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PHY4000W

# Computational Physics Test

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**Abstract**

The aim of this report ,use the Relaxation Method to calculate The Poisson equation describes the electric potential of a charge distribution.We where given a point charge q = 1C near an electrode inside a box at a potential  = 0. All calculations where be done on a lattice with a spacing of 1mm×1mm.The electric field was also calculated and visualised. Its magnitude and angle  with respect to the x axis at the points along the electrode inside the box where calculated .The charge distribution on the conducting plate inside the box was the calculated and plotted.The second part is to calculate the current on the ammeter in an unbalanced Wheatstone brigde.different values of resistances where tried out and a graph of the current for different values of resistance were plotted.The value of resistance where current through the Wheatstone bridge is zero was found.

# 1 Solving the Poisson equation

The Problem at hand is described in figure 1 below.

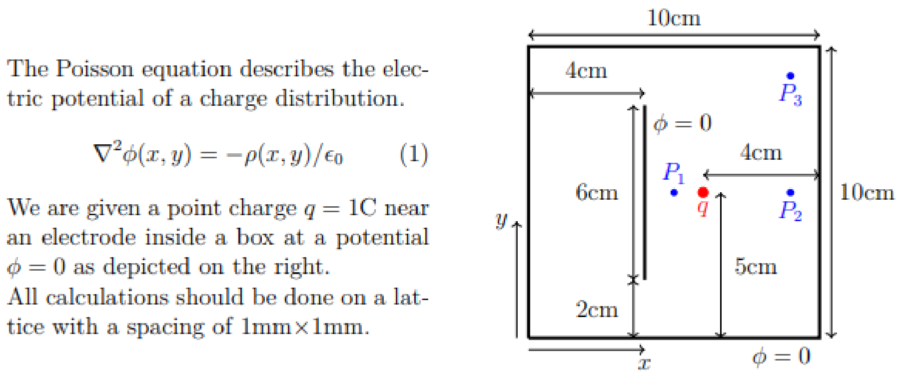


Figure 1: Charge and a ground plate inside a grounded box.

Using relaxation method eq 5.12 from the notes,The Poisson equation was solved and the potential in the centre of the box (P1), 1 cm from the right side of the box (P2) and in the upper right corner (P3),1 cm from either side was calculated.They where found to be V(P1)=0.15830811636580697,V(P2)=0.000132218418835874 ,V(P3)=0.00862384696806 the $_0$ is set to one.And the map of the potential is given by. Then the electric field was calculated and visualised.The electric field id the gradient of the potential and

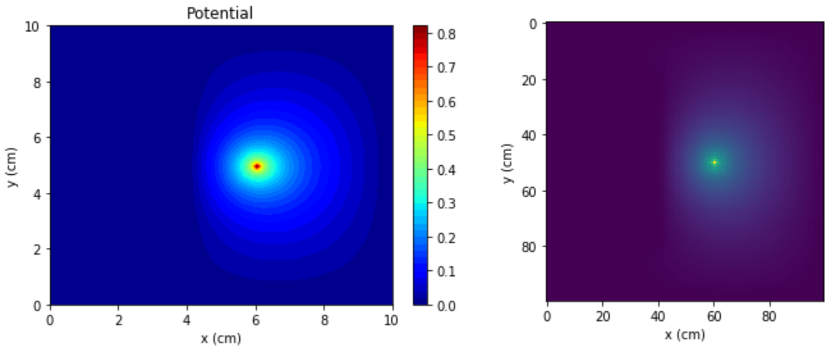


Figure 2: Potential due to charge q and the grounded conduction plates.These to figures show the some thing but the second one show the location of the charge.

can be calculated numerically as

$$E_x(i,j) = -\frac{V(i+1,j) - V(i,j)}{h} \tag{1}$$

$$E_y(i,j) = -\frac{V(i,j+1) - V(i,j)}{h} \tag{2}$$

Or using the gradient function from Numpy.A plot of electric filed is show below. As can be seen from the figure,stream lines of this show that the positive charge will induce charge density on the conducting plates.And As expected this charge distribution will arrange itself so as to leave the potential inside the conducting plates zero.If the plate was infinite, the charge distribution would be such than the system behaves as if the is a negative charge on the other end of the plate,the you can substitute the conducting plate with a an image charge.Even though this plate is not infinite,we do expect that the would be a virtual negative charge on the other side of the plate.Just as these stream plot shows.Electric field plots where much more complicated to plots,but here it is.

The electric field (magnitude and angle with respect to the x axis) at the points E(P1)="mag": 0.03075823259020751, "phi", -0.009032866274988307, E(P2)="mag": NaN, "phi": 2.9014839384437634 and E(P3)= "mag": 0.008435174562720938, "phi": -44.53370229375712.

As discussed above,the charge induces a charge distribution on the plates.The charge distribution o an surface is given by And lastly For the unbalanced Wheatstone brigde show below.

$$\sigma = -\frac{\partial V}{\partial n} \tag{3}$$

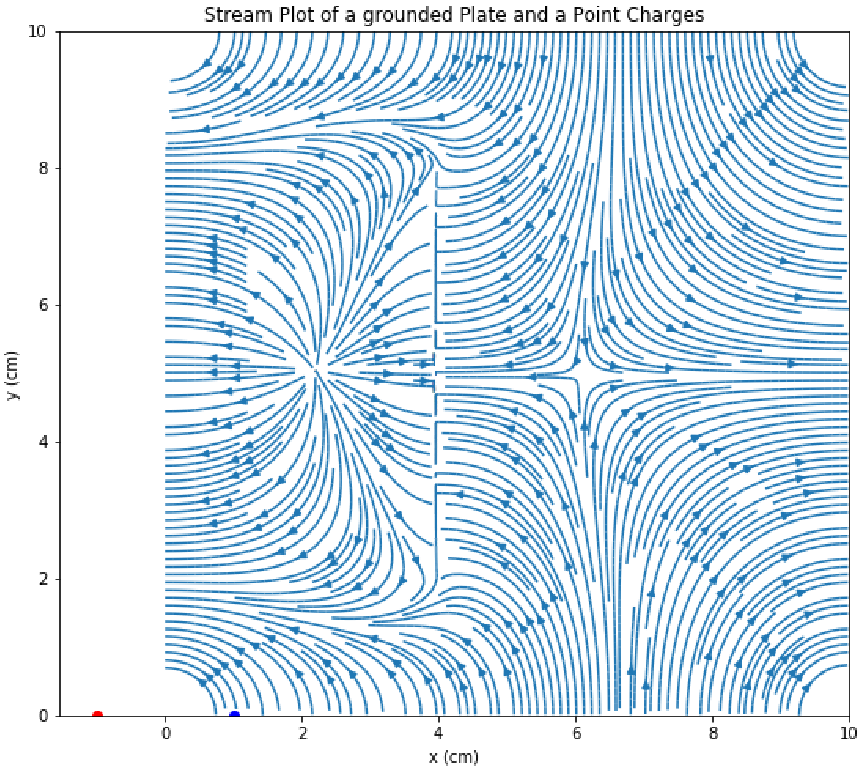


Figure 3: Stream plot showing electric field to charge and the conducting plates.

or

$$\sigma\hat{n} = E_{above} - E_{below} \tag{4}$$

Here $E_0 = 1$ as mentioned earlier.The charge density is plotted below.

Looking the at the approximation and the numerical calculation,they are almost similar.The total charge distribution on each plate is $0.017605362576141398 c/mm^2$. And for the unbalanced Wheatstone Bridget.Kickoffs laws was used to setup linear equation then they where solved using numpy.the figure below show how the current through the ammeter changes and Rx is varied from 0 Ohms to 500 Ohm.The current through the ammeter was found to be zero for for Rx=50.but more precise value is 49.875348753487536.

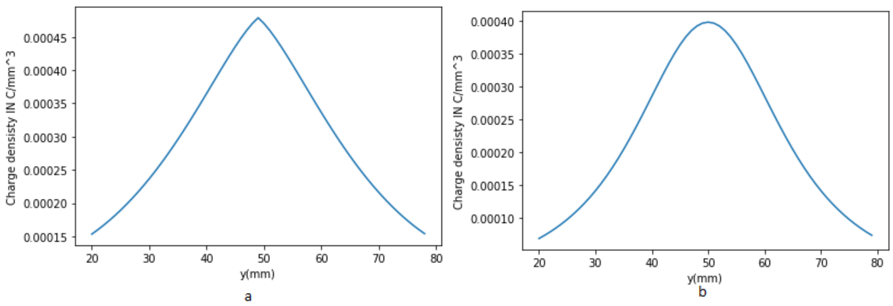


Figure 4: Plots showing charge distribution.a shows the one obtained from the by taking gradient of the potential the boundary of the conducting plate.B show one calculated approximately using method of images.this is the absolute charge distribution.on the side of the point charge its negative.

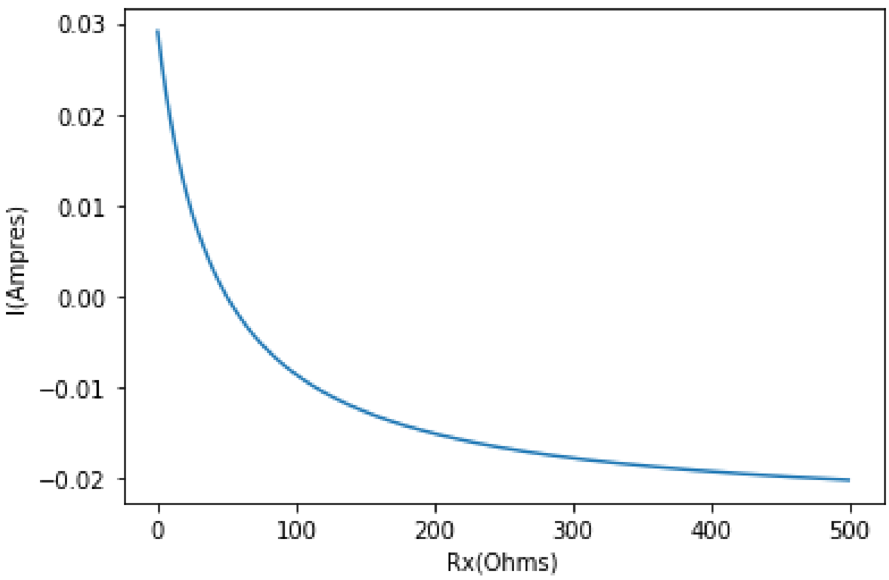


Figure 5: Current through the ammeter as Rx is varied from 0 Ohms to 500 Ohm