PreAP Electrostatics 5

You should already know that Electric Forces (like all forces) and Electric Fields are vectors and that Electric Potential Energy (like all energy) and Electric Potential (voltage) are scalars. You should also know their units and that anything that is per C (N/C or J/C) is about the position, not the charge at that position.

Let's start with some unit stuff.

1. A 6C charge is at a position that has an electric potential of 0.5 V.
   A. How much potential energy does it have?

   B. If it is released from this position, how much kinetic energy would it have after a long time?

2. A −0.2C charge is placed at a point in space that has a 4 N/C electric field.
   A. How much force does it feel?

   B. If released, does it move with or against the field?

3. 15 J of work is necessary to bring a 3 C charge to a particular position.
   A. What is the electric potential (voltage) at that position?

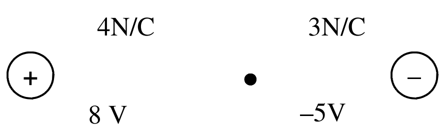
   B. How much kinetic energy will it gain after it is released?

4. A +5C charge feels 2.5 N of force when it is at a particular position.
   A. What is the electric field strength at that position?

   B. If released, will the charge move with or against the field?

Let's reinforce the ideas of scalar and vector and the direction of E. (*The numbers are made up.)*

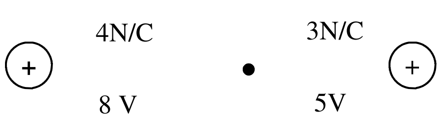
5. The diagram below gives the Electric Field strengths and Electric Potential for a given point between two charges.



   A. To find the direction of the electric field put a small + test charge at the point and draw the direction it would move to the other charges.
   B. Calculate the net electric field at the point (and give direction).

   C. Calculate the net electric potential at the point.

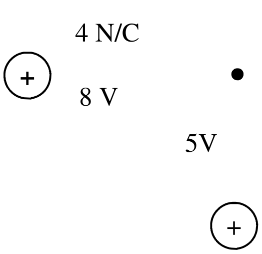
6. The sign of the right charge is changed, as shown. Notice the magnitudes stay the same.



   A. Again, using a + test charge to decide direction, draw the electric fields pushing or pulling at the point, due to the other charges.
   B. Calculate the net electric field at the point (and give direction).

   C. Calculate the net electric potential at the point.

7. The right charge is now moved directly below the point.



   A. Draw the individual electric fields pushing or pulling at the point. Then draw the direction of the net field.
   B. Calculate the net electric field at the point (and give direction).

   C. Calculate the net electric potential at the point.

$$F_e = k_c \frac{|q_1 q_2|}{r^2}$$

1A. (0.5J/C)6C = 3 J

1B: 3 J. PE = KE = W

2A: (4N/C)(0.2C) = 0.8 N (mag only)

2B: * against (opp) field since E is direction a +q would move.

3A: 15J/3C = 5 J/C = 5 Volts

3B: 15 J (KE = W)

4A: 2.5N/5C = 0.5 N/C

4B: E is what + charge would move, so "with the field"

5A: It is a push from the left charge and a pull from the right charge.

5B: 7 N/C to the right (add them together, since both are to right)

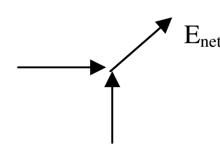
5C: 8−5 = 3 Volts (no direction: scalar)

6A: Push from left; push from right

6B: 1N/C to the right (4 is > 3), so +4−3 = +1 (and + is to the right)

6C: 8+5 = 13 V

7A:



7B: 3,4, 5 triangle, so 5N/C
$\theta = \tan^{-1}(y/x) = 36.9°$

7C. 8 + 5 = 13 V (*don't ya just love scalars*!?!)

$$F_e = k_c \frac{|q_1 q_2|}{r^2} \qquad E = k_c \frac{q_1}{r^2} \qquad PE = k_c \frac{q_1 q_2}{r} \qquad V = k_c \frac{q_1}{r}$$

Let's now learn better how to move between the four electrostatic equations. (And units may also help.)

8. How do you get the electric field equation from the force equation?

9. How can you easily calculate the electric potential (voltage) given the electric field?

10. How do you calculate the potential energy from the force?

11. Given E, how do you calculate F?

8. divide by the q at the given position
9. Mult by r
10. Mult by r
11. Mult by the q at the given position

Remembering that $\mu C = \times 10^{-6} C$, $mm = \times 10^{-3} m$ *and* $k = 9\times 10^{9}$ …

12. Two charges are separated as shown below. (*Answers below [I needed more room.*])

8μC ⊕ 3 mm ⊕ 3μC

A. Calculate the electric field at the position of the 3μC charge.

B. Calculate the force on the 3μC charge.

C. Calculate the voltage of the 3μC charge's position.

D. Calculate the potential energy of the 3μC charge.

12A) $$E = k_c \frac{|q_1|}{r^2} = \frac{|9E9(8E-6)|}{(3E-3)^2} = 8E9\ N/C$$

12B) $$F_e = k_c \frac{|q_1 q_2|}{r^2} \qquad Fe = \frac{9E9(8E-6)(3E-6)}{(3E-3)^2} = 2.4\times 10^4 N \quad or \quad F_e = qE = C(N/C) = 8E9(3E-6) = 2.4E4N$$

12C) $$V = k_c \frac{q_1}{r} = \frac{9E9(8E-6)}{(3E-3)} = 2.4E7\ \mathrm{J}/C \qquad OR\ \ \mathrm{V} = \mathrm{E(r)} = 8E9(3E-3) = 2.4E7 J/C$$

12D) $$PE = k_c \frac{q_1 q_2}{r} = \frac{9E9(8E-6)(3E-6)}{(3E-3)} = 72J \qquad OR\ \ PE = qV = (3E-6)(2.4E7) = 72J$$

* Explanation to 2B: Electric fields are defined by the direction a + test charge would move. A negative charge would go the opposite way. On 2B, just because it is a negative charge, you know it will move against the field. The 4N/C is the strength of the electric field a certain distance (r) from a charge. You don't know if the charge creating the field is + or −, just the strength at that point. It could be pointing toward a −q or away from a +q. The −0.2C charge will then either go away from a −q or toward a +q, opposite the direction of the field.