Physics 202-Section 2G
Worksheet 2- Lecture 3

Formulas and Constants
Electric field resulting from a charge:

$$E = \frac{kq}{r^2}$$

Force on a charge in an electric field:

$$F = Eq$$

Electric potential* (also called “potential difference” ; measured as volts):

$$V = \frac{kq}{r} = Er$$

Electric field in terms of electric potential (V):

$$E = \frac{\Delta V}{r}$$

Energy (work) of particles in electric systems (W or U or EPE**)

$$W = \frac{kQq}{r} = Vq$$

*Remember that forces and electric fields both have magnitudes and directions, and are treated as vector quantities, but electric potential (V) is a scalar quantity expressed without a direction.
**EPE (electric potential energy) describes the energy stored in a particle in an electrical system. Like an object in a gravitational field at any height above the earth’s surface has gravitational potential energy, a charge in an electric field can have electric potential energy.

1. Electron volts (eV) are a unit used to measure:
   A. charge
   B. energy
      Don’t be confused by the “volt” part of electron volts. Electron volts are a unit of energy. One eV is the amount of energy gained (or lost) when an electron moves across an electric potential difference of one volt.One eV is 1.6E-19 joules. This number look familiar? It’s the same number as the charge on an electron.
   C. electric potential
   D. current

2. Consider the following charge distribution:

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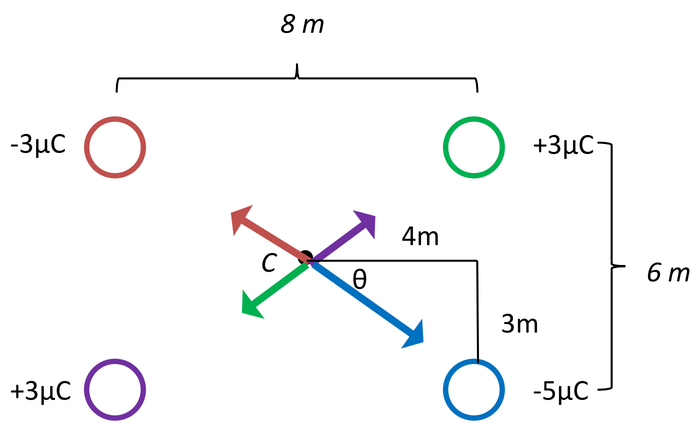
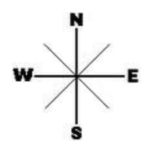




a. Assuming C is directly at the center of the rectangle formed by the 4 charges, find the electric field at point C.

Magnitude **720 N/C** Because point C is directly in the center, it is equally distant from every charge in the charge distribution. We can start by drawing arrows that represent each electric field's pull on point C. To find direction of an electric field at a certain point, we should pretend there is a "small positive test charge" at point C. If this is the case, the pulls and pushes shown in the diagram above (by colored arrows) will exist. We can see that the electric fields from the top right and botton left charges of the rectangle will cancel out (because both of these charges have the same magnitude and sign (+3 microcoulombs). Thus, we only need to calculate the electric fields resulting from the -3 and -5 charges. Using the E = kq/r^2 formula for electric field, we'll need to find the distance "r" between the corner charges and point C. Here comes the trig! Because we know that the total distance across the top is 8m and the total distance down the side is 6m, point C is 4m to the side of each charge and 3m up or down from each charge. Using the pythagorean theorem, we find that the exact distance between point C and any charge is 5m. Now we plug this into our formula, and we find that the E resulting from the -5 charge is 1800 N/C and the E resulting from the -3 charge is 1080 N/C. Because the magnitude of the field from the -5 charge is bigger, the direction of the overall electric field will point towards the -5 charge. So we subtract 1080 from 1800 and get 720.

Direction **36.9° south of east** Use trigonometry again. We need to find the angle identified in the figure above, and we know the side lengths of a triangle forming that angle. Tan (angle) = opposite/adjacent = ¾, so angle = $\tan^{-1}(3/4)$ = 36.9 degrees.

b. Find the electric potential resulting from the 4 charges at point C.

Potential: **-3600 V** Electric potential is not a vector quantity, so none of the electric potentials caused by the charges in the above rectangle can cancel. We have to add the 4 electric potentials all together: kq/r +kq/r +kq/r +kq/r. For all of these, r will be 5m, and q will be the charge. **Don't forget to include the signs of the charges here.** We're not determining a direction later so the sign of the charge is important. The resultant potential is -3600 V.

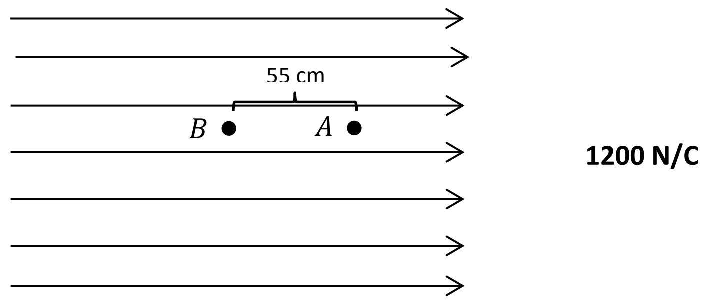
3. A charged particle (+14 μC) releases 0.03 J of energy as it moves between two points (from point A to point B). What is the potential difference between the two plates?

Potential difference: **2142.86** Units: (newtons, joules, **volts**, coulombs) From the formulas above, we know that W (energy or work) = kQq/r. kQ/r is the formula for potential difference, so we can also say that W = Vq. We know how much energy is released, so we know W, and we know the charge on the particle that moves (14 microcoulombs), so we can divide W by q to find the value of V. 0.03/14e-6 = 2142.86 V.

4. A charged particle is placed between two charged plates (4 cm apart) that create a uniform electric field (1000 N/C). The particle is released from rest **at the positive plate** and it accelerates toward the negative plate. When it reaches the negative plate, it's kinetic energy is 3000 eV. What is the charge on the particle? Be sure to state whether the charge is positive or negative.

Charge: **+1.2E-17 C** Ok, so first lets determine whether this charge is positive or negative. It accelerates from the positive plate toward the negative plate, so it must be attracted the negative plate and so must be a positive charge. Now right before the particle was released at the positive plate, it possessed an electric potential energy, and once it hit the negative plate, it only had kinetic energy. So the initial electric potential energy must equal the kinetic energy immedately before the particle touches the negative plate. So we can set KE and EPE equal to each other: KE = Vq. Because V = Er, another way to express this is: KE = Erq. Substitute in the given values of KE, E, and r. Remember to convert eV to joules first!!! One eV is 1.6E-19 joules.

5. In the electric field shown below, how much work is required to move a proton from point A to point B?



Work**: 1.056e-16 J** Use the same subsituted formula for work from the previous problem. W = kqq/r = Vq = Erq.

Express the above quantity as electron volts (eV): **660 eV** Simply divide the previous answer by 1.6e-19 because there are 1.6e-19 joules in one eV.