Homework Assignment # 1

Physics 5163: Grad. Stat. Mech.

Due: January 24th

Instructions:

This homework is due in two weeks, due to the holiday next Monday. Please do NOT start it the night before. You will NOT be able to finish it if you do.

Problems: It is not sufficient to simply obtain the correct answer. You must also explain your calculation, and each step so that it is clear that you understand the material. You may use MATHEMATIC except when instructed not to do so. (You will not have access to it during an exam.)

Questions: Your answers to questions must be in full, English sentences. (You may have to include equations in your answer, but you answer should not just be equations.) You must write your answers in a fashion that makes it clear that you understand the material. Essays should typically run about half a hand-written page. You may wish to include figures, diagrams or sketches.

Homework is due at the start of the Monday's class.

Reading: Reread the chapters in your favorite freshman undergraduate physics text on thermodynamics.

After that, read Reichl, Chapter 2.

Next week's lectures will be out of Callen, Chapters 2-5. The same material is presented in Garrod, Chapter 5.

Problems: Please solve the following questions:

1. Reichl, Problem 2.3.
2. Calculate the efficiency of Consider a thermodynamic cycle consisting of a straight-line expansion process from $1 \rightarrow 2$, followed by an adiabatic compression from $2 \rightarrow 1$. The straight-line process is described by

$$P = -m\, V + P_0 \tag{1}$$

   where $m > 0$. (Yes, this cycle is possible.)

   Calculate the efficiency of this cycle as a heat engine. *Hint:* despite its appearance it is not a two step process.

3. Reichl, Problem 2.5.
4. Reichl, Problem 2.9.
5. The equations below are purported to be fundamental equations for various thermodynamic systems. However, some of them are not consistent with our postulates of thermodynamics. Indicate which ones are impermissible and why. The variables v_0, R and θ are all positive constants.

   (a)
$$S = \left(\frac{R^2}{v_0 \theta}\right) (NVU)^{1/3}$$

   (b)
$$S = \left(\frac{NU}{\theta} + \frac{V^2}{v_0^2}\right)^{1/2}$$

   (c)
$$S = \left(\frac{R^2}{\theta^2}\right) \left(\frac{NU}{V}\right)^{2/3}$$

   (d)
$$S = \left(\frac{R^2}{\theta}\right)^{1/2} \left[NU - \frac{R\theta V^2}{v_0^2}\right]^{1/2}$$

   (e)
$$S = \left(\frac{R^2 \theta}{v_0^3}\right) \frac{V^3}{NU}$$

   (f)
$$S = NR \ln\left(UV/N^2 R\theta v_0\right)$$

   (g)
$$S = \sqrt{NU} \exp\left(-UV/RN\right)$$

   (h)
$$S = (N^2 V U^2)^{1/5}$$

6. Reichl, Problem 2.8.
7. Please download MATHEMATICA HW # 1 from the course webpage.

Questions: Please answer the following questions.

1. The appearance of life on Earth involves more complicated structures spontaneously arise out of simple ones. Does this disprove the Second Law of Thermodynamics? Explain.
2. In class we showed how an engine with an efficiency greater than that of a Carnot engine allows you to violate the Kelvin-Planck formulation of the second law. In a similar fashion, show how such an engine would also violate the Clausius formulation of the second law.
3. As you sit, you are surrounded by infrared radiation. Is it possible to build a lens to focus the ambient IR about you to start a fire? You can make it as large as you want, but you cannot use the sun or an incandescent bulb as your light source, only the ambient IR light. (*Hint:* Your answer should only appeal to thermodynamics. You don't need to do a complicated optics calculation.)