Physics 333 – Fall 2021
Due August 31 at 21:00.

Homework 02

Instructions:

Each problem should begin at the top of a new sheet of paper. (OK to use front and back if you want). The final answer (numerical or symbolic) should be copied into a box (or written in a different color) at the top right of your page. (For proofs, this isn't reasonable, so don't do it.) Each problem should have your name on the left and, below it, the *SPN*, circled. Problems should (usually) include a 3x3 inch sketch and begin with the general equations and the assumptions you make. For numerical answers, show numbers plugged into the equation before solving with a calculator. Numerical answers should include SI units.

NOTE: For the following set of problems, some should be done via Gauss' law and others by direct integration of Coulomb's law. Your first job in each case is to figure out which method is more productive.

SPN 2–01. A line of charge runs from $x = 0$ to $x = 5$ meters. It has a constant linear charge density $\lambda = 50\ nC/m$.

(a) Calculate $\vec{E}$ at the point $\vec{r}_T = 5\ \hat{y}$.
(b) The line is extended to run from $x = 0$ to $x = \infty$. Calculate $\vec{E}$ again at the same point.
(c) The y-component of $\vec{E}$ for part "b" should look familiar. How is it related to another problem we have solved?

SPN 2–02.

(a) A point charge Q is located at the center of a cube of edge s. What is the value of $\int \vec{E} \cdot d\vec{A}$ evaluated over one face of the cube?

(b) The charge is now moved to one corner of the cube. Now what is the flux of $\vec{E}$ through each face of the cube? *HINT: Consider the point as a small sphere centered at the corner*

SPN 2–03. "Coaxial" cables are a staple of electronic devices. In a coaxial cable, a wire runs down the middle of a conducting tube made of metal foil or copper fabric. The tube is wrapped around a plastic "dielectric" spacer. Dielectrics are chapter 4. For now, let the spacer be air and let the wire stay centered in the tube by magic. (Or just ignore the dielectric!). The wire has a total charge Q and long length L while the tube has an equal and opposite charge -Q and the same length.

(a) Make sure to sketch this setup and indicated where the charges are.
(b) Write an expression for the electric field for points between the wire and the tube.
(c) What is the electric field for points outside the tube?

SPN 2–04. A very large square plate of side s has a total charge Q.

(a) Calculate the electric field at any distance y above or below the plate so long as that distance $d << s$.
(b) $Q = 15\ C$, $s = 3\ km$. Calculate the electric field at $y = 100\ m$.
(c) $Q = 15\ C$, $s = 3\ km$. Calculate the electric field at $y = 100\ km$.

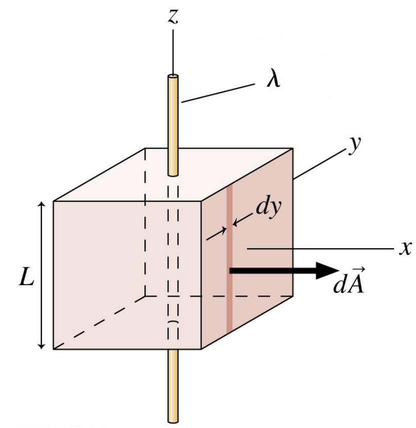
SPN 2–05. A hoop of radius R is made of charged wire. The total charge is Q.

(a) Find an expression for the electric field at an arbitrary distance z above the plane of the hoop. (Note: z is confined to a line that passes through the center of the hoop. That makes this problem much simpler.)
(b) Calculate the field at $z = 0$, $z = 1\ cm$ and $z = 1\ m$ given $R = 8\ cm$ and $Q = 2\ nC$.

SPN 2–06. A uniformly charged disk of radius R has a total charge Q.

(a) Find an expression for the electric field at an arbitrary distance z above the plane of the disk.
(b) Let R increase to ∞ (so $R >> z$). Does the expression from part "a" remind you of another expression? What?

SPN 2–07. (– *Testing Gauss' law*)
Let's test Gauss' law for a case where you CAN'T do integration by multiplication. A cube is centered on a uniformly charged wire with linear charge density λ (as shown). A cube of side length L has one vertex at the origin. In assignment 1 you derived the functional and vector form of the field outside of a straight wire (that would be an infinitely long cylinder right?). You do not need to rederive it. Integrate this electric field over the cube faces and see if you get what Gauss' Law tells you you should get.
(HINT1: The illustration suggests what integral to do).
(HINT2: The integral itself is a somewhat irritating trig substitution. You may consult a trig. table or Wolfram Alpha. Just show the general indefinite integral before plugging and chugging.)



Problem 7: A cube of side length L centered on a charged wire.