Signals & Noise Homework #2

1. Johnson noise is an example of the Fluctuation-Dissipation theorem, a general relation between macroscopic non-equilibrium dissipation and equilibrium fluctuation (in this case resistance and voltage fluctuations). You measure the root mean square (rms) voltage on the output of a noise-free (!) amplifier of selectable bandwidth with a resistor R at temperature T connected to the input. What happens to the root mean square voltage fluctuations if you double the resistance? What if you double the bandwidth?

2. In the Johnson noise experiment in class, we had a 1000K Ohm resistor, at a temperature of 290 Kelvin. The effective bandwidth of the voltmeter was 30 KHz. What do you calculate for the Johnson noise at the resistor in rms volts? What does this rms noise voltage become at a temperature of 77 deg Kelvin (liquid nitrogen boiling point). In units of dB, what change do you expect in the Johnson noise power spectral density between 390 and 77 deg K?

3. You place a 100K Ohm resistor into liquid helium at 4 deg Kelvin. This resistor is hooked to a matched transmission line to another 100K Ohm resistor inside a thermal shielded container at room temperature. Somehow you remotely sense the temperature of this second resistor as you dunk the first resistor into the liquid helium. Describe what happens to the temperature of the second resistor (if anything) and why.

4. Show in one line why it is hard to average down pure 1/f noise.