1 Notes

1.1 KVL/KCL review

Kirchoff's Circuit Laws are two important laws used for analyzing circuits. Kirchoff's Current Law (KCL) says that the sum of all currents entering a node must equal 0. For example, in Figure 1, the sum of all of the currents entering node 1 is $I_1 - I_2 - I_3 = 0$. Assuming I_1 and I_3 are known, we can easily obtain a solvable equation for V_x by plugging in Ohm's law: $I_1 - \frac{V_x}{R_1} - I_3 = 0$

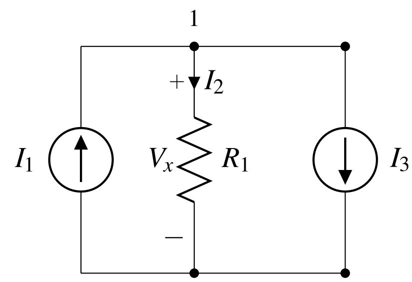

Figure 1: KCL Circuit

Kirchoff's Voltage Law (KVL) states that the sum of all voltages in a circuit loop must equal 0. To apply KVL to the circuit shown in Figure 2, we can add up voltages in the loop in the counterclockwise which yields $-V_1 + V_x + V_y = 0$. Using the relationships $V_x = i * R_1$ and $i = I_1$ we can solve for all unknowns in this circuit. You can use these two laws to solve any circuit that is planar and linear.

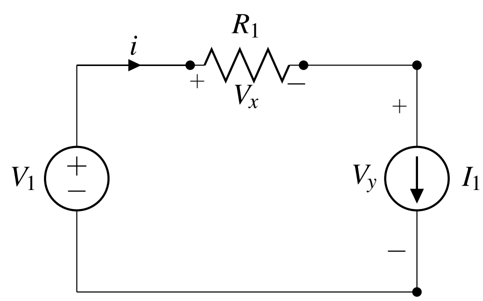

Figure 2: KVL Circuit

1.2 Op-amp Review

Figure 1 shows the equivalent model of an op-amp. It is important to note that this is the general model of an op-amp, so our op-amp golden rules cannot be applied to this unless certain conditions are met.

Conditions Required for Golden Rule:

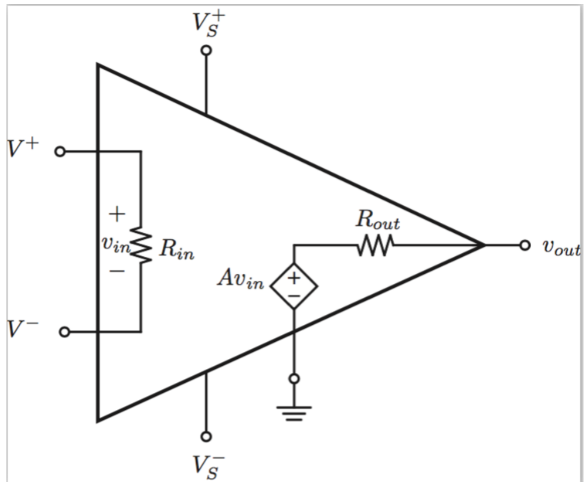

Figure 3: General Op-Amp Model

- $R_{in} \to \infty$
- $R_{out} \to 0$
- $A_{v_{in}} \to \infty$
- The op-amp must be operated in negative feedback

When conditions 1-3 are met, the op-amp is considered ideal. Figure 2 shows an ideal op-amp in negative feedback, which can be analyzed using the golden rules.

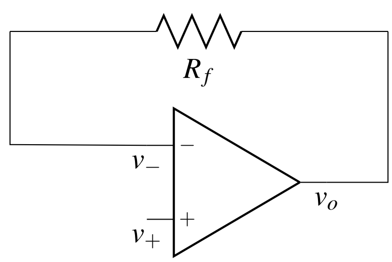

Figure 4: Ideal Op-Amp in Negative Feedback

Golden rules of ideal op-amps in negative feedback:

- No current can flow into the input terminals ($I_- = 0$ and $I_+ = 0$)
- The $(+)$ and $(-)$ terminals are at the same voltage ($V_+ = V_-$)

1. **KVL/KCL review**

   Use Kirchoff's Laws on the circuit below to find v_x, i_s, i_{in} and the power provided by the dependent current source. You can use $R_1 = 2\Omega$, $R_2 = 4\Omega$, and $R_3 = 2\Omega$. To help with solving the problem, we have already found the voltage difference across R_1 and R_3.

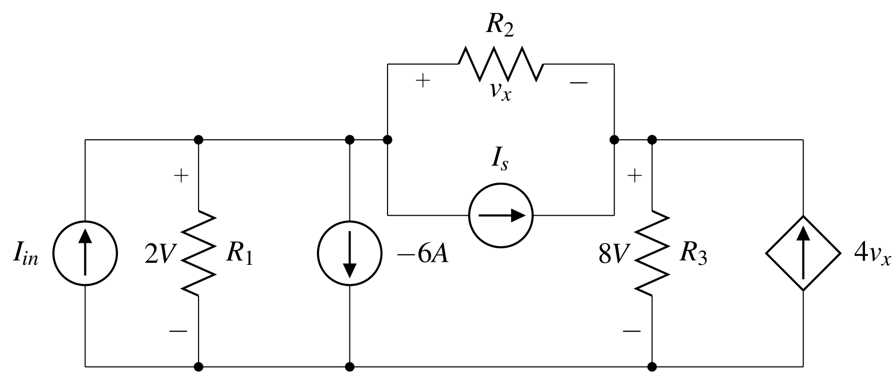

Figure 5: Example Circuit

   (a) What is v_x?

   (b) What is I_s?

   (c) What is I_{in}?

   (d) What is the power output of the dependent current source on the far right?

2. **Op-amp** Consider the following circuit:

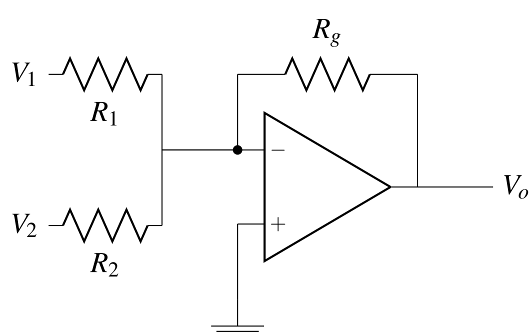

Figure 6: Op-amp Summer

What is the output, V_o, in terms of V_1, V_2? You may assume that R_1, R_2, and R_g are known.