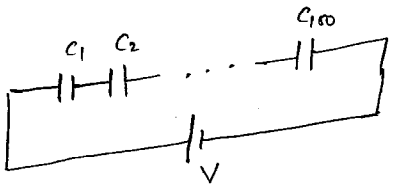
Solutions to MT02 PHYS-205B (Spring 2016)

Prob. 1

$$C = \frac{Q}{V} = \frac{20\,\mu C}{20.0\,V} = 1.00\,\mu F.$$

Prob. 2

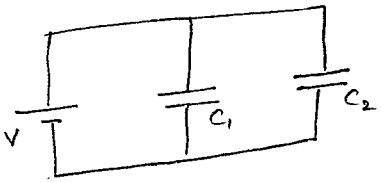


$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots \frac{1}{C_{100}}$$

$$\frac{1}{C_{eq}} = \frac{100}{C}$$

$$C_{eq} = \frac{C}{100}.$$

Prob. 3



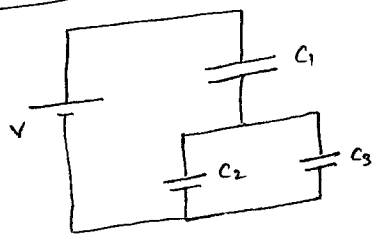
$$Q_1 = C_1 V_1 = 10.0\,\mu F \times 10.0\,V = 1.00\times10^{-4}\,C$$

$$Q_2 = C_2 V_2 = 20.0\,\mu F \times 10.0\,V = 2.00\times10^{-4}\,C$$

$$U_1 = \frac{Q_1^2}{2C_1} = \frac{(1.00\times10^{-4})^2}{2\times10.0\times10^{-6}} = 0.500\times10^{-3}\,J$$

$$U_2 = \frac{Q_2^2}{2C_2} = \frac{(2.00\times10^{-4})^2}{2\times20.0\times10^{-6}} = 1.000\times10^{-3}\,J$$

Prob. 4



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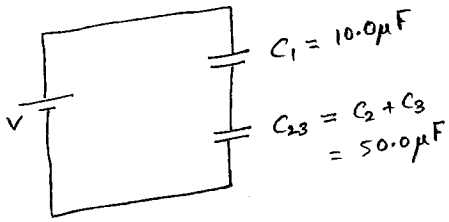

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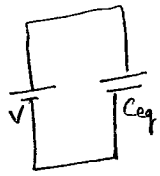


$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_{23}} = \frac{1}{10\times5} + \frac{1}{50} = \frac{6}{50} \Rightarrow C_{eq} = \frac{50.0}{6} = 8.33\,\mu F$$

$$Q_{eq} = C_{eq} V = 8.33\,\mu F \times 10.0\,V = 83.3\,\mu C$$

$$Q_1 = Q_{eq} = 83.3\,\mu C$$

Prob. 5

$$R = \frac{\rho l}{A}$$

$$R' = \frac{\rho l'}{A'} = \frac{\rho\, 3l}{(A/3)} = 9\,\frac{\rho l}{A} = 9R.$$

$$lA = l'A' \quad \text{(fixed volume)}$$

$$= 3l\,A'$$

$$\Rightarrow A' = \frac{A}{3}$$

Prob. 6

$$I = \frac{P}{V} = \frac{60\ W}{120\ V} = 0.50\ A$$

$$Q = I \times \text{time} = \frac{60}{120} \times 12 \times 60 \times 60 = 2.2 \times 10^4\ C$$

Prob. 7

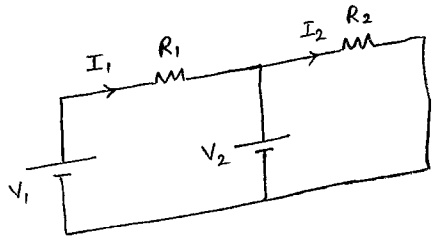
$$V = V_1 = V_2 = V_3 = 10.0\ V$$

$$I_1 = I_2 = I_3 = \frac{V}{R} = \frac{10.0}{300.0} = 33.3\ mA$$

$$P_1 = P_2 = P_3 = I_1 V_1 = 33.3 \times 10^{-3}\ A \times 10.0\ V$$

$$= 333\ mW$$

Prob. 8



$$+V_1 - I_1 R_1 - V_2 = 0$$

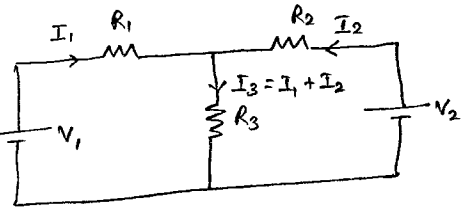
$$I_1 = \frac{V_1 - V_2}{R_1} = \frac{10.0 - 20.0}{100.0}$$

$$= -0.100\ A$$

$$= -100\ mA$$

Direction of I_1 is opposite to that shown in figure.

Prob. 9



$$V_1 - I_1 R_1 - I_3 R_3 = 0 \Rightarrow I_1(R_1 + R_3) + I_2 R_3 = V_1$$

$$V_2 - I_2 R_2 - I_3 R_3 = 0 \Rightarrow I_1 R_3 + I_2(R_2 + R_3) = V_2.$$

$$40\, I_1 + 30\, I_2 = 10$$

$$30\, I_1 + 40\, I_2 = 20$$

$$I_1 = \frac{10 \times 40 - 20 \times 30}{40 \times 40 - 30 \times 30} = \frac{4-6}{16-9} = -\frac{2}{7}$$

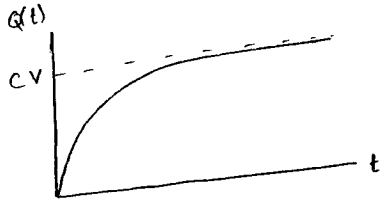
$$I_2 = \frac{40 \times 20 - 30 \times 10}{40 \times 40 - 30 \times 30} = \frac{8-3}{16-9} = +\frac{5}{7}$$

$$I_3 = I_1 + I_2 = -\frac{2}{7} + \frac{5}{7} = +\frac{3}{7} = 0.429 \text{ A}$$ (direction is the same as shown in figure.)

Prob. 10

(a) $$V - IR - \frac{Q}{C} = 0$$

(b) $$Q(t) = CV\left[1 - e^{-\frac{t}{RC}}\right]$$



$$Q_{max} = CV$$
$$= 10.0\,\mu F \times 10.0\,V$$
$$= 1.00 \times 10^{-4}\, C$$

It takes infinite time to charge the capacitor to this value.