Physics 333 – Homework 03 – Rev B

Due Sept 7, 2021.

SPN 3–01. A pentagon with one meter sides is created from positive charges (three nanocoulombs/each).

(a) What is the field in the center of the pentagon? Justify your answer. (You can do this entirely by sketching vectors, and perhaps tapping a wand, no algebra is required.)
(b) The top charge is removed. What is the field in the middle now?

SPN 3–02. The setup is the same as the previous problem, but now we are discussing potential.

(a) What is the potential in the center of the pentagon? Justify your answer.
(b) Same question, but with the top charge removed.

SPN 3–03. The axis of symmetry of a cylinder of length L lies along the x-axis. The cylinder has radius R and $L >> R$. The charge density is solely a function of distance from the axis of symmetry, $\rho(r) = be^{-r/R}$. (b is a constant.) The cylinder is centered at the coordinate origin.

(a) Sketch the cylinder, showing L, R, the origin, x-axis, and y-axis.

(b) What are the proper units for b?

(c) What is the total charge on the cylinder?

(d) What is the electric field $\vec{E}(y)$ both inside and outside the cylinder? (Integration by parts will be needed. You will need to know this integral for quantum mechanics anyway!)

(e) Why was it important that $L >> R$?

SPN 3–04. Go to `https://phet.colorado.edu/en/simulation/charges-and-fields` and mess around. Then do the following:

(a) Arrange +1 nC and -1 nC horizontally and roughly 2 meters apart. (The simulation has a ruler tool to allow this). You can show the E-field while you are playing, but for your submission just show the charges with equipotentials. (There is a tool for that too). Use the software to plot 11 equipotentials from -10 V to +10 V (including 0). Do a screen capture or print the result.
(b) With a pencil, draw in representative electric field lines that are consistent with the equipotentials you just plotted. The lines should be closer together in high field regions. It ought to remind you of last weeks' sketch.
(c) Place six 1 nC charges in an equally spaced line that is two meters in total length. Plot equipotentials at 125 V, 100 V, 75 V, 50 V and 25 V.
(d) What is λ in this case? With a pencil, add appropriate electric field-lines to the equipotentials.

SPN 3–05. (Related to 2–01) A line of charge runs from $x = -5$ to $x = 5$ meters. It has a constant linear charge density $\lambda = 50\ nC/m$. Now you have a new formula to integrate,

$$V(z) = \frac{1}{4\pi\epsilon_0} \int \frac{dq}{\mathscr{r}} \tag{1}$$

(a) Calculate V (relative to ∞) at the point $\vec{r}_T = 5\,\hat{y}$.
(b) Calculate V (relative to ∞) at the point $\vec{r}_T = 0.5\,\hat{y}$.
(c) Calculate V (relative to ∞) at the point $\vec{r}_T = 0.05\,\hat{y}$.

HINTS: This is a really simply problem to set up, but the integral is painful. I recommend you just do numerical integration. Use any tool you like. Two choices: `https://www.wolframalpha.com/` or I have written a python script that does numerical integration. Whichever tool you use, submit the output of the program (screen grab of wolfram or printout of my python code). They python code has detailed instructions for use and may be found here: `http://kestrel.nmt.edu/~rsonnenf/phys333/python_code`

SPN 3–06. (Related to SPN 2–06) A uniformly charged disk of radius R has a total charge Q.

(a) Find an expression for the potential at an arbitrary distance z above the plane of the disk. (Use formula listed in problem SPN 3–05.)

(b) Show that $\vec{E} = -\nabla V$ applied to your result from "a" gives the result from problem 2–06.

This program is a little harder to set up, but the integral is much nicer. You do not need to do numerical integration, you get an indefinite integral.