Thermal Radiation Experiment

(Blackbody Experiment)

Do Experiments **one** and **four** in the Pasco manual. The manual should be online and in the room. You should check it out before doing the experiment.

For experiment one, you only need to do part one for a couple of temperatures, one around 60ºC and another around 100ºC. These can be "piggy backed" on experiment four, i.e. done while you are doing experiment four. For experiment one part two, do (1), but you only need to do (2) for the bare bulb. For part 4, make the measurement about every 12 deg. C.

There is one extra thing to do. You should also plot the voltage from the sensor versus the temperature, i.e. a linear plot. You are only measuring the radiation over a small range of temperatures. Even a T^4 curve will look almost linear over a short range of temperatures. You should answer the question of whether the T^4 plot fits the data "better" than the linear plot does. (EXPLAIN your reasoning!)

Make sure you compare the transmission through glass to transmission through the air.

The temperature sensor is embedded in the cube. When the cube is well above room temperature, do you think the sensor is at the same temperature as the face of the cube? Also, since the faces radiate at different rates, different emissivity's, could the faces be at slightly different temperatures? How would that affect your measurements?

If you want to take the cube to 110ºC or 120ºC you can try putting a box around it so it won't lose heat to the room air. You can reach 120ºC this way. (***See me before you do this.***)

Extra Questions to Answer.

1. If your cube is at 60ºC, what is the peak wavelength in the blackbody curve?
2. If you have a blackbody (emissivity = 1) of an area equal to the area of your cube, how much energy will it radiate away every second, i.e. the power? (Assume the cube has a surface area = $200cm^2$ and T = 60ºC.)
3. If the light bulb inside is providing energy to the cube at a rate of 60W, how hot would you expect the cube to be in order to radiate that energy away. Remember that the cube is also absorbing energy from the room. You need to include that in your calculation. Assume the room is at 20ºC and that the cube has a surface area = $200cm^2$.

The Decrease of Radiated Intensity with Distance

The radiated intensity from a point source, or a spherically symmetric source, should be inversely proportional to the square of the distance. This is based on conservation of energy and should be true for radiation spreading out spherically from a point source. (Can you SHOW why this should be true?) Also there should not be any absorption of the radiation by any intervening material.

I recommend that you use a light bulb mounted at one end of an optic bench and a photodiode mounted at the same height on the bench. This will let you vary the distance from about 0.15m to about 1.8m. You should make the measurements for smaller intervals when you are closer to the bulb. (WHY?) If you start at 0.15m I would recommend making the next few at no more than 0.05m intervals before going to 0.10m intervals and then even longer ones as you get farther away. (If you get too close to the bulb it may not act like a point source or a spherical source. How close can you get before it starts deviating from the $\frac{1}{r^2}$ rule?) If you use a photodiode, remember that it is the current that is proportional to the intensity!

There are a couple of potential problems. The first is you only want to measure the radiation coming from the bulb. Other light sources in the room will interfere with this. Can you think of a way to eliminate the effects of this other light? (Note that stray light will affect your measurements more as you move farther from the bulb and eventually limit how far away from the bulb you should go.)

You should note that any reflections of radiation from the light bulb that go into your sensor can make your results deviate from the $\frac{1}{r^2}$ rule. How can you insure that no light from the bulb is reflected off of other surfaces and into your photodiode? Make two different plots. The first is intensity vs. $1/r^2$ and the second is ln(intensity) vs. ln(r). What should the slope of the second graph be? How close is it to the predicted value?

Be sure to include the following in your write up.

For Blackbody:

- Make the required measurements.
- Answer the Questions.
- Make the plot of "intensity" vs T^4 and use the Data Analysis routines to find the slope and its uncertainty.
- Also make a plot of "intensity" vs T. Can you tell whether it is linear?
- Effect of putting Glass between the sensor and the cube/light.
- Intensity for different faces.
- Include your data tables!

For the $1/r^2$ law:

- Include your data tables.
- Briefly describe your set up. What measures did you take to eliminate stray or reflected light?
- Plot of Intensity vs. $1/r^2$. How well does it fit. (Do a regression analysis.)
- Plot Ln(Intensity) vs Ln(r). What is the slope? What should the slope be? Is the plot a straight line? (Do a regression analysis.)