1. Draw a very long, straight, uniformly charged wire and a small charged particle held near the wire.
   a. If the wire and the particle have similar charges then they will _____ each other. (attract, repel) If they have opposite charges then they will ______. In *either* case the force is ________ to the wire.
   b. If the force exerted on the particle by the wire is divided by the charge of the particle the result is called the _______ of the wire's electric _______. Is that definition still on p. 118 and RS XIII? ___
   c. Use 1b and 1a to sketch the wire's field map as seen from the side and also as seen from the end.
   d. The line-density theory in #9 on RS XIII suggests that the *wire's* electric field is ____est near the wire and ____er at locations far from the wire. Illustrate by sketching a graph of E vs distance.
   e. The shape of this graph implies that the exponent in the relation will have a _____ sign.

2. Draw a straight line near the middle of a sheet of paper to represent the wire. Draw a dotted line perpendicular to the wire, starting from any point "A" on the wire. Label another point "P" somewhere on the dotted line, fairly far from the wire. Pretend that there is a charged particle at P.
   a. Mark a very short segment of the wire some distance from A. Label it "S". Very lightly draw a pair of lines from P to the two endpoints of S to form a very small angle with its vertex at P.
   b. If segment S is very short compared to distance SP then we can use Coulomb's law (#7 on RS XIII) to predict the force exerted *on the particle* at P *by the charged segment* S: **F =** _________
   c. In that equation the force exerted on the particle by segment S is represented by the symbol "__". The charge of the *particle* is represented by "__", the charge of the *segment* is represented by "__", and "___" represents the distance between the _____ and the ____. As usual, Coulomb's constant is represented by the letter "__". (Copy from RS XIII.)

3. If we double the distance AP without changing any angles then distance PS is ______ed.
   a. If that were the only change, the force exerted on the particle by the segment would have ___creased by a factor of ___, because F is proportional to ____.
   b. But the length of the segment must also have been ________ed. Because the wire was uniformly charged, the new segment must contain ___ times as much charge as the old one.
   c. Using **both** 3a and 3b, we see that the force is multiplied by ___ whenever the distance is doubled.
   d. Is 3c true for ***every*** segment of the wire? ___ (* If not, please explain.)
   e. Is it therefore true for the **SUM** of the forces exerted on the particle by **ALL** of the segments? ___
   * f. What can you conclude *about the exponent mentioned in 1e?* Write your conclusion on the back of this page, using the word "proportional". *It must be self-contained and always true.*

* 4. Describe the electric field generated by a uniformly charged **plane** which is infinitely long and wide. (Use logic similar to #1.) Near the plane are the field lines straight or curved? Which way do they point? What does this field map imply about the relation between field strength and distance from the plane? (Use #9 on RS XIII to form a hypothesis. Then prove or disprove it with logic similar to #2 & 3, by dividing the plane into small patches.) *Do not allow #4 to contradict 3f.*

5. Imagine two parallel planes with equal but opposite charges. The field anywhere is just the ______ sum of the fields created by the two uniformly charged planes. Let "E" represent the strength of the field produced by *one* plane. Between the planes, the vector sum of the two fields produced by the two planes is ____. At other locations (*not* between them) the sum is ____. *Begin with a diagram.*

6. Suppose there is a vacuum between the two charged planes in #5. The plate separation and potential difference are known. A particle with known positive charge is placed in contact with the positive plate near its center. When released it flies to the other plate, as on p. 246 in PSSC text. (5th edition)
   a. Using the definition of "voltage" or "potential difference" on RS IX, write a formula for calculating the work done on the particle by the electric field. **Work =** _____
   b. Sketch a graph of electric force vs particle displacement. (Use #4 & #5 above.)
   c. How can the work done on the particle be determined from that graph? (Use #1 on RS VI.) ______
   d. Show how the electric force can be determined from the work and the plate separation: **F =** ___
   e. Combine 6a with 6d to show how the force exerted on the particle by the plates can be determined from the plate voltage, plate separation, and charge of the particle. *Define your symbols.* **F =** ______
   f. Use the definition of "E" to eliminate the force from equation 6e.
   g. Solve 6f for "E". Check units and then copy the resulting formula into #11 on RS XIII. **E =** ____
   h. A tiny hole is drilled where the particle would have hit the target plate: According to #5, what must happen to the particle's motion after it passes through the hole? -Does p. 105 agree?___

* 1. In #11 on RS XIII you recorded a formula for the electric field strength between two oppositely-charged parallel plates. Exactly how must the plate voltage and the electric field strength be affected if we double the plate separation without changing the charges of the plates? *Please explain.*

* 2. If you were asked to measure the strength of an electric field today in the laboratory, could you do it?
-If so, please describe the procedure and explain what difficulties you might encounter.
-If not, explain why not.

* 3. Suppose you needed to *produce* an electric field with some specified strength.
Would you be able to do it, using equipment now available? (Explain)

4. Imagine a parallel-plate capacitor with air or vacuum between its plates. Let the vector "E" represent the electric field in the space between the plates; let "s" represent the plate separation, i.e. the distance between the plates. Imagine a single electron with charge "q" being removed from the positive plate and being transported directly to the negative plate without leaving the region between the plates.
   a. Use the definition of "E" (on RS XIII) to create a formula for the electric force exerted on the particle while it is between the plates: **F =** ____
   b. Now suppose the plate separation is small compared to the length and width of the plates: Will the electric force depend on the particle's location in the region between the plates? ____
   c. Use the symbols defined above to write a formula for the work done on the electron as it is moved from one plate to the other. **W =** ____
   d. If you divide that work by the charge of the electron you get a quantity that should be familiar to you. (See RS XIII or page 104.) Give its name and its units: _____ ____ in ____
   * e. You have just discovered a new formula. State it clearly and describe its limitations. Then explain how it can be used to solve problem #3, above.
   * f. Electric field strengths are sometimes expressed in "volts per meter". Explain why and show how to convert to more familiar units.

5. Example: Calculate the potential difference required to produce an electric field of 500 N/C between parallel plates 0.25 meters apart.

6. A new energy unit: If the electron in #4 is released near the negative plate, it will be pulled back to the positive plate. On the way it will lose potential energy and gain ____ energy.
   a. What causes it to accelerate? _______
   b. How can the force acting on it be calculated from q and E? **F =** ____
   c. Let "V" represent the potential difference between the plates. How is the work done on the particle related to q and V? **W =** _____
   d. If the charge is measured in coulombs and the potential difference is in volts, what units will the formula give you for work? (Simplify by using the definition of a "volt" on RS VIII.) _____
   e. It is sometimes more convenient to express the charge of a particle in terms of electrons instead of in coulombs. What work units do we get in that case? ________
   f. Define an "electron-volt", or "ev". ___________________
   g. Particle accelerators used to be rated in terms of "Kev" (kilo-electron-volts), or "Mev" (mega-electron-volts). Now we often read about accelerators in the "Gev" (giga-electron-volt) and "Tev" (tera-ev) ranges. What do these terms mean?

7. Measuring Coulomb's Constant: (adapted from the PSSC physics text) Two identical charged spheres are prepared. The electrostatic repulsion force between them is measured with a sensitive balance. At 0.15 meter separation it is found to be $6.7 \times 10^{-4}$ newton ± 5%. One of the spheres, still charged and still attached to the balance, is then placed between two oppositely charged plates. The plate separation is 0.31 meters. Their potential difference is provided by 300 batteries in series. Each battery has an emf of 90 volts. We find that when the sphere is between the plates it experiences an electric force of $3.55 \times 10^{-3}$ newton ± 1%.
   * a. Calculate the sphere's charge, showing how you get your result.
   * b. Show how Coulomb's constant can be determined from these results.
   * c. Show how the uncertainty of that result is calculated from the given information.