Hwk 5 Solutions   PHYS 142   Summer '09   Dr Jenkins

Problem 28.5

(a) first get an equivalent resistance for the 2 parallel resistors

$$\frac{1}{R'_{eq}} = \frac{1}{R_3} + \frac{1}{R_4} \Rightarrow R'_{eq} = \frac{R_3 R_4}{R_3 + R_4}$$

$$R'_{eq} = \frac{(7.0\Omega)(10.0\Omega)}{17.0\Omega} = 4.12\,\Omega$$

now all 3 in series:

$$R_{eq} = R_1 + R_2 + R'_{eq} = 4.0\Omega + 9.0\Omega + 4.12\Omega = 17.1\,\Omega$$

(b) $V_{TOT} = I R_{eq} \Rightarrow I = \frac{V_{TOT}}{R_{eq}} = \frac{34.0\,V}{17.1\Omega} = 1.99\,A$

for the 4Ω and 9Ω resistors, this is the current:

$$I_1 = I_2 = I = 1.99\,A$$

for the parallel resistors:

$$V'_{eq} = I R'_{eq} = 1.99A\,(4.12\Omega) = 8.18\,V$$

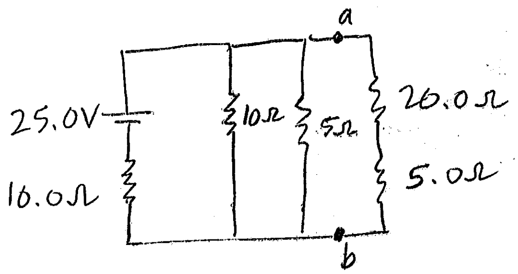
$$V'_{eq} = V_3 = V_4$$

$$\Rightarrow I_3 = \frac{V'_{eq}}{R_3} = \frac{8.18\,V}{7.0\Omega} = 1.17\,A$$

$$I_4 = \frac{V'_{eq}}{R_4} = \frac{8.18V}{10.0\Omega} = 0.818\,A$$

Problem 28.7

(a) redraw the circuit in a more typical fashion:



get eq resistance for parallel stuff:

$$R_{\parallel} = \left(\frac{1}{10\Omega} + \frac{1}{5\Omega} + \frac{1}{20\Omega + 5\Omega}\right)^{-1} = 2.94\Omega$$

current through battery is

$$I = \frac{V_{Tot}}{R_{eq}} \quad w/ \quad R_{eq} = R_{\parallel} + 10\Omega + 12.94\Omega$$

$$I = \frac{25.0\,V}{12.94\Omega} = 1.93A$$

$$V_{\parallel} = I R_{\parallel} = 1.93A\,(2.94\Omega) = 5.68\,V$$

current then through 20Ω resistor (and 5Ω) is:

$$I_{20} = \frac{V_{\parallel}}{20\Omega + 5\Omega} = \frac{5.68\,V}{25.0\Omega} = 0.227A$$

(b) V_{ab} is just $V_{\parallel} = 5.68\,V$

Problem 28.15

get I through battery:

need R_{eq}:

$$R_{\parallel} = \frac{(1.0\Omega)(3.0\Omega)}{4.0\Omega} = 0.75\Omega$$

$$R_{eq} = 2.0\Omega + 4.0\Omega + 0.75\Omega = 6.75\Omega$$

(Prob 28.15) cont.

$$I = \frac{V_{bat}}{R_{eq}} = \frac{18.0V}{6.75\Omega} = 2.67A$$

this is the current through the 2Ω and 4Ω resistors, so:

$$P = I^2 R \Rightarrow P_2 = (2.67A)^2(2.0\Omega) = 14.2W$$

$$P_4 = (2.67A)^2(4.0\Omega) = 28.4W$$

for parallel guys, need $V_{\parallel}$:

$$V_{\parallel} = I R_{\parallel} = 2.67A(0.75\Omega) = 2.0V$$

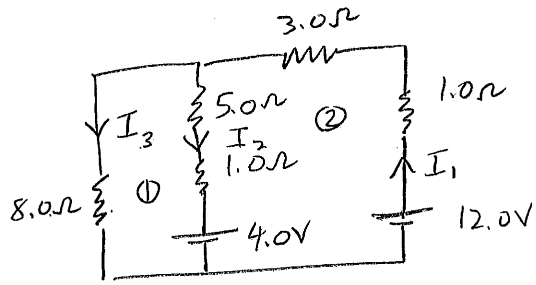
same for 1Ω and 3Ω:

$$P = \frac{V^2}{R} \Rightarrow P_3 = \frac{(2.0V)^2}{3.0\Omega} = 1.33W$$

$$P_1 = \frac{(2.0V)^2}{1.0\Omega} = 4.00W$$

Problem 28.17

use Kirchoff's rules w/ currents labeled as shown:



$I_1 = I_2 + I_3$

loop ①:

$$4.0V + I_2(1.0\Omega + 5.0\Omega) - I_3(8.0\Omega) = 0 \Rightarrow 4 + 6I_2 - 8I_3 = 0$$

loop ②:

$$12.0V - I_1(1.0\Omega + 3.0\Omega) - I_2(5.0\Omega + 1.0\Omega) - 4.0V = 0$$

$$\Rightarrow 8 - 4I_1 - 6I_2 = 0$$

$$\Rightarrow I_2 = \frac{4}{3} - \frac{2}{3}I_1$$

plug in ① w/ $I_3 = I_1 - I_2$

$$4 + \cancel{6}^{2}\left(\frac{4}{\cancel{3}} - \frac{2}{\cancel{3}}I_1\right) - 8\left(I_1 + \frac{2}{3}I_1 - \frac{4}{3}\right) = 0$$

(Prob 28.17) cont.

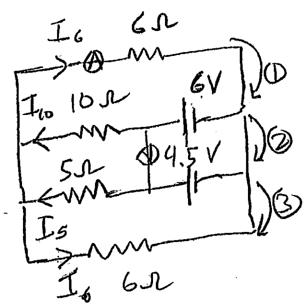
$$4 + 8 - 4I_1 - 8I_1 - \frac{16}{3}I_1 + \frac{32}{3} = 0$$

$$\Rightarrow I_1 = \frac{12 + \frac{32}{3}}{12 + \frac{16}{3}} = 1.31\ A$$

$$\Rightarrow I_2 = \frac{4}{3} - \frac{2}{3}(1.31A) = 0.462A$$

$$I_3 = I_1 - I_2 = 1.31A - 0.462A = 0.846A$$

Problem 28.21



loop rules (note since ΔV is the same for all branches, I is same through top and bottom):

① $6V - 10\Omega\, I_{10} - 6\Omega\, I_6 = 0$

② $4.5V - 5\Omega\, I_5 + 10\Omega\, I_{10} - 6V = 0$

③ $4.5V - 5\Omega\, I_5 - 6\Omega\, I_6 = 0$

④ $I_5 + I_{10} = 2I_6 \Rightarrow I_5 = 2I_6 - I_{10}$

from ② using ④

$$5I_{10} - 10I_6 + 10I_{10} = 1.5 \Rightarrow I_{10} = 0.1 + \frac{2}{3}I_6$$

plug in ①

$$6 - 1 - \frac{20}{3}I_6 - 6I_6 = 0 \Rightarrow \left(\frac{20}{3} + 6\right)I_6 = 5$$

$\Rightarrow I_6 = 0.395\,A$ reading on meter A

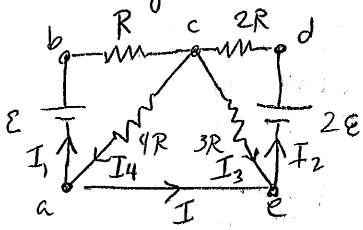
do loop rule on small loop with batteries and meter only:

$$6.0V - \Delta V - 4.5V = 0$$

$$\Rightarrow \Delta V = 1.5V$$

Problem 28.22

let's temporarily switch circuits to eleminate variables;



$$R_{eq} = \frac{(4R)(3R)}{7R} = 1.71R$$

now use loop rule eqns:

① $250 - I_1 R - (I_1 + I_2)\,1.71R = 0 \Rightarrow 2.71 R I_1 + 1.71 R I_2 = 250$

② $500 - 2I_2 R - (I_1 + I_2)\,1.71R = 0 \Rightarrow 1.71 R I_1 + 3.71 R I_2 = 500$

$\Rightarrow I_1 = 0.010\ A \quad , \quad I_2 = 0.130\ A$

now

$$\Delta V_{ca'} = \Delta V_{ca} = \Delta V_{ce} = (I_1 + I_2)\,1.71R = (0.140A)(1.71)(1000)$$

$$\Delta V_{ca} = 240V$$

$$I_4 = \frac{\Delta V_{eq}}{4R} = \frac{240V}{4(1000\Omega)} = 0.060\ A$$

now use current sum rule at point a:

$I_4 = I_1 + I \Rightarrow I = I_4 - I_1 = 0.060\ A - 0.010\ A = 0.050\ A$

Problem 28.28

$$V(t) = V_0 \left(1 - e^{-t/RC}\right)$$

solve for R

$$e^{-t/RC} = 1 - \frac{V(t)}{V_0} \Rightarrow \frac{-t}{RC} = \ln\left(1 - \frac{V(t)}{V_0}\right)$$

$$\Rightarrow R = -\frac{t}{C \ln\left(1 - \frac{V(t)}{V}\right)} = \frac{-3.0s}{1.0\times10^{-5}F \ln\left(1 - \frac{4V}{10V}\right)} = 5.87\times10^{5}\ \Omega$$

Problem 28.32

(a) $\tau = RC = (1.0\times10^5\,\Omega + 5.0\times10^4\,\Omega)(10.0\times10^{-6}\,F) = 1.50\,s$

(b) only 100kΩ resistor will affect capacitor charge

$\tau = (1.0\times10^5\,\Omega)(10.0\times10^{-6}\,F) = 1.00\,s$

(c) battery side current:

$$I = \frac{V_{bat}}{50k\Omega} = \frac{10.0V}{5.0\times10^4\,\Omega} = 2.0\times10^{-4}\,A$$

capacitor side is:

$$I = I_0 e^{-t/RC} = \left(\frac{10.0V}{1.0\times10^5\,\Omega}\right) e^{-t/1.00s}$$

total current then is:

$$I(t) = 2.0\times10^{-4}A - 1.0\times10^{-4}A\, e^{-t/1.00s}$$

Problem 29.1

using $\vec{F} = q\vec{v}\times\vec{B}$ and right-hand rule:

(a) up

(b) out of page (don't forget to acct for sign)

(c) $\vec{F} = 0$, no deflection

(d) into page (mag. $qvB\sin 45$)

Problem 29.6

(a) need speed:

$$\Delta K = \Delta U = e\Delta V \Rightarrow \frac{1}{2}mv_f^2 = e\Delta V \Rightarrow v_f = \sqrt{\frac{2e\Delta V}{m}}$$

$$v_f = \sqrt{\frac{2(1.6\times10^{-19})(2400V)}{9.11\times10^{-31}kg}} = 2.9\times10^7 \ m/s$$

force is max when $\vec{v} \perp \vec{B}$

$$F = qvB = (1.6\times10^{-19}C)(2.9\times10^7 m/s)(1.70T) = 7.90\times10^{-17}N$$

(b) force is zero when $\vec{v} \parallel \pm\vec{B}$.

Problem 29.14

again $v = \sqrt{\frac{2qV}{m}}$

set mag-force equal to centripetal force

$$qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB} = \frac{1}{B}\sqrt{\frac{2mV}{q}}$$

$$\Rightarrow R = \frac{1}{B}\sqrt{\frac{2m\Delta V}{e}}$$

and

$$R' = 2R = \frac{1}{B}\sqrt{\frac{2m'\Delta V}{2e}}$$

$$\Rightarrow m = \frac{R^2B^2e}{2\Delta V} \quad ; \quad m' = \frac{4R^2B^2(2e)}{2\Delta V}$$

$$\Rightarrow \frac{m'}{m} = 8$$

Problem 29.17

need $|F_{el}| = |F_{mag}| \Rightarrow qE = qvB$

if $E = \frac{1}{2}mv^2$, then $v = \sqrt{\frac{2E}{m}}$

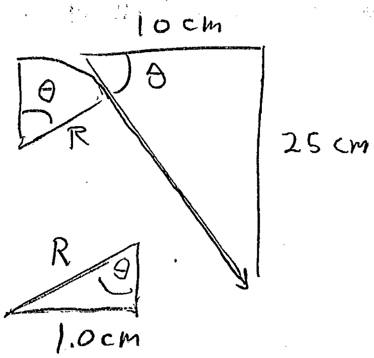
$$E = B\sqrt{\frac{2E}{m}} = 1.5\times10^{-2}\,T\sqrt{\frac{2(750\,eV)}{9.11\times10^{-31}}\left(\frac{1.6\times10^{-19}\,J}{1\,eV}\right)}$$

$$E = 2.44\times10^{5}\ N/C$$

Problem 29.23

the trick here is in the geometry:

the deflection angle needed matches the angle the e^- is deflected by the field:



$$\theta = \tan^{-1}\left(\frac{25}{10}\right) = 68.2^\circ$$

$$R = \frac{1.0\text{ cm}}{\sin 68.2^\circ} = 1.08\text{ cm}$$

$$v = \sqrt{\frac{2q\Delta V}{m}} = \sqrt{\frac{2(1.6\times10^{-19})(50\times10^{3}\,V)}{9.11\times10^{-31}\,kg}} = 1.33\times10^{8}\ m/s$$

now again

$$q\cancel{v}B = \frac{mv^{\cancel{2}}}{R} \Rightarrow B = \frac{mv}{qR} = \frac{(9.11\times10^{-31}\,kg)(1.33\times10^{8}\,m/s)}{(1.6\times10^{-19}\,C)(0.0108\,m)}$$

$$B = 0.0701\ T$$