Review for midterm

October 15, 2015

The midterm will cover the first two chapters of Griffiths, relying principally on the corresponding lectures and notes. Questions will be similar to the homework problems.

Chapter 1 The first chapter covered vector calculus and some additional mathematical tools. The most important points to understand are the following:

1. You should be able to compute dot and cross products, and the curl and divergence in any coordinate system if needed, but *any required formulas will be given.*
2. The divergence theorem
3. Stokes' theorem
4. Use of the Dirac delta function and the unit step function, especially in writing charge densities.

Chapter 2 In chapter 2, starting from Coulomb's law (which you should remember) we developed:

1. Sum and integral formulas for the electric field

$$\begin{aligned} \mathbf{E}(\mathbf{x}) &= \sum_{i=1}^{n} \frac{q_i}{4\pi\epsilon_0} \frac{\mathbf{x}-\mathbf{x}_i}{|\mathbf{x}-\mathbf{x}_i|^3} \\ \mathbf{E}(\mathbf{x}) &= \frac{1}{4\pi\epsilon_0} \int \rho(\mathbf{x}') \frac{\mathbf{x}-\mathbf{x}'}{|\mathbf{x}-\mathbf{x}'|^3} d^3x' \end{aligned}$$

2. The integral form of Gauss's law

$$\oint_S \mathbf{E} \cdot \hat{\mathbf{n}}\, d^2x = \frac{Q_{enclosed}}{\epsilon_0}$$

   where S is the boundary of a volume V and

$$Q_{enclosed} = \int_V \rho(\mathbf{x})\, d^3x$$

3. Sum and integral formulas for the electric potential

$$\begin{aligned} V(\mathbf{x}) &= \frac{1}{4\pi\epsilon_0} \sum_{i=1}^{N} \frac{q_i}{|\mathbf{x}-\mathbf{x}_i|} \\ V(\mathbf{x}) &= \frac{1}{4\pi\epsilon_0} \int_V \frac{\rho(\mathbf{x}')\, d^3x'}{|\mathbf{x}-\mathbf{x}'|} \end{aligned}$$

4. The relations between the electric field and the electric potential

$$\begin{aligned} V(\mathbf{x}) &= -\int_{\mathbf{x}_0}^{\mathbf{x}} \mathbf{E} \cdot d\mathbf{l} \\ \mathbf{E} &= -\boldsymbol{\nabla} V(\mathbf{x}) \end{aligned}$$

5. The calculation of capacitance, $C = \frac{Q}{\Delta V}$. This requires finding the difference in potential between conductors.

The exam Each of the following questions will involve some symmetry – either linear, cylindrical or spherical.

I will ask the following:

1. Write the charge density $\rho(\mathbf{x})$ (using the Dirac delta and the step function as needed) for a specified charge distribution.

2. Apply the integral form of Gauss's law to find the electric field everywhere in space for a given (symmetrical) charge distribution.

3. Calculate the electric field and/or the electric potential for a given charge distribution. The formulas above and any required integrals will be given, but you should be able to use any of the formulas. Depending on the length of the test, I will ask one or two questions of this type.

4. Compute the capacitance of a given charge distribution. This will require finding a potential difference, but you may use any of the formulas above to find it (e.g., Gauss's law to find $\mathbf{E}$ then $V(\mathbf{x}) = -\int_{\mathbf{x}_0}^{\mathbf{x}} \mathbf{E} \cdot d\mathbf{l}$ to find the potential, or if you prefer, integrating directly to find the potential.

Use of the formulas above from chapter 2 will be the main content of the test. The formulas above will be given.