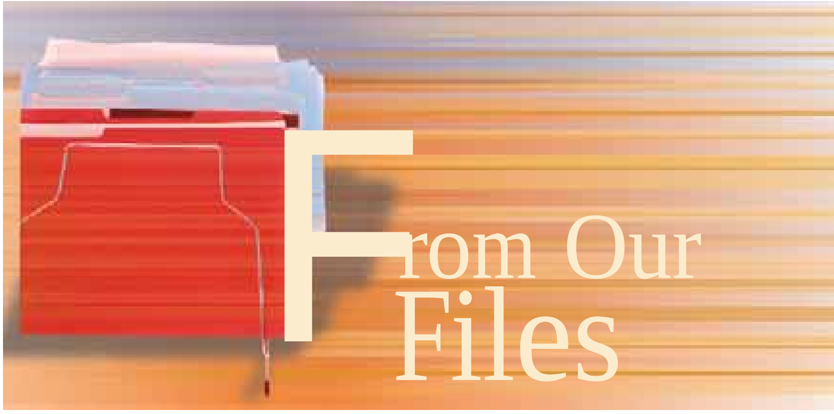

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*The solar constant: a take home lab**

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The object of our investigation was to devise an inexpensive, giveaway experiment for measuring the solar constant using equipment inexpensive enough so that we would not be concerned whether or not any of the materials were returned. A search of the literature[1-4] turned up a variety of relatively inexpensive methods, but none of them satisfied our criteria. One method[4] used crushed ice and water in a glass container using blackened foil. We tried this method and variations on it but were unable to obtain consistent results. A method using a thermometer to obtain the solar constant from the shape of the temperature vs time plot did yield consistently good results. However, the thermometer violated our financial constraint.

The method we settled upon uses energy from the sun, absorbed by aluminum discs, to melt ice, and if the students exercise care they can obtain consistent values for the solar constant. Materials needed are as follows: two plastic foam coffee cups, two 2-in. aluminum discs painted flat black on one side, and one 20-ml disposable plastic syringe. A watch or clock, preferably with a second hand, is to be provided by the student. The student also needs access to a refrigerator in order to freeze two water samples.

The procedure is outlined in Fig. 1. Two Styrofoam cups are first prepared as illustrated in A. The two cups are 2/3 filled with water and then frozen (B). The cups then should be allowed to stand for a while outside the freezer to ensure that the ice is at 0°C (C). The top part of each cup is turned upside down and used as a stabilizing base for the bottom half. This becomes important when the sun is not near the zenith. When the ice has reached 0°C, a metal disc is placed on the surface of the ice in each cup, one with the shiny side up and one with the black side up. Any accumulated water should be poured off prior to the timed run. Both cups are placed in the sunlight with the metal discs perpendicular to the sun's rays (D). The black disc will absorb about 95% of the solar energy normally incident on it and the aluminum disc will absorb about 15%.[5]

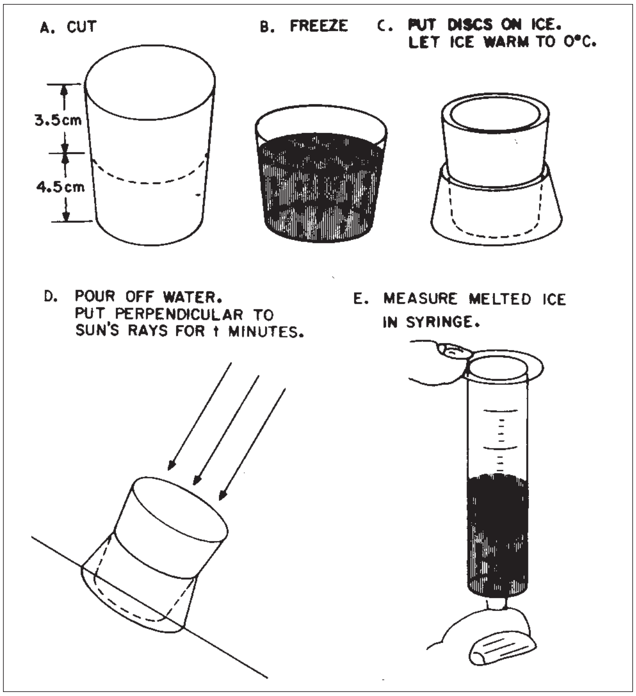

Fig. 1. Schematic representation of the various steps in performing the solar constant experiment.

The energy from the sun falling on the discs will melt some of the ice in the cup. Energy from the surroundings will also be absorbed by the ice and melt some of it. This heat exchange with the environment will be approximately the same for both cups. Thus if we keep the cups in the sun-

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light for the same length of time (t), the heat exchange for each cup can be written as:

$$0.95\ S + \text{Environmental heat} = (80\ \text{cal/gm})\ (M_B),$$

$$0.15\ S + \text{Environmental heat} = (80\ \text{cal/gm}\ (M_{a1})$$

where S is the amount of solar energy falling on each disc in the time t, and M_B and M_{a1} are the masses of ice melted under the black and aluminum discs, respectively. If we subtract these two equations we have:

$$0.80\ S = (80\ \text{cal/gm})(M_B - M_{a1}).$$

The masses of the melted ice are obtained by using the syringe to measure the water produced (E).

The solar constant at the earth's surface will be:

$$\text{solar constant} = \frac{S \text{ in calories}}{(\text{area of the disc in cm}^2)\ (t \text{ in min})}$$

Starting one cup two minutes ahead of the other allows time to measure each and record data without interference. We have found ten to fifteen minutes a good interval for timing. The experiment should be performed as close to noon as possible so that the cups do not have to be tilted too much.

The aluminum discs were cut out and painted in our shops. The syringes[6] were purchased from a local hospital supply company and given out to the students without the plungers. The total cost per setup was $0.51. The experiment has been used in a noncalculus liberal arts course and as an option in a noncalculus technical physics course. The students seemed to have little difficulty with it. However, they were not always careful about picking clear, sunny days on which to do the experiment. Frequently students would procrastinate until forced to make the measurements on the only day left, cloudy or not. This resulted in lowering the average value the group obtained for the solar constant to 0.88 cal/cm^2 min. When the experiment was performed on clear, sunny days in mild weather, the usual results fell between 1 and 1.3 cal/cm^2 min. We have also used this technique for measuring radiation for a clear light bulb.

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etcetera...

Magnetic Building

"In the late 19th century, a major research area was studies of the Earth's magnetic field. To be able to study the Earth's magnetic field, one had to have an environment that was free of extraneous magnetic fields, such as those from ferromagnetic materials. Harvard's Jefferson Physical Laboratory was opened in 1884. It was named for the third president of the U.S. and it was "the first building in the Western Hemisphere dedicated entirely to physics research and teaching.... Because it was originally designed for experiments on the Earth's magnetic field, [the] Jefferson Laboratory was to be built with no ferromagnetic materials. Despite all precautions, the completed building was found to disturb the magnetic field. Although not a single iron nail had been used in the building, it turned out that the [red] bricks themselves contained small amounts of magnetic iron oxide. Unable to perform the planned geophysical experiments, the physicists quickly turned to other fields."[1]

1. "Harvard University Department of Physics History," http://www.physics.harvard.edu/history.html.

A^{2}B