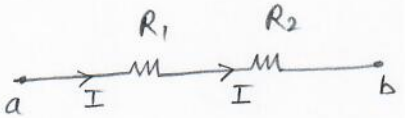
Solutions PHYS-2058 (Midterm Exam 02) Fall 2022

Problem 1



$$V_a - V_b = I\,(R_1 + R_2)$$

$$I = \frac{(4.5) - (-1.5)}{(1.0 + 2.0) \times 10^3} = 2.0\ \text{mA}$$

2.0 mA in each resistor, from a to b.

Problem 2

Left circuit: $R_{eq} = 2R$

Right circuit:

$$R_{eq} = R + \frac{1}{\left[\frac{1}{2R} + \frac{1}{\left\{R + \frac{1}{\left(\frac{1}{2R} + \frac{1}{R+R}\right)}\right\}}\right]}$$

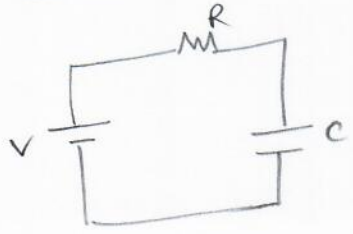
$$= R + \frac{1}{\left[\frac{1}{2R} + \frac{1}{\{R + R\}}\right]}$$

$$= R + 2R$$

$$= 2R$$

Both circuits have the same equivalent resistance of 2R.

Problem 3



An application is in the design of camera flash.

Problem 4

Circle.

Problem 5

$$V_a = \frac{kq}{\left(\frac{\sqrt{2}L}{2}\right)} + \frac{kq}{\left(\frac{\sqrt{2}L}{2}\right)} + \frac{kq}{\left(\frac{\sqrt{2}L}{2}\right)} + \frac{kq}{\left(\frac{\sqrt{2}L}{2}\right)} = 4\frac{kq}{L}\frac{2}{\sqrt{2}} = 4\sqrt{2}\,\frac{kq}{L}$$

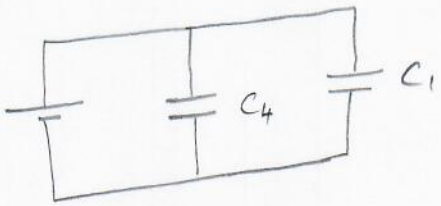
$$V_b = \frac{kq}{\left(\frac{L}{2}\right)} + \frac{kq}{\left(\frac{L}{2}\right)} + \frac{kq}{\left(\frac{\sqrt{5}L}{2}\right)} + \frac{kq}{\left(\frac{\sqrt{5}L}{2}\right)} = \frac{kq}{L}\left[2 + 2 + \frac{2}{\sqrt{5}} + \frac{2}{\sqrt{5}}\right]$$

$$= \frac{kq}{L}\,4\left(1 + \frac{1}{\sqrt{5}}\right)$$

$$V_a - V_b = \frac{kq}{L}\left[4\sqrt{2} - 4\left(1 + \frac{1}{\sqrt{5}}\right)\right] \sim -0.132\,\frac{kq}{L}$$

Problem 6

$$\frac{1}{C_4} = \frac{1}{C_2} + \frac{1}{C_3} = \frac{1}{20.0} + \frac{1}{30.0} = \frac{50.0}{600.}$$



$$C_4 = 12.0\,\text{nF}$$

$$Q_4 = C_4 V = (12.0\,\text{nF})(10.0\,\text{V})$$

$$= 120.\,\text{nC}$$

$$Q_2 = Q_4 = 0.120\,\mu\text{C}.$$

Problem 7

$$R' = \frac{\rho l'}{A'} \qquad l' = 2l$$

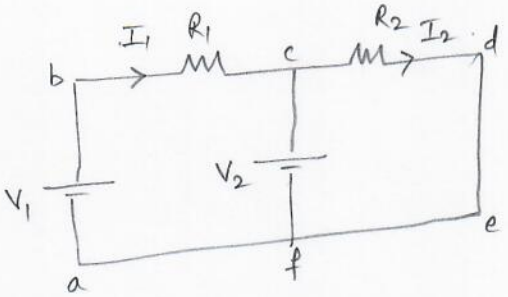
$$l'A' = Al$$

$$2lA' = Al$$

$$A' = \frac{A}{2}$$

$$= \frac{\rho(2l)}{\left(\frac{A}{2}\right)} = 4\frac{\rho l}{A} = 4R.$$

Problem 8



loop fcdef: $+V_2 - I_2R_2 = 0$

$+20.0 = I_2(200.)$

$I_2 = 0.100\ A$

$= 1.00\ mA$

loop abcfa: $+V_1 - I_1R_1 - V_2 = 0$

$+10.0 - I_1(100.) - 20.0 = 0$

$I_1 = -0.100\ A = -1.00\ mA$

I_2 is $1.00\ mA$ from $c \to d$.

I_1 is $1.00\ mA$ from $c \to b$.