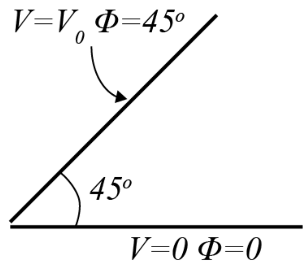
EE1204: Engineering Electromagnetics

Homework Assignment 2 **Deadline: Sunday, 21st March, 11:59 PM**

1. Do the functions (i) $x^2 + y^2$, and (ii) $x^2 - y^2$ satisfy the Laplace equation? Verify that the solutions of Laplace equation exhibit maxima and minima only at the boundaries (no local maxima or minima) by plotting these functions as a 3D surface plot. Explain.
2. Consider a wedge capacitor with two infinite conducting plates at an angle $\Phi = 45^o$. The structure is invariant in the z direction (into the paper), and there exists an insulating gap between the plates.



   (a) Determine the potential between the plates by writing the general solution to Laplace equation, and then applying the boundary conditions.

   (b) Determine the surface charge density on the conductor at $\Phi = 0^o$

3. Problem 2 can also be solved using the *averaging property* of potentials which satisfy Laplace equation. Answer the questions below:

   (a) Using the Jacobi Iteration Scheme discussed in class obtain the numerical solution for problem 2 above assuming $V_0 = 1\ V$. How many iterations are necessary to obtain 'reasonable' convergence? *Hint: A rectangular grid with suitable re-initialization between iterations may work for this geometry.*

   (b) Plot the potential along the line $\Phi = 22.5^o$ in the form of a line graph (choose 'sufficiently fine' grid). Compare this numerical result with the analytical solution obtained in problem 2.

   (c) Submit the Python Notebook with suitable comments to explain your results. Convert the notebook to pdf and submit the entire HW as one pdf file! *You are strongly encouraged to use Python to perform the coding required in this assignment. Anaconda distribution and Jupyter Lab Notebooks are a good starting point if you are unfamiliar with Python. Numpy and Matplotlib packages may be useful for matrix manipulation and plotting respectively.*

4. We have seen in the class that the relative error in finite difference approximations of derivatives reduces as the step-size is reduced. Consider a function $f(x) = 4x^4 + x^2 - x + 3$. We would like to calculate it's **second derivative** by forward and central difference approximations. Fix any suitable x, and choose appropriate starting value of step-size(h). Now with each iteration reduce the step-size by 2, and compute the relative error. Plot the dependence of relative error on step-size on a log-log plot as discussed in class. Comment on your results.

5. **Reading Assignment** Review the following

   (a) Averaging property and uniqueness theorems - sections 3.1.4-3.1.6

   (b) Method of images - section 3.2.1

   (c) Problems discussed in class (problem numbers provided in lecture notes)