Name________________________________Pd________

Do Electric Fields Have Potential?

1. A positive test charge of $6.5 \cdot 10^{-6}$ C experiences a force of $4.5 \cdot 10^{-9}$ N. What is the magnitude of the electric field at that point?

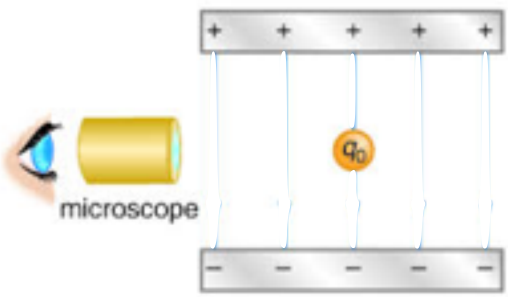
$E = F/q = (4.5 \cdot 10^{-9})/(6.5 \cdot 10^{-6}) = 0.00069$ N/C $= 6.9 \cdot 10^{-4}$ N/C (or V/m)

2. In an old-fashioned TV picture tube, electrons were accelerated from rest to very high speeds through a potential difference of 22,000 V. At what speed would an electron be moving just as it struck the TV screen?

$E_{PE} = qV = (1e)(22000\text{ V}) = 22000\text{ eV} = 3.52 \cdot 10^{-15}$ J

$E_{PE} = E_K$ So, $3.52 \cdot 10^{-15} = \frac{1}{2}(9.11 \cdot 10^{-31})v^2$

$v = 8.8 \cdot 10^{7}$ m/s (29% the speed of light!)



3. An oil drop carries a charge equal to that of three electrons and is balanced in an electric field of intensity $5 \cdot 10^{4}$ N/C. What is the weight of the oil drop, and which way is the electric field pointing?

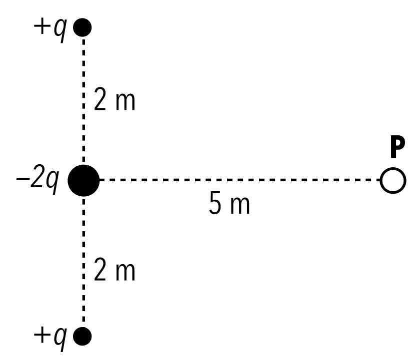
$F_E = qE = 3(1.6 \cdot 10^{-19})(5 \cdot 10^{4}) = 2.4 \cdot 10^{-14}$ N since the oil drop is balanced in the field, $F_E = F_G$

The electric field must point downward. If the drop has a negative charge, it must be pushed upward by the field, which means a small, positive test charge would move downward in the field. The field ALWAYS points in the direction a small, positive test charge would move.

4. Why do electric field lines never cross?

Since electric field lines point in the direction a small, positive test charge would move, if the lines crossed it would mean the test charge would move in two directions at once, which is impossible!

5. If $q = 1 \cdot 10^{-8}$ C, what is the voltage at point P?



Since voltage is a scalar it does not have a direction. It also doesn't depend on any charge being placed at a point, but only on the charges around a point. We can find the voltage due to each individual charge and add them together:

We do need to know the distances from the charges to point P. The distance from the positive charges to point P is $\sqrt{(29)}$ m or 5.385 m

$V_{top} = V_{btm} = kQ/d = 9 \cdot 10^{9}(10^{-8})/5.385 = +16.713$ V

$V_{mid} = kQ/d = 9 \cdot 10^{9}(-2 \cdot 10^{-8})/5 = -36$ V

So, adding the three voltages together gives: −2.574 V

6. A proton is moved 15 cm on a path parallel to the field lines of a uniform electric field of $2 \cdot 10^{5}$ V/m.
   a) What is the change in the proton's potential (Consider both cases of the proton moving with and against the field)?
   b) What is the change in energy of the proton (in eVs)?
   c) How much work would be done if the proton were moved perpendicular to the electric field's direction?

a) $V = Ed = 2 \cdot 10^{5}(0.15) = 30{,}000$ V If the proton moves with the field it loses energy so $\Delta V = -30000$ V

If the proton moves against the field, work is done, so there's a gain in energy $\Delta V = +30000$ V

b) $E_{PE} = qV = (1\text{ e})(30000\text{ V}) = 30000$ eV The sign would be the same as in the previous problem depending on the direction it moves

c) When moved ⊥ to the field lines, it moves along an equipotential, which means there's no change in energy, and no work done!