Physics 132, Midterm Exam #2, May 18, 2010

Problem 1 [25 points]. The current through the leftmost 200Ω resistor is 20 mA.

(a) [10 points]. Find the equivalent resistance of the resistors in the circuit.
(b) [15 points]. What is the battery voltage, V?

\[ V - i_5 R_5 = 0 \]

\[ V = i_6 R_6 + i_5 R_5 \]

\[ i_5 = 20 \text{ mA} \]

\[ R_5 \text{ is } \parallel \text{ to } R_{1234} \]

since \[ R_5 = R_{1234} \]

\[ i_{1234} = 20 \text{ mA} \]

node rule

\[ i_6 = 40 \text{ mA} \]

\[ V = (0.64 A) 400 \Omega + (0.62 A) 200 \Omega \]

\[ = 20 V \]
Problem 2 [25 points]. \( E_1 = 20\, \text{V}, \ E_2 = 10\, \text{V}, \ E_3 = 5.0\, \text{V}, \ E_4 = 5.0\, \text{V} \) and \( R_1 = R_2 = R_3 = R_4 = 1000 \, \Omega \).

I am only asking questions about selected components. Read each question carefully so you solve for the correct quantity.

(a) [18 points] What is the current magnitude and direction through resistors \( R_1, R_2, \) and \( R_4 \).

\[
\begin{align*}
E_1 - i_1 R_1 &= 0 \\
i_1 &= \frac{E_1}{R_1} = \frac{20\, \text{V}}{1000\, \Omega} = 0.02\, \text{A} \quad \text{left through } R_1
\end{align*}
\]

\[
\begin{align*}
E_3 - i_2 R_2 - E_2 &= 0 \\
i_2 &= \frac{E_3 - E_2}{R_2} = \frac{5\, \text{V}}{1000\, \Omega} = 0.005\, \text{A} \quad \text{right through } R_2
\end{align*}
\]

\[
\begin{align*}
E_4 + E_1 + E_3 - i_y R_4 &= 0 \\
i_y &= \frac{E_4 + E_1 + E_3}{R_4} = \frac{30\, \text{V}}{1000\, \Omega} = 0.03\, \text{A} \quad \text{left through } R_4
\end{align*}
\]

(b) \( i_{E_1} = i_1 + i_y = 0.05\, \text{A} \) (in the natural direction for a battery supplying power)

\[
\begin{align*}
P_{E_1} &= \frac{E_1}{i_{E_1}} = \frac{(0.05\, \text{A})(20\, \text{V})}{1\, \text{W}}
\end{align*}
\]

No more than 1 point total was taken off for units

0 pts if you set \( i_{E_1} = \text{current through any resistor} \) (must use name)
the problem breaks into two parts:
1) Find C_{FB}  
2) Find \( V_{AB} \)

\[
U = \frac{1}{2} C_{FB} V_{AB}^2
\]

\( I_{left} = 30 - 10 = 0 \) \( 5 \) points

Outercycle (counterclockwise current)
\[ 30 - I_{left} \cdot 400 - I_{right} \cdot 400 - 10 = 0 \]

Node A: \( I_{left} = I_{right} + I_{cap} = I_{right} + 0 \)

\[ \Rightarrow I = \frac{30 - 10}{400 + 400} = \left( \frac{1}{40} \right) A = 0.025 \text{Amp} \] \( 5 \) points

Walk from A to B:
Left Branch: \( V_{AB} = 30 - (0.025) 400 = 20 \) \( 5 \) points

Right Branch: \( V_{AB} = 30 + (0.025) 400 = 20 \)

Note: You go from A to B through \( R_{right} \) against the current

\[
U = \frac{1}{2} \left( \frac{60}{7} \times 10^{-4} F \right) (20 \text{V})^2 = 1.71 \times 10^{-3} \text{Joule} \] \( 5 \) points
**Multiple Choice Section.** Circle the best answer to each question.

**Problem 5 [15 points].** Three large, equally spaced, conducting plates are connected to batteries or ground as shown in cross-section in the figure. The plates are not directly connected to each other. An x-axis is given, as well. Note carefully the orientation and voltage of the batteries.

(a) [5 points]. The charge on the right side of the middle plate is: positive zero negative

(Hint: You might want to sketch the charge on the other plates, first.)

(b) [10 points]. Circle the graph which best represents $E_x$ along the x-axis. The shaded regions of the graphs indicate where the conducting plates are.

![Figure showing the conducting plates (big grey rectangles).](image)

**Problem 6 [5 points].** Resistors A and B are both made of aluminum and in the shape of a cylinder. Resister A is $100 \, \Omega$. Resister B has twice the radius and twice the length of A. Its resistance is:

(a) $25 \, \Omega$  
(b) $50 \, \Omega$  
(c) $100 \, \Omega$  
(d) $200 \, \Omega$  
(e) $400 \, \Omega$

$$R_A = \rho L/A = 100 \, \Omega$$

$$R_B = \rho (2L)/(4A) = \frac{1}{2} R = 50 \, \Omega$$

**Problem 7 [5 points].** Circle each statement that is true for typical experience. More than one statement might be true, or none of them might be true.

- “1 Ω is a small resistance.”
- “1 F is a small capacitance.”
- “1 V/m is a small electric field.”