Instructions:

Some errors were corrected.

Each problem should begin at the top of a new sheet of paper. 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.

** SPN 3–01.** A large flat cloud is 2 km thick and has a uniform charge density of \( \rho = -2.5 \text{nC/m}^3 \). The center of this cloud is at an altitude of 3 km above the ground. (Assume the ground does not affect the result ... though in Chapter 3 we find out that it does).

(a) Plot the electric field as a function of altitude from 0-5 km. (Use software or a pencil and paper)

(b) Plot the potential as a function of altitude. Define the potential at ground as zero volts.

* SPN 3–02. Four "point" charges are brought together from \( \infty \) to form a square with sides of 0.5 meters. Each charge has a magnitude of one microcoulomb. (As originally written, it was one nanoCoulomb)

(a) How much work does this take?

(b) If the charges are distributed uniformly over small spheres (negligible size compared to 0.5 meters) with mass 250 g each, and the charges are now released, what is their speed when the square has increased to 2 meter sides?

* SPN 3–03. Do Problem 2.38. (– Behavior of charged conductors)

* SPN 3–04. Do Problem 2.43. (– A coaxial capacitor)

* SPN 3–05. Given an arbitrary uncharged capacitor s.t. \( Q = CV \), use the definition that \( U = qV \) and show that the total energy required to charge it to \( V_0 \) is \( U = \frac{1}{2} CV_0^2 \). (– Reproduce class work)

* SPN 3–06. Using result from previous problem, show that, for a parallel plate capacitor, the energy density in the electric field is \( u = \frac{1}{2} \epsilon_0 E^2 \)

** SPN 3–07.** Do Problem 2.48. (– Potential of a hemisphere. Hint ... you do NOT have to begin by calculating electric field. Also, you calculate the potential (relative to infinity) of the point at center of Hemisphere, then calculate potential at North Pole and subtract them. This is the easiest approach ... still not trivial.)

* SPN 3–08. Go to phet.colorado.edu/sims/charges-and-fields/charges-and-fields_en.html 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.

(c) Repeat part a with +2 nC and -1 nC. You do not have to draw field lines.
(d) Place nine 1 nC charges in an equally spaced line that is two meters in total length. Plot equipotentials at 200 V, 150 V, 100 V, and 50 V.

(e) What is $\lambda$ in this case? With a pencil, add appropriate electric field-lines to the equipotentials.


* SPN 3–10. Real capacitors can be made by coating a thin plastic film with an aluminum electrode on both sides, and then rolling it up to make it strong (and compact). The plastic roughly triples the capacitance compared to vacuum (we will see why in Chapter 4). Consider the unrolled capacitor. It is two electrodes separated by 0.01 mm of plastic. The capacitor is 3 cm wide and 3 meters long. What will its total capacitance be? (Come up with a number).

* SPN 3–11. We’ve done cylindrical and planar capacitors now. The third “easy” capacitor to calculate is two concentric spheres (even if it’s not practical). Consider oppositely charged concentric spheres of radii one and two meters. 1000 Volts is applied between them. What is their capacitance, and what are their charges?