In The Name Of God

Assignment number 4 of Electromagnetics 1

Spring 2020

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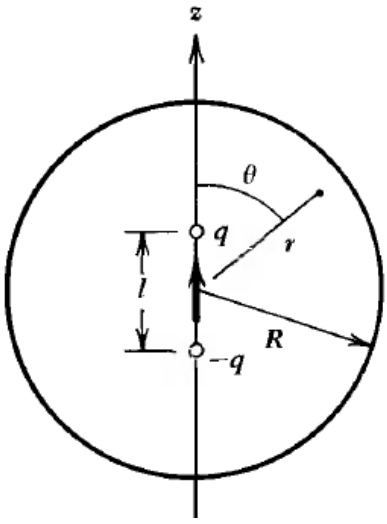
1. Please answer the following questions from "Introduction to Electrodynamics" by D.J. Griffiths (fourth edition):

   - 3.5
   - 3.10

2. Think what happens if there had been no *"Uniqueness Theorem"*, write your opinions in a paragraph.

3. Please answer the following question from *"Electricity and Magnetism"* by *M.H. NAYFE*:

   The method of images can be used to solve for the effect of introducing an electric dipole at the center of a grounded sphere. By using this method, find the surface charge density at r=R.



4. Please answer the following questions from “Electricity and Magnetism” by E.M. Purcell and D.J. Morin (third edition - 2013):

4.1 :

Image charges for two planes **

A point charge q is located between two parallel infinite conducting planes, a distance d from one and $\ell - d$ from the other. Where should image charges be located so that the electric field is everywhere perpendicular to the planes?

4.2 :

The relaxation method **

Here's how to solve Laplace's equation approximately, for given boundary values, using nothing but arithmetic. The method is the relaxation method mentioned in Section 3.8, and it is based on the result of Exercise 3.75. For simplicity we take a two-dimensional example. In Fig. 3.43 there are two square equipotential boundaries, one inside the other. This might be a cross section through a capacitor made of two sizes of square metal tubing. The problem is to find, for an array of discrete points, numbers that will be a good approximation to the values at those points of the exact two-dimensional potential function $\phi(x, y)$. We make the array rather coarse, to keep the labor within bounds.

Let us assign, arbitrarily, potential 100 to the inner boundary and zero to the outer. All points on these boundaries retain those values. You could start with any values at the interior points, but time will be saved by a little judicious guesswork. We know the correct values must lie between 0 and 100, and we expect that points closer to the inner boundary will have higher values than those closer to the outer boundary. Some reasonable starting values are suggested in the figure. Obviously, you should take advantage of the symmetry of the configuration: only seven different interior values need to be computed. Now you simply go over these

seven interior lattice points in some systematic manner, replacing the value at each interior point by the average of its four neighbors. Repeat until all changes resulting from a sweep over the array are acceptably small. For this exercise, let us agree that it will be time to quit when no change larger in absolute magnitude than one unit occurs in the course of the sweep. Enter your final values on the array, and sketch the approximate course that two equipotentials, for $\phi = 25$ and $\phi = 50$, would have in the actual continuous $\phi(x, y)$.

The relaxation of the values toward an eventually unchanging distribution is closely related to the physical phenomenon of *diffusion*. If you start with much too high a value at one point, it will "spread" to its nearest neighbors, then to its next nearest neighbors, and so on, until the bump is smoothed out.

Relaxation method, numerical ***

The relaxation method is clearly well adapted to numerical computation. Write a program that will deal with the setup in Exercise 3.76 on a finer mesh – say, a grid with four times as many points and half the spacing. It might be a good idea to utilize a coarse-mesh solution in assigning starting values for the relaxation on the finer mesh.

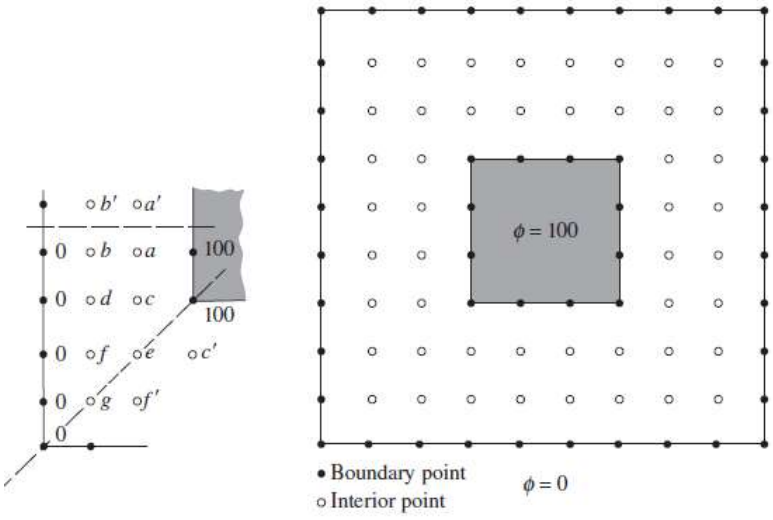


Figure 3.43.
Replace value at an interior point by $1/4 \times$ sum of its four neighbors: $c \rightarrow (100 + a + d + e)/4$; keep $a' = a$, $b' = b$, $c' = c$, and $f' = f$. Suggested starting values: $a = 50$, $b = 25$, $c = 50$, $d = 25$, $e = 50$, $f = 25$, $g = 25$.

NOTE: Some questions contain coding and you may do it by any programming language you prefer. Your submission for this questions must contain two files, the code itself and a report of the code with it's output.

Please do not copy the codes; This is just an assignment to improve your learning, both in electromagnetism and coding! :)