# Physics 157 Homework 1: due Wed, Sept 18th by 5pm

In class, we have talked about how macroscopic properties of physical systems (size, volume, appearance in visible light or IR, etc…) depend on their temperature. For a quantitative property of some material (i.e. something we can assign a number to), we can represent this dependence either by an equation or by a graph. From either of these, we can predict what the property will be at a certain temperature, or we can figure out the temperature from a measurement of that property (thus using the system as a thermometer). The goal of this week's homework is for you to become comfortable working with these quantitative relationships and to help you achieve the following skills:

- Given the equation/graph for how a physical property depends on temperature, deduce the value of that property from the temperature or the temperature from a value of this physical property.
- Given the form of the relationship between temperature and some property (e.g. a linear relationship), come up with the equation or graph that describes this given enough data (e.g. two data points in the case of a linear relationship).
- For an object made of some material, to calculate the changes in length that object undergoes in response to changes in temperature, given the initial length and thermal expansion coefficient

**Question 0:** Complete the Mastering Physics online homework assignment (in Canvas).

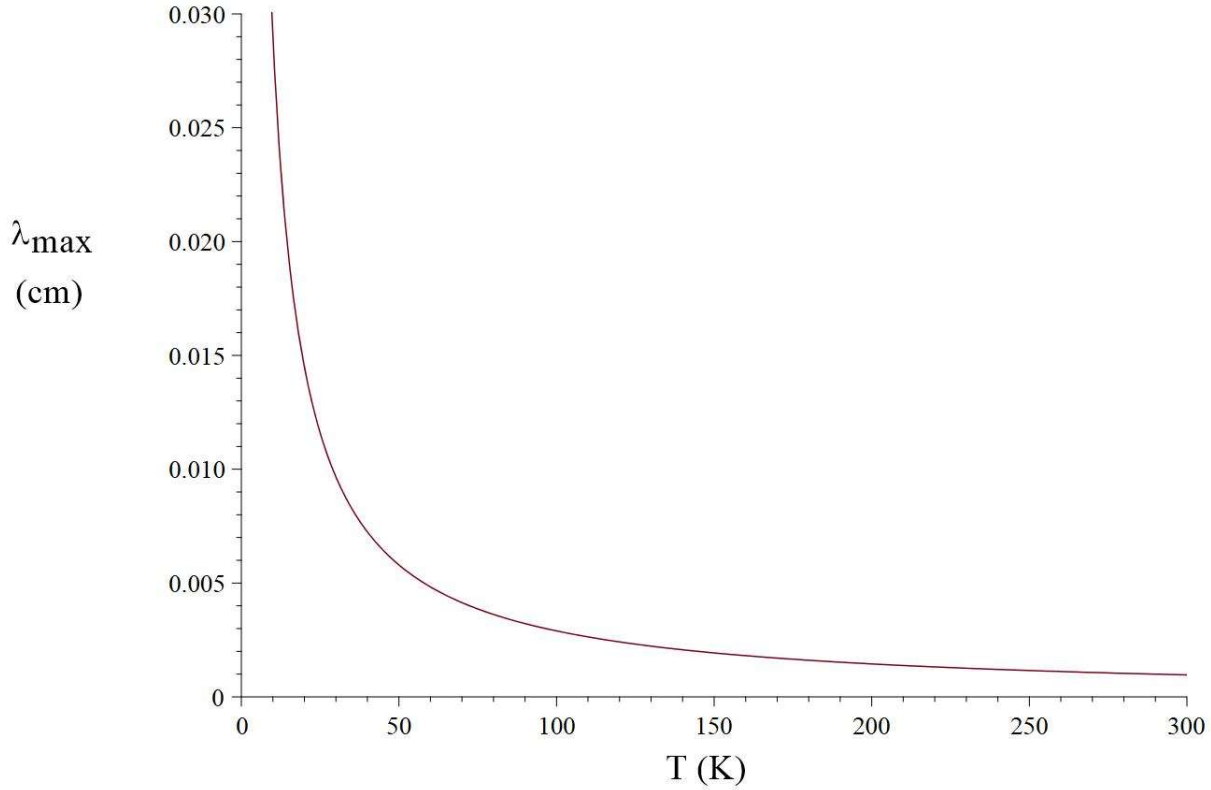
**For the questions below, write out your solutions and hand them in by the deadline to the homework box for your tutorial section outside room 2408 in the Life building. Write your name, student number, and tutorial section on your submission. Explain your work. Don't just write equations and give the answer.**

**Question 1:** Sally's pet lizard makes a weird groaning noise every couple of seconds. She notices that the number of groans per minute is very regular, but increases as the temperature increases. Further observations reveal that the number of groans per minute actually has a linear relationship with temperature over the normal range of temperatures in the lizard's natural environment. So she decides to make use of her lizard as a thermometer.

Sally measures that the number of groans per minute at 20.0°C is 30.0, and the number of groans per minute at 55.0°C is 35.2. If she measures that the number of groans per minute in the lizard's usual aquarium is 31.5, what is the temperature in the aquarium, in degress Celcius? You can check your answer using the Mastering Physics assignment.

*Math tip: A linear relationship between two quantities X and Y, means that for a change in X (which we usually call $\Delta X$), the change in Y is given by $\Delta Y = m\,\Delta X$, where m is some constant. In the range of X where this linear relationship exists, we can write $Y = m\,X + b$. If we graph Y vs X, then m is the slope and b is y-intercept where the graph crosses the y axis.*

**Question 2:** All objects emit electromagnetic radiation whose intensity for the different wavelengths depends on the temperature of the object. Physicists and astronomers often use measurements of this electromagnetic radiation to determine the temperature of an object. The wavelength $\lambda_{max}$ at which the intensity of this "thermal radiation" is greatest is inversely proportional to the temperature i.e. given by an equation $\lambda_{max} = C/T$, for some constant C. The precise relationship is plotted in the graph on the next page. In 1965, microwave radiation peaking at $\lambda_{max}$= 0.107cm was discovered coming in all directions from space. To which temperature does this correspond? This is the ambient temperature of the universe, i.e. temperature that an object in outer space far from any stars will have once it comes to equilibrium. Where did this radiation come from? (To find the answer, look up what the 1978 and 2006 Nobel Prizes in Physics were given for.)




**Question 3:** A platinum resistance thermometer is a device that allows us to determine the temperature by measuring the resistance of a piece of pure platinum wire. In the interval between the freezing point of water and 700.0°C, the relationship between the resistance and the Celsius temperature $T_C$ is accurately captured by the formula

$$R = R_0 (1 + A\, T_C + B\, (T_C)^2)$$

where A and B are constants determined by measurements at the freezing point of water, the boiling point of water, and the melting point of lead (327.46°C). (a) If R equals 5.000 ohms at the freezing point of water, 6.973 ohms at the boiling point of water, and 10.80 ohms at the

melting point of lead, find $R_0$, A, and B (b) If the resistance is measured to be 8.300 ohms, what is the temperature? (c) Plot R versus $T_C$ in the range from 0°C to 700.0°C.

*Math tip: When we have several equations for several unknown variables, we can use the first equation to solve for one of the variables in terms of the others and then replace that variable in the remaining equations with this new expression. Or we can add/subtract equations with different coefficients to get a simpler equation where one or more of the variables has been eliminated.*