PHYSICS 535, Spring 2016 – ASSIGNMENT 7 – Due April 1, 2016
Reading Bazelyan and Raizer Ch. 1 and Ch. 2 through 2.3

Bazelyan Ch. 1 is fairly easy reading, just summarize it in the same way as you have been till now. See if it raises a couple questions (it probably will because it is so general).
After Ch. 1 Bazelyan becomes so dense that your summary of Ch 2 should be page by page. What is he trying to tell us on each page? Ask two questions, one of which you can answer. You will have MANY questions.

ALSO, along with your summary of Ch. 2, prepare a sheet of definitions of all the symbols that Bazelyan is using beginning with Ch 2 (and what page he first uses them on). You will need it to survive anyway. Try to specify units for every quantity as well as the symbol and a description of its definition.

Problems Due 4/1
1) Calculate the mobility of N_2^+ , O_2^- and a free electron e^- at 300 Kelvin at p=1.00 atmosphere. Along the way, verify Bazelyan's value of $N=2.51\times10^{19}\frac{1}{cm^3}$ and calculate the collision frequency (reciprocal of collision time) for each of these three particle species. Use a collision cross section of $\sigma=4\pi\times10^{-20}\ m^2$ for the molecules and (one quarter of that value for the free electron).

2)Assuming that the primary charge carriers in air are O_2^- ions, that the conductivity is $\frac{1}{\rho}=1.0\times10^{-14}\frac{1}{\Omega\ m}$ and that you are at 1 atmosphere and 293 Kelvin. Use equation 2.3 to calculate the ionization fraction of room air.

3a) Derive the relation between $v_{1i}, v_{2i}, v_{1f}, v_{2f}$ for two masses m_1, m_2 in a 1-D elastic collision.
3b) Show that the fraction of kinetic energy "lost" by the mass m_1 in a collision is equal to $4\frac{m_1}{m_2}$ provided that $\frac{m_1}{m_2}\ll1$ and $v_{2i}=0$.
4) Attempt to reproduce figures 2.1 on page 16. Suggested approach:
a) Do all your calculations in SI units. Let E vary from 0 to 1.6 MV/m. Set p=1.00 atmosphere and set T=293K. To convert to E/p units, just divide E by p (converted to Torr), you will then have Bazelyan's x-axis.
Use your calculated electron mobility from problem 1 and calculate the velocity v_e (in cm/s) for E=1 MV/m. Then plot v_e vs. E/p for the range of fields provided (like Bazelyan Fig 2.1a). Your x-axis will look like Bazelyan's, but your y-axis will likely be a factor of 100 too large.
b) Using the definition that $\frac{1}{2}m v_{thermal}^2=\frac{3}{2}k_B T$ generalize the definition of temperature as follows: $\frac{1}{2}m v_{Total}^2=\frac{3}{2}k_B T_{effective}$ where v_{total} combines $v_{thermal}$ and v_{drift} in quadrature. Calculate the effective temperature of an electron in a field of 1 MV/m. Do the same for an O_2^- ion.
c) Now that you have figured out how to get $T_{effective}$ given v_{drift} , use your values from part a and plot $T_{effective}$ vs E/p, with Temperature in Kelvin.
d) Redo the plot with temperature converted to electron-volts. Not surprisingly, your results will be about 10X larger than Bazelyan's Fig 2.1b, and your curve will be a parabola … quite different than his.
e) Drop the concept of (constant) mobility, but keep the relationships $v_e=\frac{qE}{m_e\nu}$ & $\nu=\bar{v}\sigma N$. Calculate v_e for E= 1 MV/m, but allow for the fact that the large total velocity v_e increases the collision rate ν . You will have to do this iteratively. First assume the temperature is 300 K and calculate v_e . Convert this to a new effective temperature and use that to recalculate $\bar{v}$ and thus ν . Use that value to recalculate v_e . Iterate the process. You might need to do it 100 or 200 times before the value of v_e converges. (For me it oscillated until it converged). You should see that your value for v_e is still too large, but is closer to Bazelyan's.
f) Having reduced this to a function, you should be able to replot both figure 2.1a and 2.1b. You can refer to the plots in lecture 26. You will still not reproduce Bazelyan's plots. At least the values for 2.1b will be close and it won't be parabola any more!