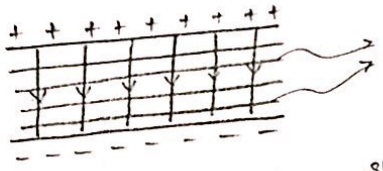
Solution PHYS-205B (Midterm Exam 2) Fall 2021

Problem 1

Electric potential is the same everywhere on a conductor, thus at $\frac{R}{2}$ we have

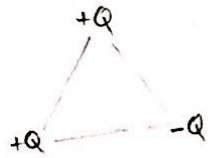
$$V = \frac{1}{4\pi\epsilon_0}\frac{Q}{R}.$$

Problem 2



Equipotential surfaces are surfaces of equal electric potential.

Problem 3



$$U = +k\frac{Q^2}{L} - k\frac{Q^2}{L} - k\frac{Q^2}{L}$$

$$= -k\frac{Q^2}{L}$$

Problem 4

$$I = \frac{\Delta V}{R} = \frac{6.0 - 1.5}{1.5\times10^3} = 3.0\times10^{-3}\ A$$

$$= 3.0\ mA$$

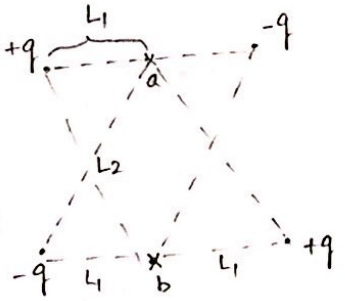
Problem 5

$$\text{Energy} = (\text{Power})\,(\text{time})$$

$$= (12 \text{ watts})\,(365 \times 24 \times 60 \times 60 \text{ seconds})$$

$$= 0.38 \times 10^9 \text{ J}$$

Problem 6

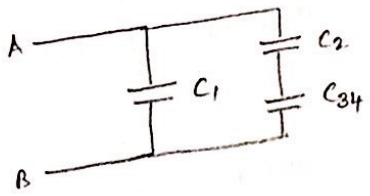


$$V_a = +k\frac{q}{L_1} - k\frac{q}{L_1} - \frac{kq}{L_2} + \frac{kq}{L_2} = 0$$

$$V_b = +k\frac{q}{L_2} - k\frac{q}{L_2} - \frac{kq}{L_1} + \frac{kq}{L_1} = 0$$

$$V_a - V_b = 0$$

Problem 7



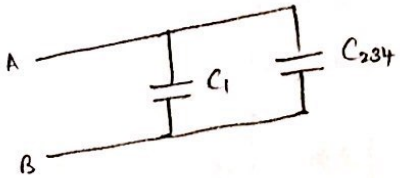
$$C_{34} = C_3 + C_4 = 7.0\,\mu F$$

$$\frac{1}{C_{234}} = \frac{1}{C_2} + \frac{1}{C_{34}}$$

$$= \frac{1}{2.0\times10^{-3}\,\mu F} + \frac{1}{7.0\,\mu F}$$

$$= (500 + 0.14)\,(\mu F)^{-1} = 500\,(\mu F)^{-1}$$

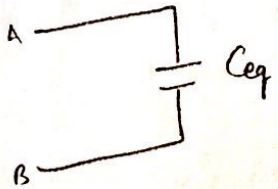
$$C_{234} = \frac{1}{500}\,\mu F = 2.0\,nF$$



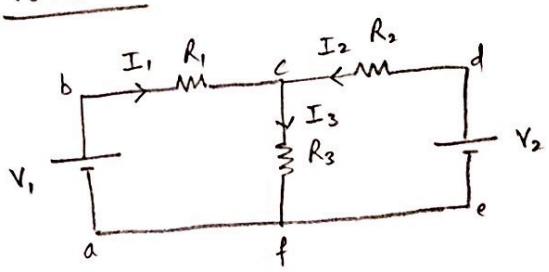
$$C_{eq} = C_1 + C_{234}$$

$$= 1.0\,nF + 2.0\,nF$$

$$= 3.0\,nF$$



Problem 8



$I_2 = 0$

junction c : $I_1 + I_2 = I_3$

$\Rightarrow I_1 = I_3$

loop abcda : $V_1 - I_1 R_1 - I_3 R_3 = 0$

$7.0 = I_1 (10.0 + R_3)$

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

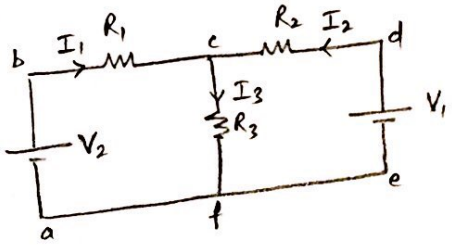
$5.0 = I_1 R_3$

$\frac{7.0}{5.0} = \frac{10.0 + R_3}{R_3}$

$7.0 R_3 = 50.0 + 5.0 R_3$

$R_3 = 25\ \Omega$

Problem 9



junction c : $I_1 + I_2 = I_3$

loop abcfa : $V_2 - I_1 R_1 - I_3 R_3 = 0$

$V_2 - I_1 R_1 - (I_1 + I_2) R_3 = 0$

$40.0\ I_1 + 30.0\ I_2 = 20.0$

loop edcfe : $V_1 - I_2 R_2 - I_3 R_3 = 0$

$V_1 - I_2 R_2 - (I_1 + I_2) R_3 = 0$

$30.0\ I_1 + 50.0\ I_2 = 10.0$

$$I_1 = \frac{\begin{vmatrix} 20.0 & 30.0 \\ 10.0 & 50.0 \end{vmatrix}}{\begin{vmatrix} 40.0 & 30.0 \\ 30.0 & 50.0 \end{vmatrix}} = \frac{1000 - 300.}{2000 - 900} = \frac{700.}{1100} = 0.636\ A$$

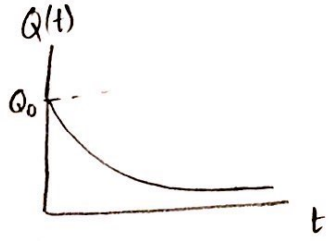
I_1 is 0.636 A from b to c.

Problem 10

(a) $-IR - \frac{Q}{C} = 0$ $\qquad I = \frac{dQ}{dt}$

$$\frac{dQ}{dt} = -\frac{Q}{RC}$$

(b) $Q(t) = Q_0 \, e^{-\frac{t}{RC}}$



→ It takes infinite time t discharge the capacita completely.

→ $\frac{Q_0}{2} = Q_0 \, e^{-\frac{t}{RC}}$

$$\frac{1}{2} = e^{-\frac{t}{RC}}$$

$$\ln \frac{1}{2} = -\frac{t}{RC}$$

$$t = RC \ln 2$$

$$= (30.0 \times 10^3)(10.0 \times 10^{-6}) \ln 2$$

$$= 0.208 \text{ seconds}$$