ECEN 3400, Fall 2013, Zoya Popovic

Project 1 (covers material in chapters 3-11)

Assigned: October 1, 2013
Due: October 18th, by class time. You have plenty of time, but start soon, it takes more time than you think to make up a problem set.

For this first project, you are asked to design and solve a long homework problem set related to a typical storm cloud. The homework set should have 8-10 problems. Please type up the problems, but you do not need to type the solutions. You can scan them and send everything electronically, or turn in hard copies, your choice. I will be grading the projects and the midterms.

The following concepts that we have studied in electrostatics and time-invariant currents need to be covered in the homework problem set you design:

1. Electric field of a specific charge distribution due to a cloud above ground
2. Electrostatic potential in the field above
3. Boundary conditions and image method
4. Surface charge on conductors; distribution depending on radius of curvature
5. Electric field breakdown in air
6. Electrostatic energy in a region of space
7. Current density in imperfect conductor
8. Resistance of grounding electrode; ohm's law in point form
9. Voltage drop between two points at some distance from grounding electrode

Assumptions:
- Ground is perfect conductor for E-field calculations in air
- Ground is non-perfect conductor for current density and field calculations
- Cloud is big and you can assume it is flat for some parts of the problem, you can also assume the earth is flat relative to the height of the cloud

Some other guidelines:
- You can use ideas from problems in the workbook, but do not copy them directly, at least change numbers or what is given.
- You are also welcome to use examples from other textbooks, but please reference them in that case (I would like to see if you read another book, so this is viewed as positive).
- Below is an example outline without the details, but you can make up your own as well if you wish.
- I would like to see some creativity, but it is more important that you understand the problem, use precise technical wording to formulate it, and do a correct solution.
- A good idea is to give your problem(s) to another student to read to make sure it is clear. Off course, it will help if you do not leave this for the last minute.
- I gave you a lot of time because you have a midterm in the meantime, but keep in mind that the midterm is very related in terms of content. Because you have plenty of time, I expect high quality and a professional job.

Example outline

Here is an example of what a problem might look like (I did not specify everything, that is left up to you):

1. Find the typical charge of a cloud that is likely to result in lightning. State your source, and also give range of cloud height and dimensions. Present your results in a table.

2. Assume all the charge in the cloud can be represented by a set of point charges. (Give details about what they look like here). What is the electric field in air at the ground surface equal to? (Ask the reader to evaluate at some coordinate.)

3. Find the surface charge distribution as a function of some coordinate and plot it.

4. Come up with a problem that allows energy calculation in a region of space.

5. Add a hill (of building, tree, etc.) in the shape of a semi-sphere, give some dimensions. Find electric field at top of the hill. Make sure you state the problem precisely (where is the hill, etc.)

6. If field at top of hill breaks down, there is a lightning stroke. Look up typical currents in a lightning stroke, state your source. Find out all you can about this current (size, resistance of column of ionized air, etc.)

7. How is the current distributed in the ground? Find the current density vector at all points in the ground. Find the electric field in the ground. You will have to give a reasonable number for the ground resistivity or conductivity.

8. Find the resistance of a grounding electrode for a lightening arrester (give dimensions of electrode).

9. A man is standing at some distance from the grounding electrode. Find the voltage between his legs. You can also ask for the voltage between parts of objects if you can think of a relevant example.

You should work on these problems independently and challenge yourself. Do not work in groups, and do not copy from anyone. I will not be kind if you copy, I want everyone to do this at their level, the best they can. This is how you will learn the material. I will definitely give extra credit to those who do an exceptionally good job.