Homework #2:
Integrations

Set-up

As you learned in electrodynamics (well...and Physics 2) the electric potential of some charge distribution $\rho(\vec{r})$ is a scalar quantity given by the integral

$$V(\vec{r}) = \frac{1}{4\pi\epsilon_0}\int \frac{\rho(\vec{r}')}{(\vec{r}-\vec{r}')}d^3\vec{r}, \tag{1}$$

where $\vec{r}'$ is the position of the charge distribution and $\vec{r}$ is the position at which you are calculating the potential. The difficult part of this problem involved expressing the charge density $\rho(\vec{r}')$ correctly and evaluating that integral. Luckily, you now have a computer to do the hard part, leaving you another hard part - coding it. From this expression, you could then find the electric field at any point $\vec{r}$ by taking the gradient of the potential,

$$E(\vec{r}) = \vec{\nabla}V(\vec{r}) \tag{2}$$

Consider 3 charge distributions: a 1D case and two 2D cases. First, a charged line,

$$\lambda(x) = 2x, \quad 0 < x < 1. \tag{3}$$

Second, a charged 'L' made from two charged lines - one parallel to the x axis and the other parallel to the y axis

$$\begin{aligned} \lambda(x,y) &= x^2, \quad 0 < x < 1 \\ &= y, \quad 1 < y < 2. \end{aligned} \tag{4}$$

Third, a charge disk in the x-y plane, centered at the origin plane with a radius of 2 and a charge distribution of

$$\sigma(r,\phi) = r\cos(\phi) \tag{5}$$

Goal

Write a program in Python and MATLAB to calculate the (i) electric potential and (ii) electric field in the vicinity of each charge distribution. Graph the electric potential and electric field (try a 3D plot for the field).