PHYSICS 535, Spring 2016 – HOMEWORK #1 Due 1/27/2016

Readings –
1) Read Read "Lightning: Physics and Effects", Chapter 1. Provide a chapter summary not exceeding one page.
2) Read "The Earth's Electrical Environment", Chapter 15 through page 221. 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 section.

Chapter Questions –
In addition to your summary, pose two questions raised by each of the readings suitable for homework or classroom discussion. You need know the answer to one of these questions.

PROBLEM SET #1 :

1-0) What problems are you most interested in? (You can keep updating this list on every assignment)

1-1) Assume a cylindrical lightning channel with a net charge of 1 C / kilometer: What is it's diameter at ground level and at 6 km altitude? (Hint: Consider how the breakdown voltage of air varies with altitude). How do you reconcile this calculation with the size of the divots you saw on lightning rods?

Interestingly, though lightning does not propagate up to the ionosphere, other electrical phenomena (sprites, elves, jets) do. Repeat your calculation for an altitude of 60 km. What is the radius of your cylindrical "channel" now?

1-2) Make "cartoons" of each of the four panels in Rakov's Figure 1.1.
Each cartoon should consist of three panels showing the cloud and ground before the leader begins, while the leader propagates, and after the return stroke. A vector at ground level should represent the magnitude and direction of the measured electric field. The cloud should begin in an electrically neutral state.
Try to conserve charge in your sketches.

1-3 A simple (too simple) model of the electrosphere assumes the earth is a spherical capacitor with a uniform electric field of E_fair = 150 V/m
from the surface of the Earth up to the height of the electrosphere. There are equal (and opposite) charges on the earth and the electrosphere, and the potential of the electrosphere is said to be 300 kV. How high is the electrosphere? What is the capacitance of the Earth and the charge stored on it?

1-4) Assume a simple (too simple) model of the atmosphere in which the conductivity increases exponentially with altitude (z). ($\sigma = \sigma_0 \exp(z/z_0)$.
Use the continuity equation ($\nabla \cdot \vec{J} = -d\rho/dt$) and the relation between E and J

($\bar{J} = \sigma \bar{E}$) to derive an expression for electric field as a function of altitude.

1-5) Plot equation 1.1 for E(z) vs. z. Numerically integrate to get potential vs. z. Plot potential vs. z.

1-6) A more accurate model of the Earth's electrosphere uses the decreasing Electric field beginning at the Earth's surface to calculate, Voltage, Capacitance, and Charge on the Earth's surface. Use Volland's equation (1.1) to calculate Q on the Earth, the potential of Earth relative to infinity and thus capacitance of the Earth. You can do this analytically.

1-7) Given an average discharge current of 1000A, how long should the electrosphere stay charged?