

Solutions

Midterm Exam 02, PHYS-205B, 2017 Spring

Prob. 1

$$50.00 \text{ USD} = 50.00 \text{ USD} \frac{1 \text{ kWh}}{0.12 \text{ USD}}$$

$$= \frac{50.00}{0.12} 10^3 \text{ W} 60 \times 60 \text{ s}$$

$$= \frac{50.00 \times 10^3 \times 3600}{0.12} \text{ J} = 1.5 \times 10^9 \text{ J}$$

Ws = J

Prob. 2

$$Q = VC$$

$$= E \frac{\epsilon_0 A}{d}$$

$$= E \epsilon_0 A$$

$$= 1500 \frac{\text{V}}{\text{m}} \left(8.85 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2} \right) \left(2.5 \times 10^{-4} \text{m}^2 \right)$$

$$= 3.3 \times 10^{-12} \text{ C}$$

$$V = Ed$$

$$C = \frac{\epsilon_0 A}{d}$$

Prob. 3

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

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

$$= R \left(\frac{l'}{l} \right)^2$$

$$= 9R$$

$$l A = l' A'$$

$$A' = \frac{l A}{l'}$$

$$\frac{l'}{l} = 3 \text{ (given)}$$

Prob. 4

$$(a) \frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{10} + \frac{1}{20} = \frac{3}{20}$$

$$C_{eq} = \frac{20.0}{3} = 6.67 \mu F$$

$$(b) Q_1 = Q_2 = Q = C_{eq} V = (6.67 \mu F) (10.0 V) = 66.7 \mu C$$

$$(c) V_1 = \frac{Q_1}{C_1} = \frac{66.7 \mu C}{10.0 \mu F} = 6.67 V$$

$$V_2 = \frac{Q_2}{C_2} = \frac{66.7 \mu C}{20.0 \mu F} = 3.33 V$$

$$(d) U_1 = \frac{Q_1^2}{2C_1} = \frac{(66.7 \mu C)^2}{2(10.0 \mu F)} = 0.222 mJ$$

$$U_2 = \frac{Q_2^2}{2C_2} = \frac{(66.7 \mu C)^2}{2(20.0 \mu F)} = 0.111 mJ$$

Prob. 5

$$C_2 V_2 = C_3 V_3 \quad (\text{since } Q_2 = Q_3)$$

$$\Rightarrow V_2 = \frac{3}{2} V_3$$

$$V_2 + V_3 = 10.0$$

(since voltage distributes)

$$\frac{3}{2} V_3 + V_3 = 10.0 \Rightarrow V_3 = 4.0 V$$

Thus,

$$\begin{aligned} Q_3 &= C_3 V_3 \\ &= (30.0 \mu F) (4.0 V) \\ &= 120 \mu C \\ &= 1.2 \times 10^{-4} C \end{aligned}$$

Prob. 6

loop abcfa:

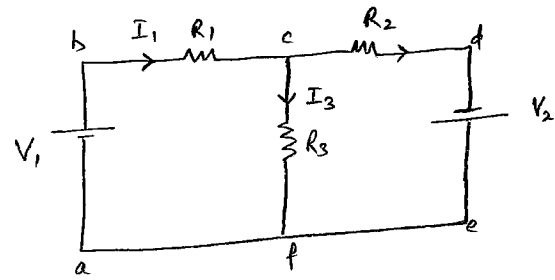
$$+V_1 - I_1 R_1 - I_3 R_3 = 0$$

$$+10.0 - 2.0 \times 10.0 - I_3(30.0) = 0$$

$$10.0 - 20.0 = I_3 30.0$$

$$I_3 = -\frac{10.0}{30.0} = -0.33 \text{ A}$$

direction: current in R_3 flows from f to c.



Prob. 7

loop abcfa: $+V_1 - I_1 R_1 - I_3 R_3 = 0$

$$10.0 - I_1 10.0 - I_3 30.0 = 0$$

$$10.0 I_1 + 30.0 I_3 = 10.0 \quad \text{--- (1)}$$

loop edcfe: $+V_2 - I_2 R_2 - I_3 R_3 = 0$

$$+20 - (I_3 - I_1) R_2 - I_3 R_3 = 0$$

$$+20 - 20.0 I_3 + 20.0 I_1 - 30.0 I_3 = 0$$

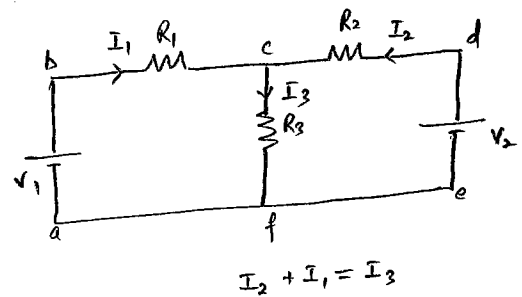
$$-20.0 I_1 + 50.0 I_3 = 20.0 \quad \text{--- (2)}$$

$$10.0 I_1 + 30.0 I_3 = 10.0$$

$$-20.0 I_1 + 50.0 I_3 = 20.0$$

$$\Rightarrow I_3 = \frac{10.0 \times 20.0 + 20.0 \times 10.0}{10.0 \times 50.0 + 20.0 \times 30.0} = 0.36 \text{ A}$$

(from c to f)



Prob. 8

$$Q = Q_0 e^{-\frac{t}{\tau}}$$

$$\left(1 - \frac{2}{3}\right) Q_0 = Q_0 e^{-\frac{t}{\tau}}$$

$$\frac{1}{3} = e^{-\frac{t}{\tau}}$$

$$-\frac{t}{\tau} = \ln \frac{1}{3}$$

$$t = \tau \ln 3 \approx 1.1 \tau$$

$$-\ln \frac{1}{3} = \ln 3$$