PHYSICS 535, Spring 2016 – HOMEWORK #4 Due 2/24/2016

Readings –
1) H. Kasemir, Qualitative Overview of Potential, Field and Charge ..., from *Das Gewitter*, H. Israel, editor. (1950).

2) P. Krehbiel, J. Riousset, V. Pasko, R. Thomas, W. Rison, M. Stanley, H. Edens, "Upward Electrical Discharges from Thunderstorms', *Nature Geoscience,* Published online: 23 March 2008; doi:10.1038/ngeo162.

3) P. Krehbiel, et al.,
Supplement to "Upward Electrical Discharges from Thunderstorms', *Nature Geoscience*, Published online: 23 March 2008; doi:10.1038/ngeo162.

Do Article Summary and Questions for Article #1 only. Article #2 and #3 are provided for reference for problem 4-2
Article 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.

Article 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 #4

4-1) Develop an analytical expression for the field and potential (relative to infinity) of a uniformly charged sphere with total charge Q=20 C and radius R=2 km. Plot E and phi vs. r, for r=0-10 km.

4-2) Add numerical integration to problem 3.2 so that you can calculate electric potential from electric field. Overlay, on the same plot, E-field and potential vs. altitude. (Scale them so that you can see both.)

4-3) We are going to do a storm simulation as was done by Krehbiel et al., 2008. In fact, we will simulate that same storm. To prepare, we will upgrade last week's simulation code. Rewrite it with the following requirements (and suggested structure):

a) Able to simulate four cylindrical layers called "LP", "MN", "UP", "SC".

b) For each layer, be able to accept a total charge Q.

c) For each layer, be able to accept z0, which is altitude of center of layer.

d) For each layer, be able to accept d, which is thickness of layer.

e) Be able to accept R, which is radius of layer. (All four radii will not be the same).

f) Initial parameters are as follows:

g) During the simulation, d, z0 and R will be constant, but Q will change every time there is a lightning flash. Thus your code should be written in such a way that you can easily change Q and easily redo the calculations of E and Phi.

h) For now, do a simulation with the following fixed parameters:

```
disk.d=1000*[0.5 1.5 1.5 1.5];
disk.R=1000*[4 4 3 1.5];
disk.Q=[-20 60 -58 13];
disk.MSL=1000*[11 9.75 6.75 5];
disk.AGL=disk.MSL-3000;
disk.name=[{'SC'},{'UP'},{'MN'},{'LP'}];
```

Code Structure:

Do what you want, but I recommend the following, as I think it is most flexible and less likely to get confusing.

Create arrays for Z, RHO, R and Q. All should be the same length, which you can set with a variable called SLICE. For starters, let Z range from 0-10 km, with SLICE=200. (So each slice is 50 meters thick).

Create a function called "rho_stuffer" which calculates rho as a function of altitude and stuffs it in the array RHO.

function [RHO, R, Q] = rho_stuffer(RHO,R,Z,LL,UL,Q,r,q)

Since RHO(Z) depends on the radius and charge of each disk. "d" determines how many slices are in each disk. Thus if your slices are 50 meters thick and d for your disk is 1 km thick and it has a total charge 10 Coulombs and a radius of 2 km, you should put a charge of 0.5 Coulomb in each slice and calculate RHO accordingly based on volume of that slice.

Once you have rho, you can calculate sigma.

It is easy to come up with a closed form expression for the field from a thin disk. (It is harder to come up with one for a thick disk ... you may have already struggled with that). I recommend writing a function that calculates the field

function E=Edisk(sigma, z, z0, R) .

While you are at it, you can write another one
that calculates the field from the image of that disk.

Once you have stuffed your rhos, you calculate field at an arbitrary height z_target by calculating the field from each thin disk and adding them up.

You then proceed to the next altitude.

So the calculation part of your code will have two main loops, one to add up the fields from each slice and one to do the same for each altitude.