PHYSICS 535, Fall 2010 – ASSIGNMENT 9/10

Assignment 9
Reading Read Uman75. Uman, McLain and Krider, "The Electromagnetic Radiation from a Finite Antenna", Am. J. Phys, January 1975. It is a resource for the problem.

Problem Due 11/5 Reproduce figures 3abc from Uman75. Please note that for Figure 3b, Uman multiplied the E-field by -1 without saying he did so!

Assignment 10
Reading
Bazelyan and Raizer Ch. 1 and Ch. 2 through 2.3

Problems Due 11/12
1) Calculate the mobility of N_2^+ , O_2^+ and a free electron e^- at 300 Kelvin. Along the way, please calculate and quote numerical values for the number density, cross section, and collision frequency (reciprocal of collision time) for each species. Use a collision cross section of $\sigma = 4\times 10^{-20}\ \mathrm{m}^2$ for the molecules and for the free electron.

2) Attempt to reproduce figures 2.1 on page 16. You will not succeed exactly. Here are the differences I expect. For panel a, your mobilities will come out about a factor of 10 larger than the figure. Also, your plot will be a straight line (of course) with no curvature. Panel b shows a plot with decreasing slope. Your plot will probably be a parabola, but the range of values in your plot and in panel b will be very nearly the same. You'll have to decipher the units used in Bazelyan and convert to those from SI.
The reason your plot differs from Bazelyans is he is reporting measured data and you are using a simple model. Speculate briefly on the ways in which your model may be inadequate.

3) Compare formulae for $\frac{\alpha}{p}$ vs. $\frac{E}{p}$

a) Reproduce figures 2.2a and 2.2b using the Townsend formula (2.10).

b) Now plot the same figures including 2.10 and the three formula in 2.11. You should see that indeed the approximate formulae are approximately right in the specified ranges of E/p.

c) Convert the A and B constants from equation 2.10 to SI units (from $\frac{1}{\mathrm{cm\,torr}}$ to $\frac{1}{\mathrm{m\,Pa}}$)

4) Beginning with the Townsend formula (2.10)

a) use the meaning of alpha and simple mechanics to show that the average energy an electron must acquire to produce an ion pair is $w = \frac{e\,E}{A\,p}\exp\left(\frac{-B\,p}{E}\right)$.

b) Plot w vs. $\frac{E}{p}$ for air given $100 < \frac{E}{p} < 1000$ The x-axis should be in $\frac{1}{\mathrm{m\,Pa}}$.
Plot w in electron-volts.

c) Your plot shows that there is a minimum in w vs. E/p. Use calculus to get the exact value of E/p and the minimum value of w (in eV).

5) Using equation on bottom of page 22, show that you arrive at the numbers quoted for vibrational-to-translational relaxation time for dry and moist air at room temperature.

6) Solve differential equation 2.14. (The solution is given ... just demonstrate it.)

7) Use the Saha equation to calculate and plot the ionization fraction for $N_2 + 15.6\,\mathrm{eV} \rightarrow N_2^+ + e^-$ and $O_2 + 13.62\,\mathrm{eV} \rightarrow O_2^+ + e^-$. Use a temperature range of 0-30000 K.