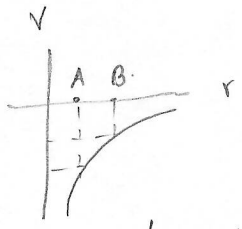
Solution

PHYS-2058-002 (Midterm Exam 02) Spring 2025

Problem 1

Electric potential decreases as we go closer to a negative charge.

$$V = -\frac{k|Q|}{r}$$



$\Rightarrow$ Point B is at higher potential relative to point A.

Problem 2

Points a, b, and c, have the same potential, relative to d. Thus, resistors R_1, R_2, and R_3, are in parallel.

$$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} \quad \Rightarrow \quad R_{eq} = \frac{R}{3}.$$

Problem 3

$$\text{Energy} = (\text{Power})(\text{time}) = \left(12\ \frac{J}{s}\right)(365 \times 24 \times 60 \times 60\ s) = 3.8 \times 10^8\ J$$

Problem 4

$$[RC] = \frac{[V]}{[I]}\frac{[Q]}{[V]} = [t] = T$$

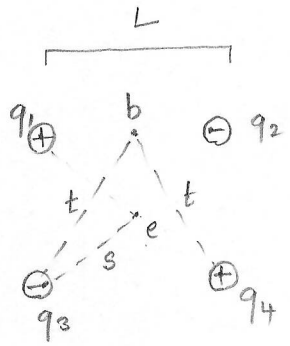
$V = IR$

$V = \frac{Q}{C}$

$I = \frac{Q}{t}$

$\hookrightarrow$ dimension of time.

Problem 5



$$V_e = \frac{kq_1}{s} + \frac{kq_2}{s} + \frac{kq_3}{s} + \frac{kq_4}{s}$$

$$= \frac{k}{s}(q_1 + q_2 + q_3 + q_4)$$

$$= \frac{kq}{s}(+1 - 2 - 3 + 3)$$

$$= -\frac{kq}{s} = -\frac{kq}{(L/2)}\sqrt{2} = -\frac{(9.0\times10^{9})(1.0\times10^{-9})\sqrt{2}}{(6.0/2)}$$

$$s = \sqrt{\left(\frac{L}{2}\right)^2 + \left(\frac{L}{2}\right)^2} = \frac{L}{2}\sqrt{2}$$

$$= -4.2 \text{ Volt}$$

$$V_b = \frac{kq_1}{L/2} + \frac{kq_2}{L/2} + \frac{kq_3}{t} + \frac{kq_4}{t}$$

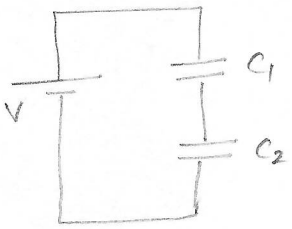
$$= kq\left[+\frac{1}{L/2} - \frac{2}{L/2} + \frac{3}{t} - \frac{3}{t}\right] \quad (\checkmark \ \checkmark)$$

$$= -\frac{kq}{(L/2)} = -\frac{(9.0\times10^{9})(1.0\times10^{-9})}{(6.0/2)} = -3.0 \text{ Volt.}$$

$$V_b - V_e = -3.0 - (-4.2) = 1.2 \text{ Volt.}$$

Problem 6

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{1.0} + \frac{1}{2.0} \Rightarrow C = \frac{2.0}{3.0}\mu F = 0.67\mu F$$

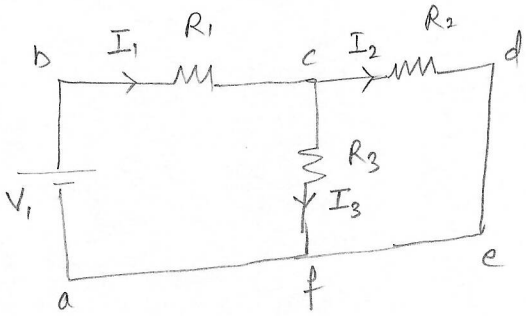


$$Q = Q_1 = Q_2 = VC = 6.7\,\mu C$$

$$U_1 = \frac{Q_1^2}{2C_1} = \frac{(6.7\times10^{-6})^2}{2(1.0\times10^{-6})} = 23\,\mu J$$

$$U_2 = \frac{Q_2^2}{2C_2} = 12\,\mu J$$

Problem 7



junction c: $I_1 = I_2 + I_3$ —(i)

loop abcfa:

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

$$+10. - 10.(I_2 + I_3) - 30.\, I_3 = 0$$

$$10.\, I_2 + 40.\, I_3 = 10. \quad — (ii)$$

loop fcdef:

$$+I_3 R_3 - I_2 R_2 = 0$$

$$30.\, I_3 = 20.\, I_2$$

$$I_2 = 1.5\, I_3 \quad — (iii)$$

Using (iii) in (ii)

$$10.(1.5\, I_3) + 40.\, I_3 = 10.$$

$$55\, I_3 = 10. \Rightarrow I_3 = 0.18\ A \quad — (iv)$$

Using (iv) in (iii)

$$I_2 = 1.5(0.18) = 0.27\ A \quad — (v)$$

Using (iv) and (v) in (i)

$$I_1 = 0.27 + 0.18 = 0.45\ A.$$