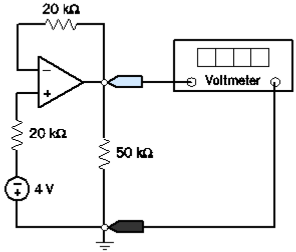
ECSE 200 - Electric Circuits 1
Tutorial 8

ECE Dept., McGill University

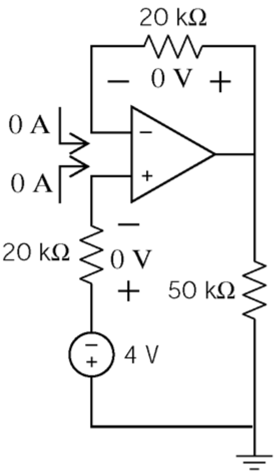
Problem P 6.3-1

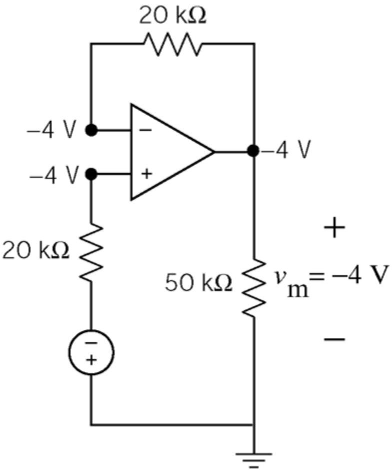
Determine the value of voltage measured by the voltmeter in the figure.



Problem P 6.3-1 Solution

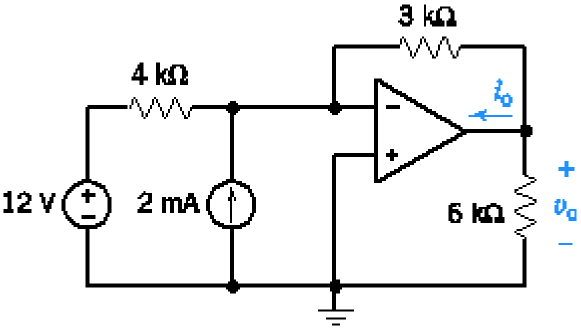
Solution:





Problem P 6.3-5

Find v_o and i_o for the circuit of the figure.



Problem P 6.3-5 Solution

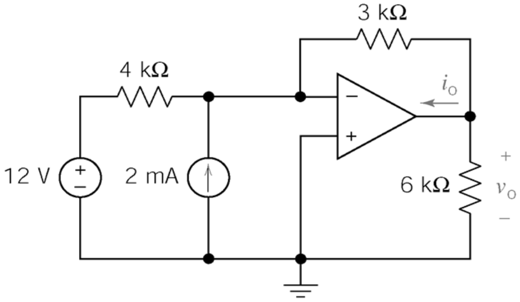
Solution:
The voltages at the input nodes of an ideal op amp are equal, so $v_a = 0$ V . Apply KCL at node *a*:

$$-\left(\frac{v_o - 0}{3000}\right) - \left(\frac{12-0}{4000}\right) - 2\cdot 10^{-3} = 0$$

$$\Rightarrow v_o \;=\; -15\text{ V}$$

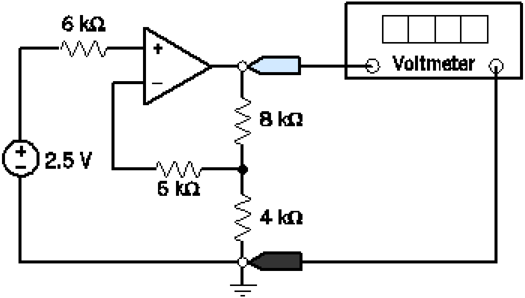
Apply KCL at the output node of the op amp:

$$i_o + \frac{v_o}{6000} + \frac{v_o}{3000} = 0 \Rightarrow i_o = 7.5\text{ mA}$$



Problem P 6.3-6

Determine the value of voltage measured by the voltmeter in the figure.



Problem P 6.3-6 Solution

Solution:

The currents into the inputs of an ideal op amp are zero and the voltages at the input nodes of an ideal op amp are equal so $v_a = 2.5$ V.

Apply Ohm's law to the 4 kΩ resistor:

$$i_a = \frac{v_a}{4000} = \frac{2.5}{4000} = 0.625 \text{ mA}$$

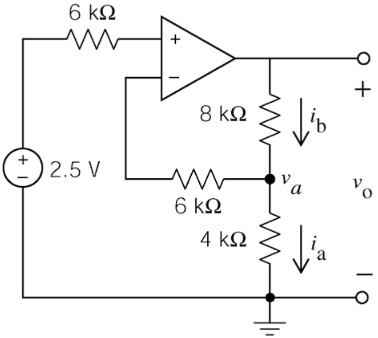
Apply KCL at node a:

$$i_b = i_a = 0.625 \text{ mA}$$

Apply KVL:

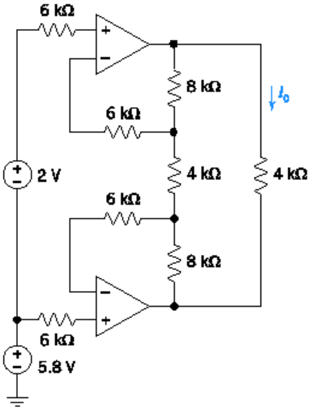
$$v_o = 8000\, i_b + 4000\, i_a$$

$$= \left(12\times10^3\right)\left(0.625\times10^{-3}\right) = 7.5 \text{ V}$$



Problem P 6.3-8

Determine the current io for the circuit shown in the figure.



Problem P 6.3-8 Solution

Solution:

The node voltages have been labeled using:

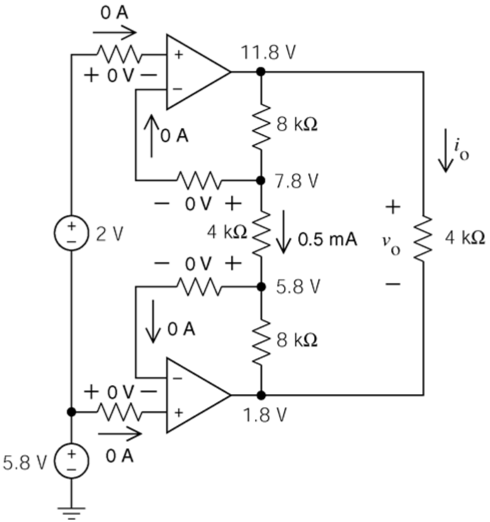
1. The currents into the inputs of an ideal op amp are zero and the voltages at the input nodes of an ideal op amp are equal.

2. KCL

3. Ohm's law

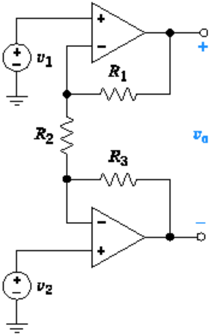
then $v_0 = 11.8 - 1.8 = 10 \text{ V}$

and $i_o = \frac{10}{4000} = 2.5 \text{ mA}$



Problem P 6.4-4

The output of the circuit shown in the figure is v_o. The inputs are v_1 and v_2. Express the output as a function of the inputs and the resistor resistances.



Problem P 6.4-4 Solution

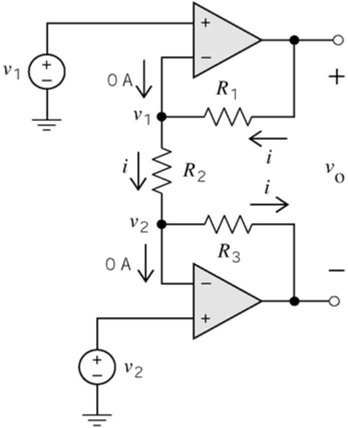
Solution:

Ohm's law:

$$i = \frac{v_1 - v_2}{R_2}$$

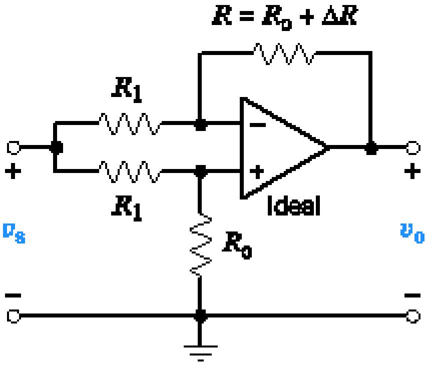
KVL:

$$v_0 = (R_1 + R_2 + R_3)\, i = \frac{R_1 + R_2 + R_3}{R_2}(v_1 - v_2)$$



Problem P 6.4-10

The circuit shown in the figure includes a simple strain gauge. The resistor R changes its value by ΔR when it is twisted or bent. Derive a relation for the voltage gain v_o/v_s and show that it is proportional to the fractional change in R, namely $\Delta R/R_o$.



Problem P 6.4-10 Solution

Solution:

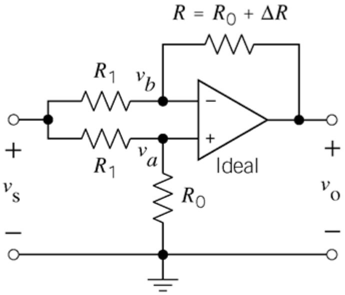
By voltage division (or by applying KCL at node a)

$$v_a = \frac{R_0}{R_1+R_0} v_s$$

Applying KCL at node b:

$$\frac{v_b - v_s}{R_1} + \frac{v_b - v_0}{R_0 + \Delta R} = 0$$

$$\Rightarrow \quad \frac{R_0 + \Delta R}{R_1}(v_b - v_s) + v_b = v_0$$

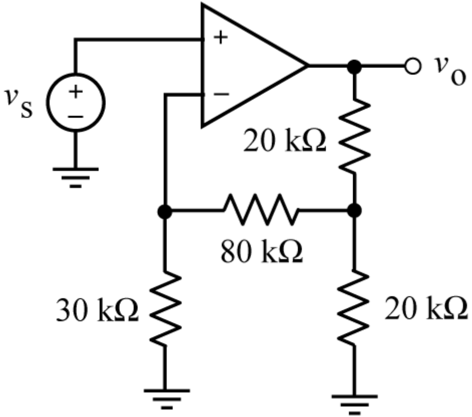


The node voltages at the input nodes of an ideal op amp are equal so $v_b = v_a$.

$$v_0 = \left[\left(\frac{R_0+\Delta R}{R_1}+1\right)\frac{R_0}{R_1+R_0} - \frac{R_0+\Delta R}{R_1}\right] v_s = -\frac{\Delta R}{R_1+R_0} v_s = \left(-v_s \frac{R_0}{R_1+R_0}\right)\frac{\Delta R}{R_0}$$

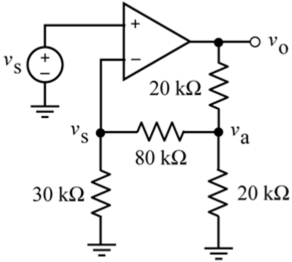
Problem P 6.4-23

The input to the circuit shown in the figure is the voltage source voltage v_s. The output is the node voltage v_o. The output is related to the input by the equation $k = v_o/v_s$ is called the gain of the circuit. Determine the value of the gain k.



Problem P 6.4-23 Solution

Solution:
Label the node voltages as shown. Apply KCL at the inverting input node of the op amp to get



$$\frac{v_s}{30000} + \frac{v_s - v_a}{80000} = 0 \quad \Rightarrow \quad 11 v_s = 3 v_a \quad \Rightarrow \quad v_a = \frac{11}{3} v_s$$

Apply KCL at the right node of the 80 kΩ resistor to get

$$\frac{v_s - v_a}{80000} + \frac{v_o - v_a}{20000} = \frac{v_a}{20000} \quad \Rightarrow \quad v_s - 9 v_a + 4 v_o = 0$$

$$\Rightarrow \quad v_s - 9\left(\frac{11}{3} v_s\right) + 4 v_o = 0$$

$$\Rightarrow \quad v_s - 33 v_s + 4 v_o = 0$$

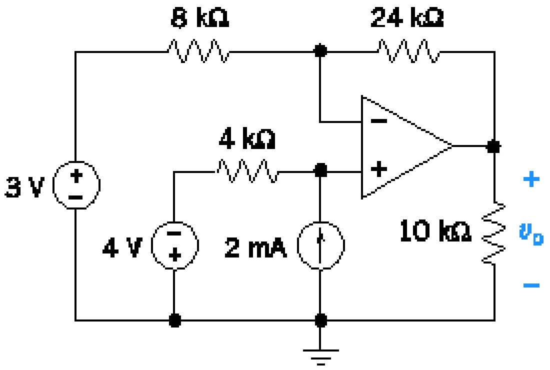
$$\Rightarrow \quad 4 v_o = 32 v_s$$

$$\Rightarrow \quad v_o = 8 v_s$$

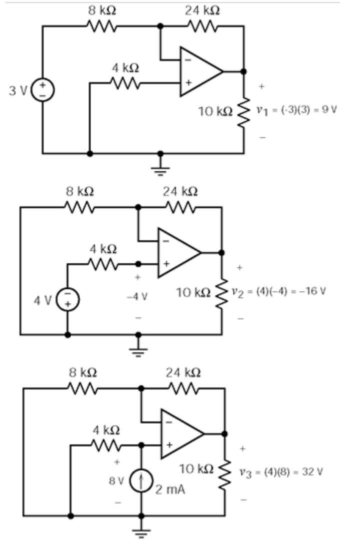
Comparing this equation to $v_o = k\, v_s$, we determine that $k = 8$ V/V.

Problem P 6.5-9

Determine the voltage vo for the circuit shown in the figure. *Hint*: Use superposition.



Problem P 6.5-9 Solution



Using superposition, $v_o = v_1 + v_2 + v_3 = -9 - 16 + 32 = 7$ V

Thank you !