Problem Set 1

1. Some numbers.
   (a) Calculate how many conduction electrons pass through a given area per second when a current of 1 A flows.
   (b) Estimate the thermal velocity of an electron in a metal at 300 K.
   (c) Estimate the drift velocity of an electron in a current of 50 A in a wire with cross-sectional area of 1 mm^2 made from a metal whose resistivity is $\rho \approx 10^8$ Ωm.
2. Suppose we have a current in a piece of copper wire. We suddenly break the circuit by throwing a switch or the like. Determine the time it takes for the current to decay to half its initial value. You may assume the inductance and capacitance of the circuit are zero. For this, use the classical Drude model.
3. AC conductivity in the Drude model. If you have the second edition of Griffith's E&M book, he does some of this in section 8.4.3 (it seems to be gone from the third edition).
   (a) Write down the differential equation for $\langle v_x \rangle$ in the presence of an ac electric field $E = E_{xo} e^{i\omega t}$. Show that the solution is of the form $\langle v_x \rangle = \langle v_x \rangle_o e^{i\omega t}$. What is $\langle v_x \rangle_o$?
   (b) Show that the real part of the ac conductivity σ is related to the dc conductivity σ_{dc} by
   $$\Re(\sigma) = \frac{\sigma_{dc}}{1 + \omega^2 \tau^2}$$
   (c) Use matlab (or Excel, if you really must) to plot the functional form of the real part of σ as a function of frequency times the relaxation time τ ($\Re(\sigma)$ vs. $\omega\tau$).