PHY101 : HW 8 Solutions   Fall 2017

1. Use $U_E = k_e \frac{q_1 q_2}{r} = \frac{\left(8.9\times10^9 \frac{Nm^2}{C^2}\right)(5\times10^{-6}C)(-2\times10^{-6}C)}{5m} = \underbrace{-1.8\times10^{-2}J}$

2. a) To find V, the electric potential, use $V = \frac{k_e Q}{r}$. Since there are two charges, the voltages are added together, or $V_{point\,a} = \frac{k_e Q_1}{r_1} + \frac{k_e Q_2}{r_2}$
$= \left(8.9\times10^9 \frac{Nm^2}{C^2}\right)\left(\frac{2.5\times10^{-9}C}{.05m} + \frac{(-2.5\times10^{-9}C)}{.15m}\right) = \underbrace{300V}$ at point a.

Also, $V_{point\,b} = \frac{k_e}{r_b}(q_1+q_2) = \frac{k_e}{r_b}(2.5\times10^{-9}C - 2.5\times10^{-9}C) = \underbrace{0V}$
(distance is the same)

b) Using Work $= q\Delta V = q(V_{point\,b} - \infty) = q(0V - 0V) = 0J$, where V_∞ is the voltage at $r=\infty$.

3. Using the conservation of kinetic and electric potential energies (the only types of energies involved here), we have $K_i + U_{Ei} = K_f + U_{Ef}$, or

$$K_F = K_i + U_{Ei} - U_{Ef} = K_i - \Delta U_E = K_i - q\Delta V = K_i - (2e)(\Delta V)$$

$$= 1.2\times10^{-16}\,J - 2(1.6\times10^{-19}\,C)(-.5\,mV) = 1.2\times10^{-16}\,J - 2(1.6\times10^{-19}\,C)(.5\times10^{-3}\,V)$$

$$= \underbrace{2.8\times10^{-16}\,J}$$

(4) a) Let's first find the capacitance, then ΔV, and then E (direction and magnitude). For a parallel plate capacitor, $C = \frac{\varepsilon_0 A}{d}$

$$= \frac{(8.85\times10^{-12}\,\frac{C^2}{Nm^2})(1\times10^{-4}\,m^2)}{(.25\times10^{-3}\,m)} = 3.54\times10^{-12}\,F.$$

Then $\Delta V = \frac{Q}{C} = \frac{4\times10^{-12}\,C}{3.54\times10^{-12}\,F} = 1.13\,V$ and $E = \frac{\Delta V}{d} = \frac{1.13\,V}{.25\times10^{-3}\,m} = 4.52\times10^{3}\,\frac{V}{m}$

with the direction toward the negative plate.

b) Since $\Delta V \propto d$, if d doubles, then ΔV also doubles, while E stays the same since it is determined by the ratio of the two.

(5) To find ΔV between the birds' feet, use $\Delta V = IR$. To find R, use $R = \frac{\rho L}{A}$, where A is the cross-sectional area of the wire, or $A = \pi r^2 = \pi\left(\frac{d}{2}\right)^2$,

where r is the radius and d, the diameter. So $R = \frac{(2.65 \times 10^{-8}\ \Omega m)(.02 m)}{\pi \left(\frac{.02 m}{2}\right)^2}$ such

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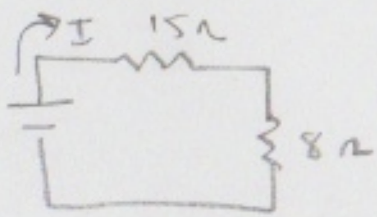
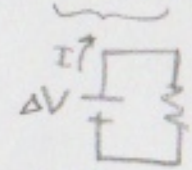
that $\Delta V = \frac{(150 A)(2.65 \times 10^{-8}\ \Omega m)(.02 m)}{\pi \left(\frac{.02 m}{2}\right)^2} = \underbrace{2.5 \times 10^{-4}\ V}$.

(6) The 12Ω and 24Ω resistors are in parallel so combining them into one equivalent resistor leads to $\frac{1}{R_{eq_1}} = \frac{1}{12\Omega} + \frac{1}{24\Omega} = \frac{2+1}{24\Omega} = \frac{3}{24\Omega} = \frac{1}{R_{eq_1}}$

$\Rightarrow R_{eq_1} = \frac{24\Omega}{3} = 8\Omega$.

Now we have 

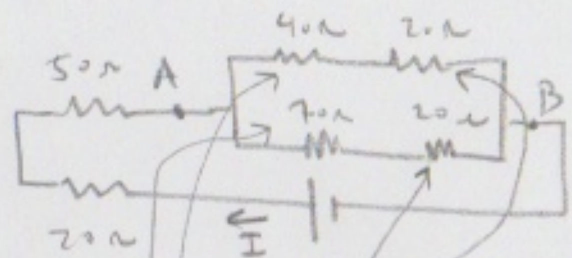
. So the 15Ω and 8Ω resistors are in series. To reduce them to one equivalent resistor, we add them to arrive at $R_{eq} = 15\Omega + R_{eq_1} = 15\Omega + 8\Omega = \underbrace{23\Omega}$.

b) Now that we have simplified the circuit to 

R_{eq}, we can use $\Delta V = IR_{eq}$ to find I in the circuit, or $\frac{\Delta V}{R_{eq}} = I = \frac{276 V}{23\Omega} = 12 A$.

Since 12Ω resistor is in parallel with the 12Ω resistor, some of the current will pass through the 12Ω and some, the 24Ω. To determine how much respectively, find ΔV across the 12Ω resistor and then use $I_{12\Omega} = \frac{\Delta V_{12\Omega}}{R}$ to find the current through it. First, the voltage drop across both the 12Ω and 24Ω resistors is $\Delta V_{12\Omega} = (12A)(\underbrace{8\Omega}_{R_{eq_1}})$ $= 96V = \Delta V_{24\Omega}$ (since they are in parallel, the voltage drop across them is the same). Then $I_{12\Omega} = \frac{96V}{12\Omega} = 8A$ and $I_{24\Omega} = \frac{96V}{24\Omega}$ $= 4A$.

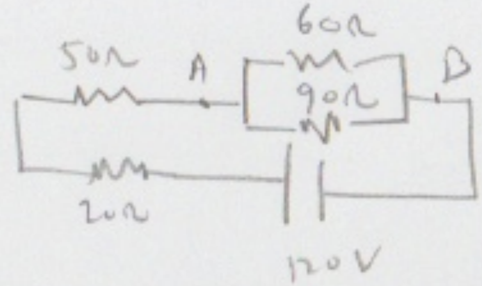
(7) a) start w/



. To find the current that flows from the battery, find R_{eq} for this circuit first and then invoke Ohm's law.

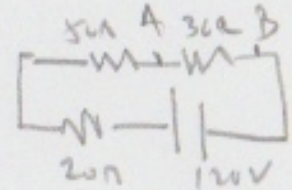
To find R_{eq}, the 40Ω and 20Ω resistors are in series as are the 70Ω and 20Ω.

So we have

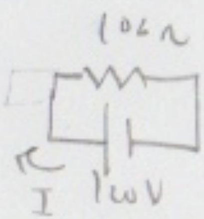


. Now these "new" 60Ω and 90Ω resistors are in parallel, so $\frac{1}{R_{eq_1}} = \frac{1}{60\Omega} + \frac{1}{90\Omega} = \frac{6+4}{360\Omega} = \frac{10}{360\Omega} = \frac{1}{R_{eq_1}}$

$\Rightarrow R_{eq_1} = \frac{360}{10}\Omega = 36\Omega$. Then,



, all three resistors are now in series, so $R_{eq} = 20\Omega + 50\Omega + 36\Omega = 106\,\Omega$ and



with $I = \frac{120V}{106\Omega} = 1.13A$,

b) Since the 36Ω is the only one between points A and B, then $\Delta V_{AB} = (1.13A)(36\,\Omega) = 40.75\Omega$ given that there is only one path for the current to flow from the battery until point A.

c) At the junction point right after A, the current splits. How does

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it split ? Well, the current through the top wire (branch) is $\frac{40.75\,V}{60\,\Omega} = 0.68\,A$ and through the bottom wire is $\frac{40.75\,V}{90\,\Omega} = 0.45\,A$.

d) Use Power $= I^2 R = (0.68\,A)^2 (40\,\Omega) = 18\,W$.