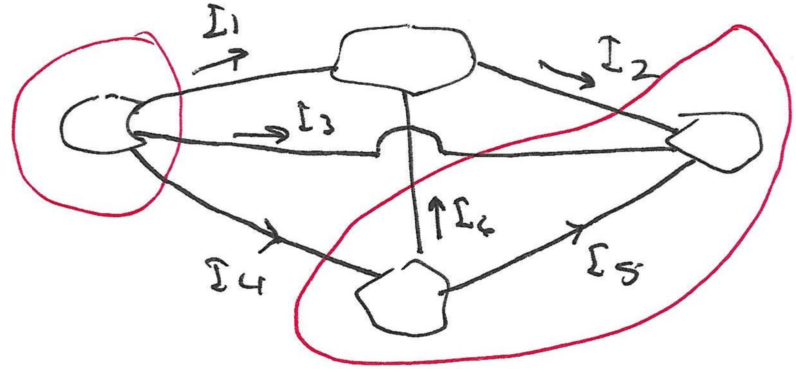


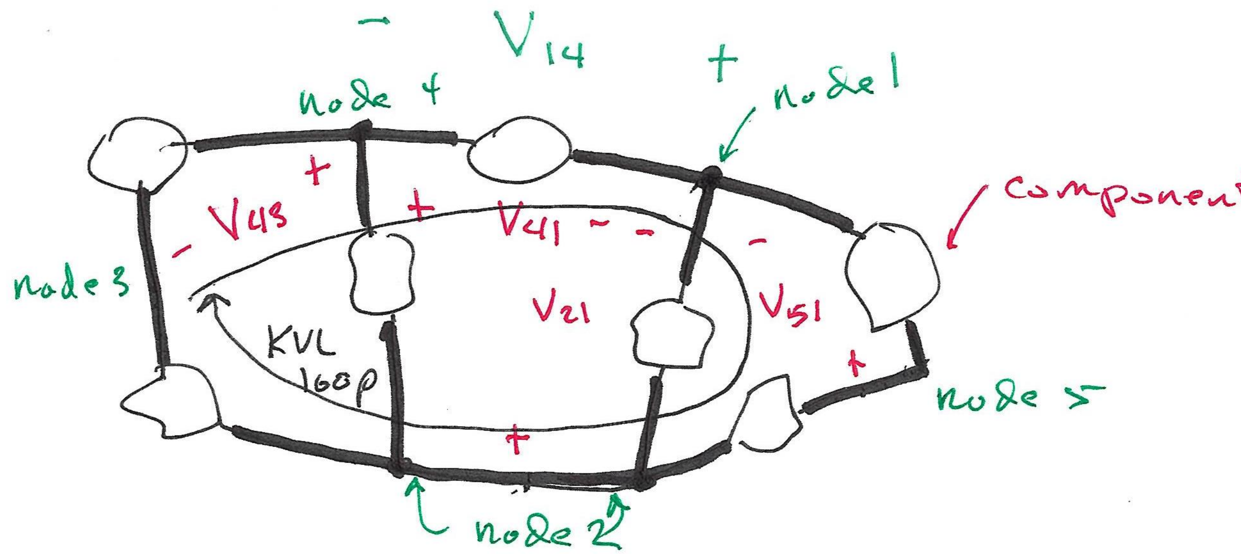
KCL: The algebraic sum of all currents crossing any closed boundary is zero.

$$I_1 + I_3 + I_4 = 0$$

$$-I_1 - I_3 - I_4 = 0$$

$$I_2 + I_3 + I_4 - I_6 = 0$$

KVL: The algebraic sum of all voltages encountered around a closed loop is zero.



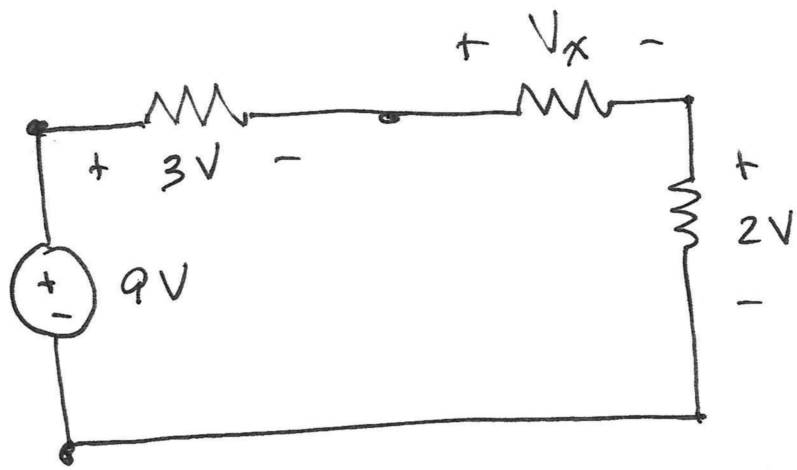
$$+V_{15} + V_{52} + V_{23} + V_{34} + V_{41} = 0$$

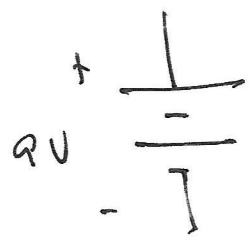
$$-V_{51} - V_{25} - V_{32} - V_{43} - V_{14} = 0$$

$$V_{15} - V_{25} + V_{23} - V_{43} + V_{41} = 0$$

$$V_{15} + V_{52} - V_{32} + V_{34} + V_{41} = 0$$

Independent voltage source



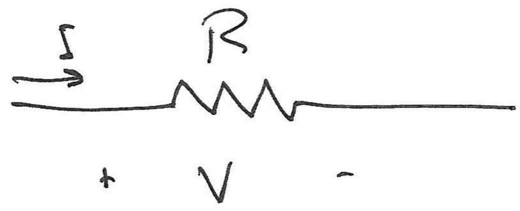


Use KVL to find V_x.

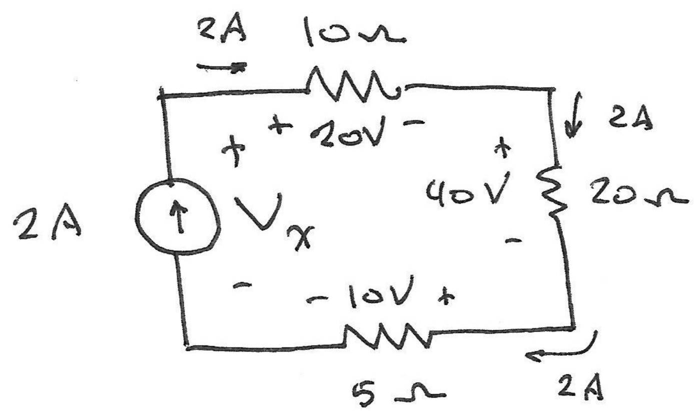
$$+3 + V_x + 2 - 9 = 0$$

$$V_x = 4\,V$$

Resistor



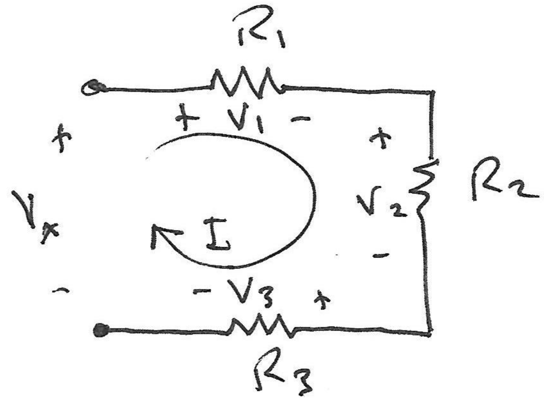
$V = R I$ Ohm's Law



Series Resistors

$$-V_x + 20 + 40 + 10 = 0$$

$$V_x = 70\ V$$



$$V_1 = R_1 I$$

$$V_2 = R_2 I$$

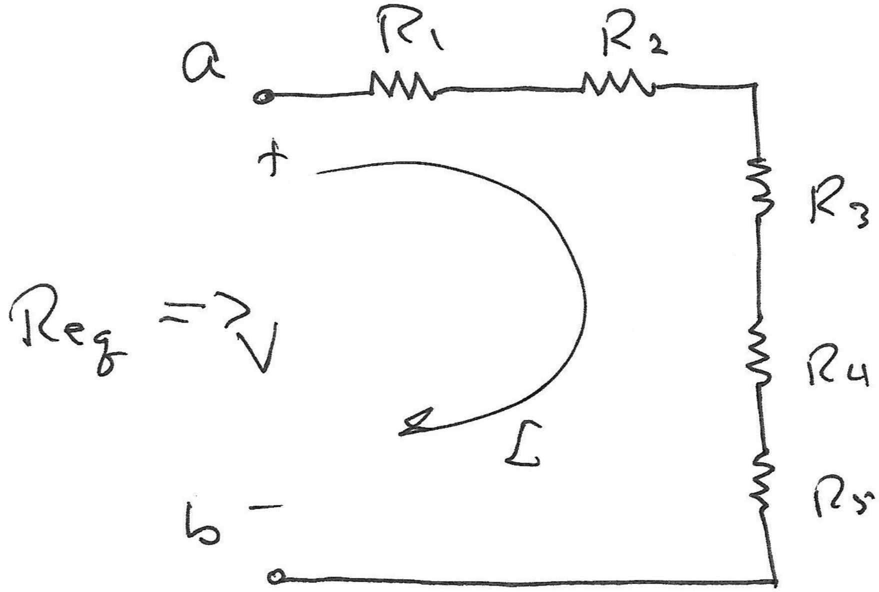
$$V_3 = R_3 I$$

$$-V_x + V_1 + V_2 + V_3 = 0 \qquad \text{(KVL)}$$

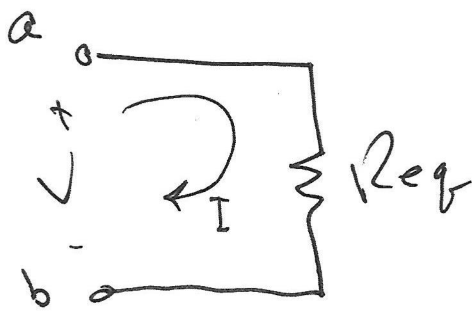
$$-V_x + R_1 I + R_2 I + R_3 I = 0$$

$$-V_x + (R_1 + R_2 + R_3) I = 0$$

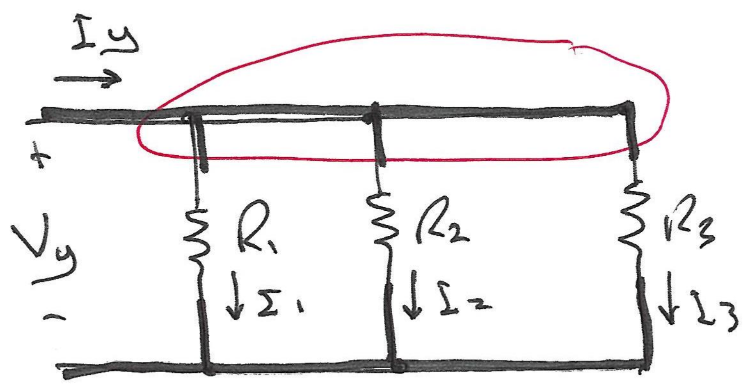
$$V_x = \underbrace{(R_1 + R_2 + R_3)}_{\text{equivalent resistance}} I$$



$$R_{eq} = R_1 + R_2 + R_3 + R_4 + R_5$$



Equivalent Circuit



Parallel Connection

(All resistors connected to the same two nodes)

$$I_1 = \frac{V_y}{R_1} \qquad I_2 = \frac{V_y}{R_2} \qquad I_3 = \frac{V_y}{R_3}$$

$$I_y = I_1 + I_2 + I_3$$

$$= \frac{V_y}{R_1} + \frac{V_y}{R_2} + \frac{V_y}{R_3}$$

$$= \underbrace{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)}_{G_1 + G_2 + G_3} V_y$$

equivalent conductance

G_{eq}

$$I_y = G_{eq} V_y$$

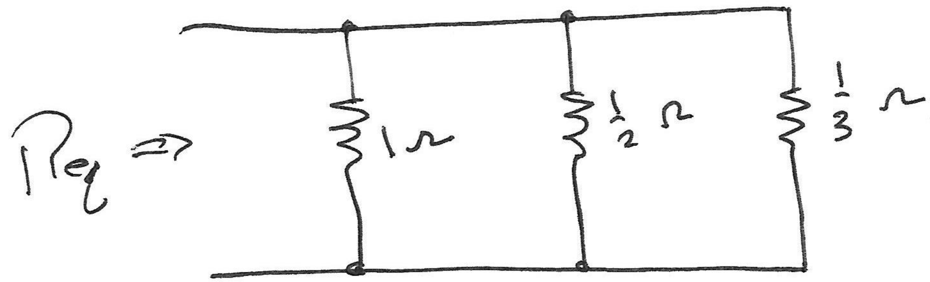
$$\downarrow$$

$$\frac{1}{R_{eq}}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

or

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

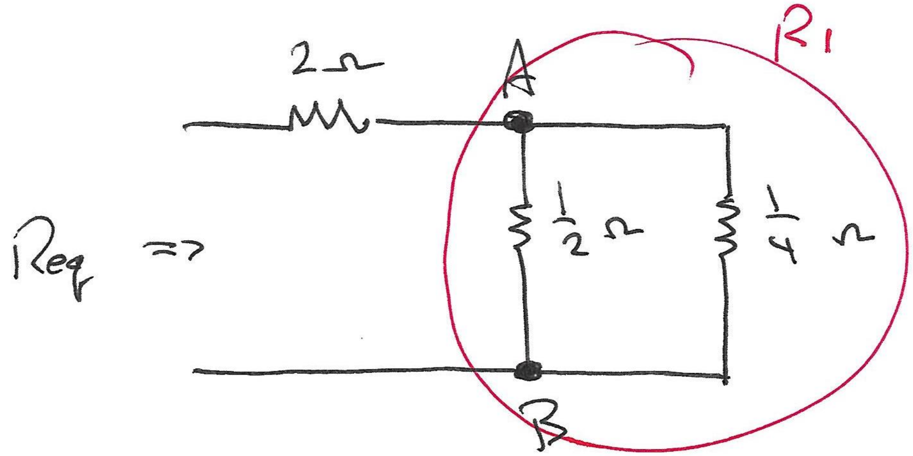


$$G_{eq} = \frac{1}{1} + \frac{1}{(\frac{1}{2})} + \frac{1}{(\frac{1}{3})}$$

$$= 1 + 2 + 3$$

$$= 6\ S$$

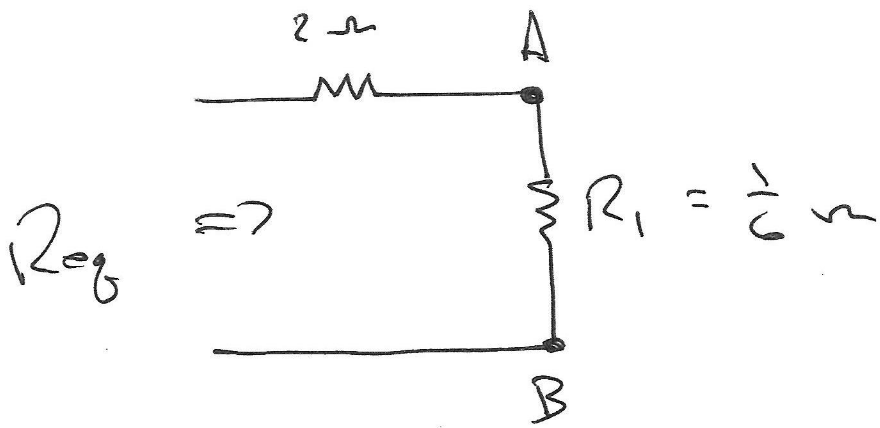
$$R_{eq} = \frac{1}{G_{eq}} = \frac{1}{6}\ \Omega$$



$$\frac{1}{R_1} = 2 + 4$$

$$= 6$$

$$R_1 = \frac{1}{6}\ \Omega$$



$$R_{eq} = 2\tfrac{1}{6}\ \Omega$$