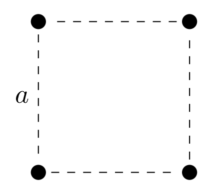
1. Sometimes we will want to describe the distribution of charges using the Dirac delta function. Here the goal if for you to gain confidence in using the Dirac delta functions for fields that you could check through other means.
   (a) Write down the expression for the volume charge density, $\rho(\vec{\boldsymbol{r}})$, for a point charge q, located at $\vec{\boldsymbol{r}}_s$.
   (b) Consider an electric dipole with a $+q$ charge at $+d$ on the y-axis and a $-q$ charge at $-d$ on the y-axis. Write down the volume charge density, $\rho(\vec{\boldsymbol{r}})$, for this distribution.
   (c) Using Coulomb's law (direct integration), show that you can obtain the electric field of this dipole at any location x on the x-axis.
   (d) Write down the appropriate expression for the volume charge distribution, $\rho(\vec{\boldsymbol{r}})$ for an infinite plane of charge at $z = a$ with surface charge density σ_0. Comment on the units of each term in your distribution.

2. This past week in class we looked at the electric field:

$$\vec{\mathbf{E}} = k(y^2\hat{\boldsymbol{x}} + (2xy + z^2)\hat{\boldsymbol{y}} + 2yz\hat{\boldsymbol{z}})$$

   and confirmed that it did indeed have a curl equal to zero (Make sure you could repeat this on your own).
   (a) Given that electric field calculate the following at all points in space:
      i. the corresponding potential
      ii. the corresponding charge density
   (b) For each element (the electric field, potential, and charge density) plot three slices of the xy-plane at $z = 0, 2$ and 5 (everything is symmetric over the $z = 0$ plane so we won't worry about $-z$'s). For each element choose a plot type or style that makes sense for visualizing that sort of physical phenomena, and place all three slices next to each other for easy comparison.

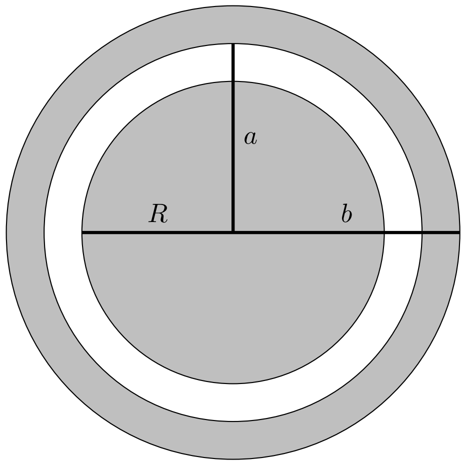
3. When studying crystal structures (for example in condensed matter physics), it is often times convenient to model these crystals as rectangular grids of charged ions. Imagine then a small square (with side length a) with 4 point charges $+q$ at the corners.



   (a) Calculate the total energy stored in the system (i.e. the amount of energy required to assemble it).
   (b) Calculate how much work it would take to "neutralize" these charges by bringing in one more point charge ($-4q$) from far away and placing it at the center of the square.

4. This problem this week is based off your completing the "Numerically Computing Fields" tutorial and all its sections. Turn it in for this problem.

5. A *metal* sphere of radius R, carrying a charge $+q$, is surrounded by a thick concentric *metal* shell (inner radius a and outer radius b). The shell carries no net charge. Be sure to explain your reasoning for full points!



(a) Sketch the charge distribution everywhere. If the charge is zero anywhere, indicate that explicitly.

(b) Determine the surface charge density σ at R, at a, and at b.

(c) Sketch the electric field everywhere, and explain how you know the field you've drawn is correct.

(d) Find the potential everywhere, using $r = \infty$ as your reference point for where $V = 0$.

(e) The outer surface is now touched by a grounding wire, lowering its potential to 0. How do your answers to parts (b) and (d) change? Explain your reasoning!