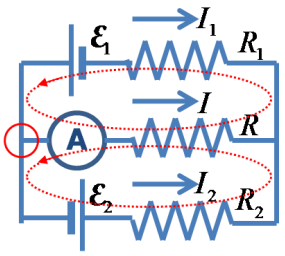
Physics 1214, Homework #4: solutions

Answers to multiple choice questions: M1: A, M2: C.

P1: the resistance of the heated resistor $R_2 = 100\ \Omega(1 + 0.005 \times 10) = 105\ \Omega$



$$I + I_1 + I_2 = 0$$

$$\mathcal{E}_1 = -I_1 R_1 + IR$$

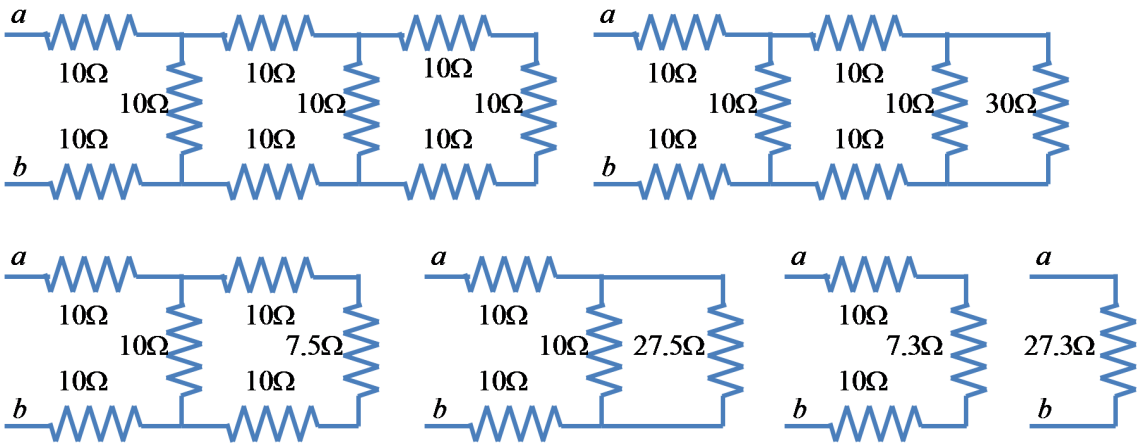
$$\mathcal{E}_2 = I_2 R_2 - IR$$

$$I_1 = \frac{IR - \mathcal{E}_1}{R_1},\ I_2 = \frac{\mathcal{E}_2 + IR}{R_2}$$

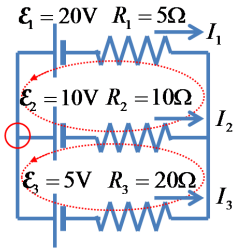
$$I + I\frac{R}{R_1} - \frac{\mathcal{E}_1}{R_1} + \frac{\mathcal{E}_2}{R_2} + I\frac{R}{R_2} = 0$$

$$I = \frac{\frac{\mathcal{E}_1}{R_1} - \frac{\mathcal{E}_2}{R_2}}{1 + \frac{R}{R_1} + \frac{R}{R_2}} = \frac{\frac{12}{100} - \frac{12}{105}}{1 + \frac{10}{100} + \frac{10}{105}} = 4.78 \times 10^{-3}\ \text{A}$$

P2: the equivalent resistance is 27.3 Ω as shown below



P3: similar to P1



$$I_1 + I_2 + I_3 = 0$$

$$\mathcal{E}_1 - \mathcal{E}_2 = -I_1 R_1 + I_2 R_2$$

$$\mathcal{E}_2 - \mathcal{E}_3 = -I_2 R_2 + I_3 R_3$$

$$I_1 = \frac{\mathcal{E}_2 - \mathcal{E}_1}{R_1} + I_2 \frac{R_2}{R_1}$$

$$I_3 = \frac{\mathcal{E}_2 - \mathcal{E}_3}{R_3} + I_2 \frac{R_2}{R_3}$$

$$\frac{\mathcal{E}_2 - \mathcal{E}_1}{R_1} + I_2 \frac{R_2}{R_1} + I_2 + \frac{\mathcal{E}_2 - \mathcal{E}_3}{R_3} + I_2 \frac{R_2}{R_3} = 0$$

$$I_2 = \frac{\dfrac{\mathcal{E}_1 - \mathcal{E}_2}{R_1} + \dfrac{\mathcal{E}_3 - \mathcal{E}_2}{R_3}}{1 + \dfrac{R_2}{R_1} + \dfrac{R_2}{R_3}} = \frac{\dfrac{10}{5} + \dfrac{(-5)}{20}}{1 + \dfrac{10}{5} + \dfrac{10}{20}} = 0.5 \text{ A}$$

$$I_1 = \frac{10 - 20}{5} + 0.5\frac{10}{5} = -1 \text{ A}$$

$$I_3 = \frac{10 - 5}{20} + 0.5\frac{10}{20} = 0.5 \text{ A}$$

cross-check: $I_1 + I_2 + I_3 = 0$

P4: the time constant $t = RC = (3.5\ \Omega) \times (12.5 \times 10^{-12}\ \text{F}) = 4.38 \times 10^{-11}\ \text{s}$