# Lab1: Radiation

*The lab write-up is due next Friday.*

**Please, please, don't point the laser of the radiometer where it might catch anybody's eye!**

This lab exercise centers on radiation and temperature. Be neat and clear in your work. Use the space provided here to note down your answers and observations, but don't hand in this worksheet. **I'd like a short (i.e., concise!) write-up of your methods, data, results and conclusions**, including answers to all of the questions asked in this lab assignment. Also submit a table of your data – a spreadsheet may be the best way. And also include the graphs I ask for. Staple everything together so I don't lose track.

You will be able to take all of the data during lab time, but you will likely have to complete your write-up after lab hours.

Do feel free to talk about the results in groups, and with us. Your write-up of the results, though, should be your own.

## Preliminaries:

We have 4 to 5 radiometers, so you will have to share. These tasks are best done by working together, and compiling the data.

i) Take several different temperature readings of the same object. Does it always give the same answer? What might be accounting for any variation?

ii) What is the precision of your thermometer? What do you estimate its accuracy to be?

## Task 1: Cooling rates.

**Data for this task should be collected first**. We'd like you to determine the rate of cooling of a piece of aluminum that is heated in water and then laid on the lab table. The purpose is to calculate how the temperature of the object varies with time once it is exposed to the ambient temperature.

There are some finicky details to this experiment. Try to measure the temperature in the same way each time (i.e. hold the radiometer at the same angle). Before you do your actual data run, you may want to make at least one trial run. In your write-up discuss the major sources of error in doing this experiment.

1. First, heat water. Note the temperature of the water by taking a reading with the radiometer (in ºC is easiest). The water does not have to boil, but should be well above room temperature. Water temperature: ___________________________

2. Place one of the pieces of aluminum in the hot water with the tongs and allow it to warm up for a minute or so.

3. Measure the ambient air temperature of the room with the radiometer (point it at 5 different objects which you think are at the air temperature and enter the values in the table). Try to explain any differences you find. Write the best (or average) value here: _____________________________

4. Remove the aluminum from the hot water and lay it on the lab table **with the black side up.** Aim the radiometer at the black surface of the aluminum and measure the temperature at intervals of time. *Write down the time and temperature for each measurement in the table included below*. **You** will have to decide how often to measure the temperature. Wait long enough for the temperatures to change significantly between readings. It will likely be more than 20 seconds between readings. So don't panic! You can always repeat the experiment if you choose too long or too short a time. The point is to record the decay of temperature from its initial high value until it is nearly room temperature.

5. After you have collected your temperature decay data, put the aluminum back in the hot water (re-heat the water as necessary). When the aluminum block is hot again, lay it on the lab table **with the shiny side up**. Measure the temperature of the shiny face of the aluminum and write the value here: _________________________. Are you surprised by this value? In your write-up, explain what you think caused this temperature reading.

***The following analysis should be done after you have collected the data for task 2***.

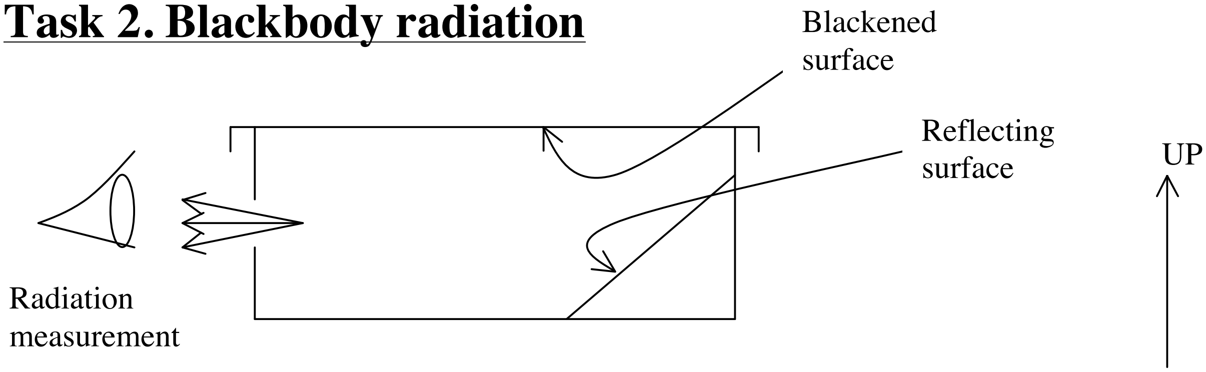
**In an ideal world the difference between the temperature of the aluminum and the temperature of the room should be an exponential curve. Let $\Delta T$ be the difference between the ambient temperature and the temperature of the object.**

1. Using your data plot $\Delta T$ as a function of time. By interpolating the measurements on your graph, how long does it take (just a rough number is okay) for $\Delta T$ to fall to 1/2 its initial value? To 1/4, 1/8, 1/16? For some of these values there may not be enough time, or resolution of the instrument to measure from your data, but try extrapolating from your graphs. Does any pattern emerge?

2. Plot $\log_{10}(\Delta T)$ against time. A convenient way to do this is with the "semi-log" graph paper that is included with this. What happens?

**Include these plots in your write-up (stapled if necessary). LABEL AXES ON ALL PLOTS AND INCLUDE UNITS!**

## Task 2. Blackbody radiation




Using our extremely high-tech equipment(!), you will demonstrate blackbody radiation and the effect of radiation from different sources. The inside of the shoebox is painted black to approximate a blackbody cavity. Include your observations and answers to the following questions in your write-up.

**This data will be collected outdoors**. Wait for the temperature of the shoebox to equilibrate to the outside temperature (you can tell this when the reading stops changing.)

a) Determine the outside air temperature by again pointing the radiometer at various objects that you think should be at the air temperature and enter the values in the table. What is your best (or average) value? ________________________

b) What does the radiometer give as the temperature of the interior of the box (with the lid on)? _________________________

c) What does the radiometer give as the temperature of the interior of the box with the lid off? ________________ (Make sure when you do this, the mirror is pointing up to the sky.)

d) Reverse the mirror (so the cardboard surface is facing into the box). What is the temperature measurement? _______________________

e) Point the radiometer at the sky. What do you get? ______________________

f) Point the radiometer at a cloud (if there are any). What do you get? _______________

g) If possible, find a car that has been recently driven and measure the temperature of its hood. __________________

In all cases the temperature of the box is not changing. Explain the differences in radiometer temperatures that you see.

When the lid is off, the interior of the box is losing heat by radiation (why?). Explain why the temperature does not change much in response to this loss.

## Task 3.

Assuming that both the ground and the sky (clouds) act as a blackbody (which is a pretty good approximation here), determine how much radiation the ground and the sky are emitting (in $Wm^{-2}$).

How much energy flux is it radiating from the hood of the car? Again assume that it behaves like a black body.

## Data table for cooling rates:

**Room** air temperatures (take average of a least 5 readings):

1. ______________________ ______________________
2. ______________________ ______________________
3. ______________________ ______________________
4. ______________________ ______________________
5. ______________________ ______________________

**Average:** __________________ ______________________

Table for cooling rates: you do not need to fill this table up!

| **Time** | **Temperature** | **ΔT (difference of plate from room T)** | **$Log_{10}$ (**ΔT) (or use log graph paper below) |
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**Linear-linear graph paper**. Use max and min of axes wisely. Label axes, and include units.

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**Semilog graph paper:** Use max and min of axes wisely. Label axes, and include units.

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