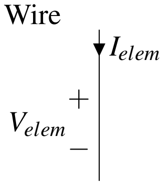
EECS 16A Designing Information Devices and Systems I
Spring 2023 Discussion 6A

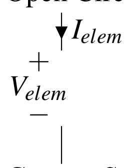
1. Circuit Components and Ohm's Law

(a) We will look at the $I-V$ characteristics of different circuit components. For each of the components listed below, plot the $I_{elem}-V_{elem}$ characteristic curves.

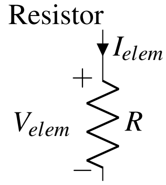
i. Wire



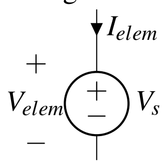
ii. Open Circuit



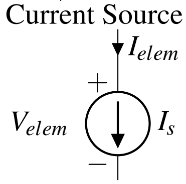
iii. Resistor



iv. Voltage Source

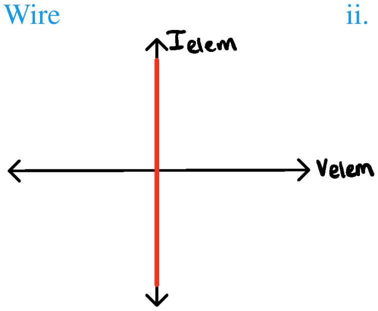


v. Current Source

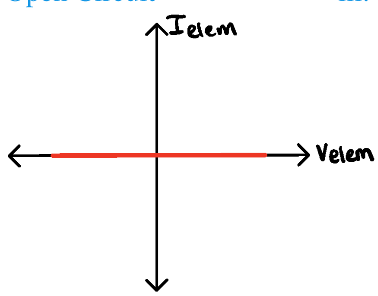


Answer:

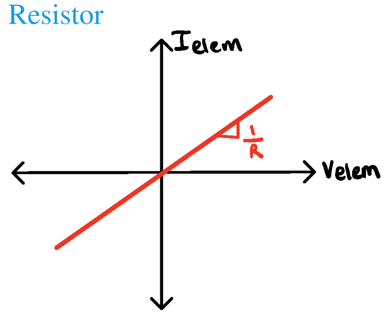
i. Wire



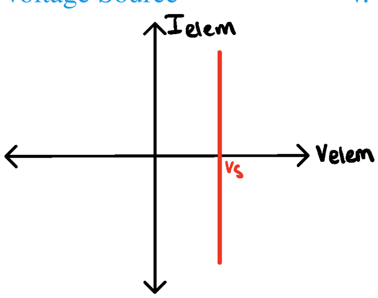
ii. Open Circuit



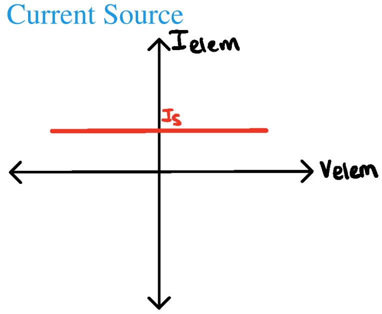
iii. Resistor



iv. Voltage Source

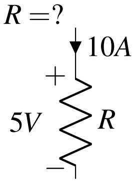


v. Current Source

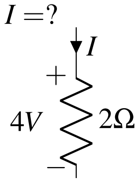


(b) Use Ohm's Law to find the missing component values in the circuits below. You may assume that each circuit is part of a larger circuit where there is a closed path for current to flow.

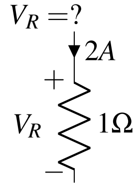
i. $R=?$



ii. $I=?$



iii. $V_R=?$



Answer:

i. $R = \frac{5V}{10A} = 0.5\Omega$

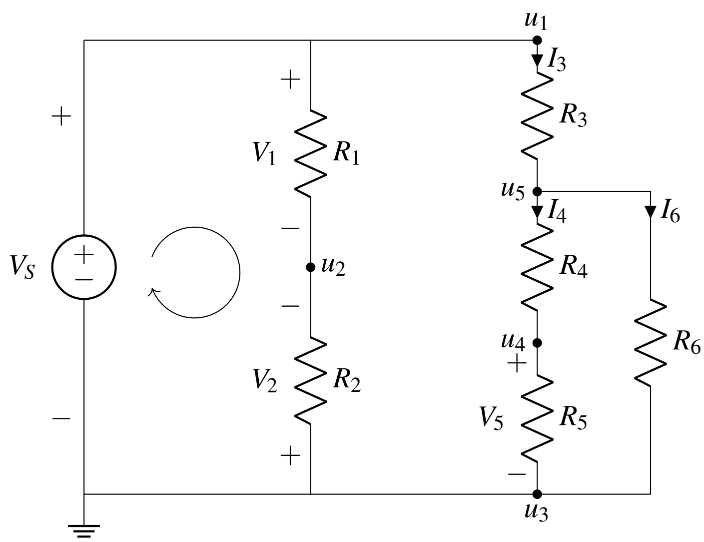
ii. $I = \frac{4V}{2\Omega} = 2A$

iii. $V = 2A \times 1\Omega = 2V$

2. Passive Sign Convention and NVA Basics

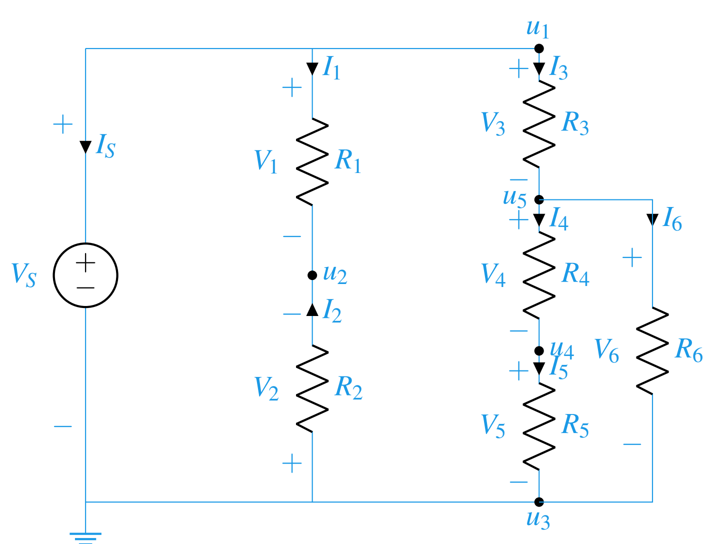
The following question is a modified version of Spring 2022 Midterm 2 Question 1

Suppose we have the following circuit:



(a) Following passive sign convention, **label** the missing currents and the missing voltages for each element in the circuit, including the voltage source.

Answer: Following the passive sign convention (current flows into the terminal with a positive voltage), we have the missing labels:



(b) **Write the KCL expression** at node u_5 in terms of currents I_3, I_4, and I_6 as labeled in the circuit diagram.

Answer: I_3 flows into the node, and I_4, I_6 flow out of the node, so the KCL expression is

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

Any equivalent expressions (for example, $I_3 - I_4 - I_6 = 0$, $I_3 = I_4 + I_6$, etc.) are acceptable.

(c) Find the voltage across R_4, R_5, and R_6 in terms of the node voltages u_3, u_4, and u_5. Then use Ohm's law to express the currents across R_4, R_5, and R_6 in terms of node voltages and resistances.

Answer:

Solving for the voltages in terms of node voltages, we have:

$$\begin{aligned} V_4 &= u_5 - u_4 \\ V_5 &= u_4 - u_3 = u_4 \\ V_6 &= u_5 - u_3 = u_5 \end{aligned}$$

Now for Ohm's law, we have the following:

$$\begin{aligned} I_4 &= \frac{V_4}{R_4} \\ I_5 &= \frac{V_5}{R_5} \\ I_6 &= \frac{V_6}{R_6} \end{aligned}$$

Combining the equations in terms of node voltages, we get the new set of equations in terms of node voltages and resistors:

$$\begin{aligned} I_4 &= \frac{V_4}{R_4} = \frac{u_5 - u_4}{R_4} \\ I_5 &= \frac{V_5}{R_5} = \frac{u_4}{R_5} \\ I_6 &= \frac{V_6}{R_6} = \frac{u_5}{R_6} \end{aligned}$$

(d) **Write the KVL expression** for the loop drawn in the circuit diagram in terms of voltages V_S, V_1, and V_2.

Answer: If we travel in the loop, we will first meet the negative terminal of V_S, the positive terminal of V_1, and the negative terminal of V_2, respectively. So the KVL expression is

$$-V_S + V_1 - V_2 = 0.$$

Any equivalent expressions (for example, $V_S - V_1 + V_2 = 0$, $V_S + V_2 = V_1$, etc.) are acceptable.