Phys 332
Electricity and Magnetism II
Prof. Fulvio Melia
Computer Projects

There are four possible projects, of which you need to complete one. You would recognize these from Phys 331. So if you did one of those, choose a different one this semester.

Guidelines

1. All text must be typed.

2. All analytical calculations must be typed as well, either using LateX, if you are familiar with it, or word, or any other medium of your choice.

3. It should look like a professional presentation.

4. Also provide a printout of your code. You can choose any language or approach you wish, but the calculation needs to be numerical.

5. We will be dividing the class evenly among the four projects. It is first come first serve. E-mail me your choice and I will pencil you in for your preferred category. In the end, we may have to move people around in order to weight the projects evenly.

6. Projects are due in class on Thursday, April 21.

1: Field due to a Charged Sphere with a tiny hole

Introduction

If we have a spherical shell of radius a and total charge Q, we know that $\vec{E}_{\text{inside}} = 0$, while $\vec{E}_{\text{outside}} = \frac{Q\hat{r}}{4\pi\epsilon_0 r^2}$. Thus, there is a discontinuity in the electric field right at the surface of the sphere due to the surface charge density on the sphere. But what happens if there was a small part of the spherical surface that wasn't charged? That is what you are going to investigate here.

Part I: Analytic calculation of the Field

Your sphere is uniformly charged except for the region where $\theta \leq 1°$ (which has $\sigma = 0$). Imagine that your field point is somewhere on the positive z-axis (so z could be larger or smaller than a). Determine $\vec{E}$ as a function of z.

Part II: Numerical Calculation of the Field

Now write a computer program to do the integral. You should evaluate the field at $z = 0.01na$ where n is an integer. Do this from $n = 0$ to $n = 500$. You will also need to give me a printout of your code.

Part III: Graphing/interpreting the results

On the same graph, graph the *function* you obtained above in Part I and the points you obtained in Part II. Do not connect the points with a line. Verify that both calculations gave the same answer. If the graph is too messy, you may want to subdivide it into several graphs ($z = 0 \to a$, $z = a \to 2a$, etc.) or you may want to try just plotting a fraction of the points you calculated. If things are varying too much, you may need to use the log of your results. You will have to decide how to display your data in a useful way.

Is the change in $\vec{E}$ as you go from $z < a$ to $z > a$ what you would expect? Explain.

You should also graph the "difference" between the field and what it would be if the sphere didn't have the hole (for points with $z > a$). Is that "difference" larger near the surface of the sphere or is it larger farther away? Does your result make sense? Explain.

Part IV: Conclusion

What have you learned from this calculation? Consequences?