PHYSICS 535, Spring 2016 – HOMEWORK #2 Due 2/5/2016

Readings –
1) Read Lightning: Physics and Effects, Chapter 3 through 3.2.5. Provide a chapter summary not exceeding one page.
2) Read "The Earth's Electrical Environment", Chapter 8. Provide a chapter summary not exceeding one page.

Chapter Summary –
Chapter summaries should include what YOU think were the most important points in the chapter. If one section contained most of what you found valuable, you can focus on that.

Chapter Questions –
In addition to your summary, pose two questions raised by each of the readings suitable for homework or class discussion. You should know how to answer one of these questions.
PROBLEM SET #2:

2-1) [a] Derive closed-form expressions for Electric field at the ground vs. distance D from the point directly beneath a point charge Q at height H above flat ground. Derive both components E_r (parallel to the ground) and E_z (perpindicular).

[b] Now add an "image charge" -Q a distance H below the ground. Show that E_r vanishes and that E_z (dipole) is simply $2\,E_z$ (monopole).

2-2) Calculate the induced surface charge $\sigma(r,\theta)$ at the ground in the middle of a dipole. Integrate $\sigma(r,\theta)$ and show that it sums to Q.

2-3) [a] Derive (Analytically) equation 3.4 for the sign reversal distance D_0 for a dipole composed of equal and opposite charges.

[b] Derive the slightly more general expression for D_0 if the dipole charges are Q_P and Q_N are not equal.

[c] Calculate D_0 for two values each of Q_P, Q_N and H_P, H_N (that's four calculations). Pick what you think are reasonable values of Q's and H's based on your reading.

2-4) Using the tripole model of Rakov in Fig. 3.1a, numerically calculate (Matlab or similar) and reproduce figures 3.2c and 3.2d. (Note that Rakov's "tripole" is really three dipoles (or a hexapole …), once you take ground conductivity into account.

2-5) Simulate a negative CG as viewed by an electric field sensor 100m, 500 m, 3 km, and 15 km from it's strike point. Represent the CG as a channel bringing 6 C to ground with a stepped leader. Begin the flash at 6 km altitude.
Let leader extend at 0.001c. For each "step" put a charge dQ-=steplength*lambda.

Let lambda be a constant= -1 mC/m

As leader extends, leave behind an opposite charge Q+ at the origin site of flash. So Q+ grows by dQ every time the leader extends.

When leader reaches ground, immediately (in <0.1 ms) eliminate all dQ- charges on the leader, leaving only the positive charge Q+ back in the clouds.

Note: Every charge must have an image charge