Exercise 8: Crystalline and Mechanical Properties

Name(s): ______________________________

Uni(s): ______________________________

In this exercise, we will be looking at how certain microstructural features can affect mechanical properties. Specifically, we will examine the behavior of nickel that has a few key differences from the steel strings we were looking at before. First, the nickel wires are made of pure nickel; steel is a mixture of Fe and C in which much of the strength results from the addition of C. Second, our nickel wires have been annealed, whereas the steel strings had been previously work-hardened during fabrication. These two factors mean that the nickel wire exhibits a much greater degree of plasticity.

Nickel is also an interesting material because it the only other common material used in making guitar strings because it is the only other common material; our magnetism unit should give you a hint about why that may be. Proponents of "pure nickel" guitar strings claim that nickel sounds "warmer" in tone than plain steel. The higher-gauge strings on the guitar with an outer winding are also plated in nickel in order to give this supposed change in tone.

Plastic Deformation

In this section, we expect to see a demonstration of how plastic deformation occurs in materials. The procedure is similar to that which we followed to measure the mechanical properties of steel, but this time, try to start collecting data at very low strains (i.e. at very low frequencies), and use larger turns of the tuning knob - 1/2 turns should be a good choice.

1. As you may have guessed, we will be changing the strain on the string by changing using the tuning pegs. As before, record the fundamental frequency you see in the spectrum analyzer as a function of strain ϵ. However, this time, start recording values at as low a frequency as you can observe, but turn the tuning knob with 1/2 turns. You'll notice some times that when you turn up the knob, the frequency jumps before dropping again - this is a good indication of plastic deformation! Again, record data points **until the string breaks**.

   Also, be sure that your spectrum analyzer (such as AudioXplorer `http://www.arizona-software.ch/audioxplorer/` for Macs or Spectrum Lab `http://www.qsl.net/dl4yhf/spectra1.html` for Windows) is set to record frequencies with a resolution of at most 2 Hz. This will likely mean setting your FFT sample length to at least 4096 samples. Remember that longer samples and better frequency resolution results in better data!

2. As before, make a plot of ν^2 as a function of ϵ by using the following expression:

$$\nu^2 = \left(\frac{E}{4L^2\rho}\right)\epsilon \tag{1}$$

3. Convert your y-axis values of ν^2 into values for stress σ. You should use the relationship given in equation (2) as well as the definition that, in the linear regime,

$$\sigma = E\epsilon \tag{2}$$

4. Make a plot of your values of stress σ, on the y-axis as a function of strain ϵ, on the x-axis. This graph is known as a *stress-strain plot*.
   Q: What is the strain at fracture (given in percent)? ____________
   Q: How does this value compare with the strain you measured for the steel strings?