PHYS580 Lab 7, Oct 3, 2019

Assignment:

1. Use the starter programs *capacitor_Jacobi.m* and *capacitor_update_Jacobi.m* (or your equivalent programs) to solve the Laplace equation for a parallel-plate capacitor using the Jacobi relaxation algorithm. In the *z* direction, the plates are assumed to extend from $z=-\infty$ to $+\infty$ (translational symmetry), so the problem is only two-dimensional. Calculate and plot the potential surfaces, equipotential contours **and** the electric field (cf. pp.140-141 in the textbook). How many iterations (sweeps through the lattice) are required as a function of the mesh size to reach a given level of accuracy? At fixed mesh size, how does the total number of iterations needed depend on the desired accuracy? Compare your convergence results with the theoretical expectations.

   [Note] You need to add the contour plot and the ***E*** field calculation to the starter program. This can be done either by first saving the data and then post-processing it with your favorite 3D plotting program (for example, *gnuplot*, available from *www.gnuplot.info*), or by using built-in Matlab functions such as *contour* for contour plots and *quiver* for vector fields (look these up in *Help*). Be careful about how 2D matrices are plotted by these programs as the row and column indices might mean something different from what you have expected.

2. Implement the Gauss-Seidel method to solve the same capacitor problem as in (1). Calculate the potential and analyze any differences in convergence compared to what you found for the Jacobi algorithm in (1).

3. Numerically solve the Poisson equation for the capacitor problem in (1) by introducing a term $-\rho/\varepsilon_0$ on the right hand side of the **two-dimensional** Laplace equation, at your favorite location away from the capacitor and the boundaries. Calculate the electric potentials and fields in this case using any of the three methods discussed so far (see Section 5.2 for how to include charge in the calculation). Compare with theoretical expectations in limiting cases where that is possible (where you can). Explain what the constant term you added corresponds to physically in this 2D calculation; is this a true point charge?