a rotating shaft with 4 vanes (painted black and white on opposite sides). The shaft and the vanes are sealed in a glass container with air inside. When you expose the radiometer to a light source (lamp or sun) heat is radiated through the glass towards the shaft. The black side absorbs heat better than the white painted side and as a result, air in the vicinity of the black side increases in temperature with an associated pressure increase (remember the ideal gas law). The pressure difference causes movement of the vane from high to low pressure both directly and through airflow. A microscopic explanation is that the kinetic energy of air molecules near the black side is higher than near the white side resulting in more collisions with the vanes (pressure) on that side relative to the white resulting in net momentum transfer to the vane. Note that when air is removed from the radiometer (that is in vacuum) the shaft could rotate in the opposite direction due to a transfer momentum of photons (a quantum mechanical effect). Photons hitting the black side of the vane are absorbed while those hitting the white side bounce back with an opposite momentum, imparting a higher momentum to the white vane than the black. Usually this effect (called radiation pressure) is not strong enough to overcome the friction of the shaft and no rotation occurs (for more see Nichols Radiometer in Wikipedia).

3. Absorption of radiation

Materials:

- Two same size cans, one black and one silver. The lid of the can should have a hole through which you can insert a thermometer.
- Two thermometers
- A heat lamp

** Note: you can get a pre-made radiation kit at Sciencekit.com*

Instructions:

- (a) Observe the two thermometers; one immersed in a shiny tin can, the other in a black one. The same light source shines on both. Why is there a difference in temperature between the cans?
- (b) Will the temperature increase forever or will a final temperature be reached?
- (c) Can you think of a way by which principles learned from this activity can be linked to absorption of electromagnetic radiation at the earth's surface and regulation of temperature on earth?



Explanation for Absorption of Radiation Activity:

The black can absorbs heat better than the shiny can and therefore heats faster. The temperature of each can will reach a final temperature when the gain of short wave radiation equals the loss to long wave radiation + the loss of heat to the surrounding air through conduction (for more details see “heat temperature – background” handout).