PY 410 Homework Spring 2017 Due: Thursday March 23rd

You can directly turn in Python notebooks for coding assignments

1. Sethna 3.5. Also check out (hyperlinked) this really amusing paper that shows the power of this kind of thinking: Damasceno et al., Science 6093 p453-457 (2012) and layman article from the wonderful Quanta Magazine.

2. Sethna 3.8

3. Sethna 3.9

4. Sethna 3.10

5. Sethna 3.11

6. For a classical, monatomic, non-ideal gas we have to modify the equations of state of the gas to compensate for excluded volume (like the first problem in the HW) and long range, attractive van der Waals interactions.The equation of state is

$$P(T,V) = \frac{Nk_BT}{(V-bN)} - a\left(\frac{N}{V}\right)^2. \tag{1}$$

There corrections to not change constant volume heat capacity C_V of the gas. The gas is held in a "massless" container, isolated from its surroundings, with volume V_0.

a) Speculate about which correction is for excluded volume and which is for long range attractions. Give some qualitative arguments.

b) The gas is initially confined to 1/4 of the volume V_0 by a partition and is in thermal equilibrium at $T = T_i$. At t = 0 a hole is opened in the partition allowing the gas to expand irreversibly into the rest of the container, thus attaining a final volume V_0. List all quantities that are conserved in this process. Hint: there are three.

c) Prove the relationship that if we think of thermodynamic system as a function V and T (i.e the physical variable is T not E), then $\left(\frac{\partial S}{\partial V}\right)_T = \left(\frac{\partial P}{\partial T}\right)_V$. To prove this, you might want to use Legendre transform fundamental relation).

d) Use the relationship above to find $E(T,V)$ and use this to find the final temperature T_f.