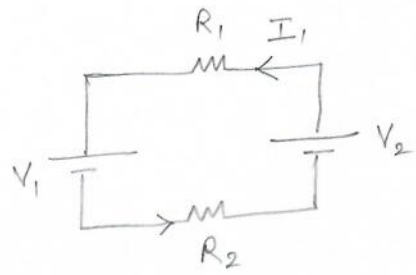
Solutions Midterm Exam 02 (PHYS 205B-001) Spring 2023

Problem 1



$$+V_2 - I_1 R_1 - V_1 - I_2 R_2 = 0 \qquad (I_1 = I_2)$$

$$V_2 - V_1 = I_1 (R_1 + R_2)$$

$$I_1 = \frac{V_2 - V_1}{R_1 + R_2} = \frac{20.0 - 10.0}{300.0}$$

$$= 33.3 \text{ mA}$$

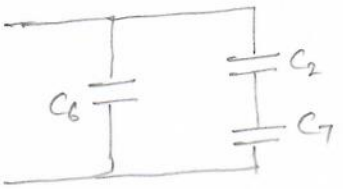
Problem 2

Smaller than 1 m/s.

Problem 3

C_1 and C_5 are in parallel.

C_3 and C_4 are in parallel.

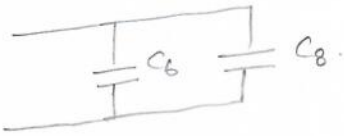


$$C_1 + C_5 = C_6 = 6.0\mu F$$

$$C_8 + C_4 = C_7 = 7.0\mu F$$

$$\frac{1}{C_2} + \frac{1}{C_7} = \frac{1}{C_8}$$

$$\frac{1}{2.0} + \frac{1}{7.0} = \frac{1}{C_8} = \frac{9.0}{14} \Rightarrow C_8 = \frac{14}{9.0}\mu F$$

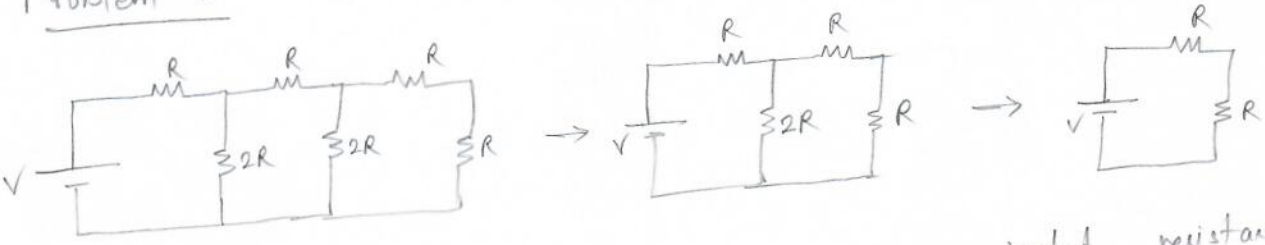


$$C_{eq} = C_6 + C_8 = 6.0 + \frac{14}{9.0} = 7.6\mu F$$

Problem 4

$[RC] = T = \text{time}.$ (using $Q = VC\left(1 - e^{-\frac{t}{RC}}\right)$)

Problem 5

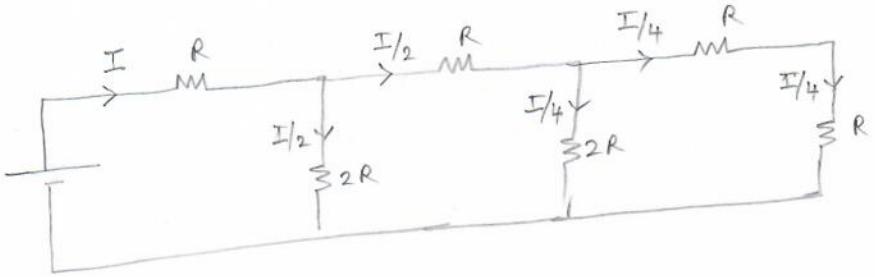


Thus, $R_{eq} = 2R$. At each junction the equivalent resistance to right is $2R$. Thus, current divides into half at each junction.

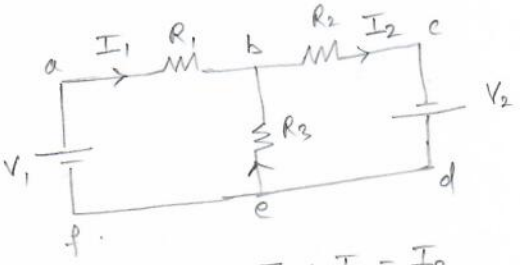
$$I = \frac{V}{2R} = \frac{10.0}{2 \times 5.0 \times 10^3} = 1.0\ mA$$

$$\frac{I}{2} = 0.50\ mA$$

$$\frac{I}{4} = 0.25\ mA$$



Problem 6



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

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

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

$$40.0\, I_1 - 30.0\, I_2 = 10.0$$

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

$$V_2 - (I_2 - I_1) R_3 - I_2 R_2 = 0$$

$$V_2 + I_1 R_3 - I_2 (R_2 + R_3) = 0$$

$$-30.0\, I_1 + 50.0\, I_2 = 20.0$$

$$4.00\, I_1 - 3.00\, I_2 = 1.00$$

$$-3.00\, I_1 + 5.00\, I_2 = 2.00$$

$$I_1 = \frac{\begin{vmatrix} 1.00 & -3.00 \\ 2.00 & 5.00 \end{vmatrix}}{\begin{vmatrix} 4.00 & -3.00 \\ -3.00 & 5.00 \end{vmatrix}} = \frac{11.0}{11.0} = 1.00\ A$$

$$I_1 + I_3 = I_2$$

$$I_2 = \frac{\begin{vmatrix} 4.00 & 1.00 \\ -3.00 & 2.00 \end{vmatrix}}{\begin{vmatrix} 4.00 & -3.00 \\ -3.00 & 5.00 \end{vmatrix}} = 1.00\ A$$

$$I_3 = I_2 - I_1$$

$$= 0.$$

Problem 7

Total force on the loop is 0. Thus,

$$\vec{F}_3 = -\vec{F}_1 - \vec{F}_2$$

$$= -0 + \hat{z}\, I L_b B$$

$$= +\hat{z}\,(2.0)\left(6.0\times10^{-2}\right)(0.30)$$

$$= +\hat{z}\ 36\ \text{mN}$$

$$\vec{F}_1 = I\vec{L}_a \times \vec{B}$$

$$= 0 \quad (\sin\theta = 0)$$

$$\vec{F}_2 = I\vec{L}_b \times \vec{B}$$

$$= -\hat{z}\, I L_b B.$$