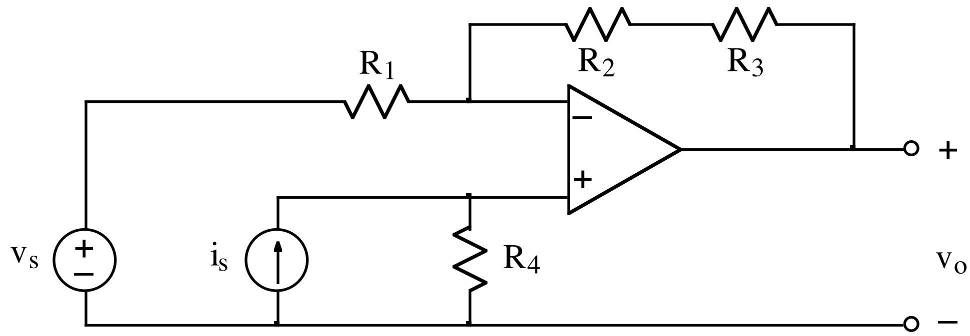
HOMEWORK #4 solution

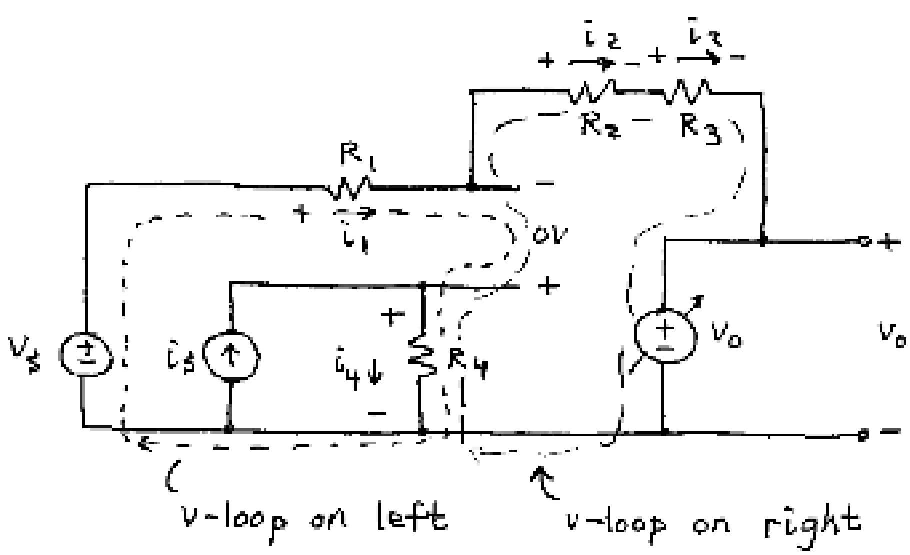
Ex:



The op-amp operates in the linear mode. Using an appropriate model of the op-amp, derive an expression for v_o in terms of not more than v_s, i_s, R_1, R_2, R_3, and R_4.

sol'n: We treat the op-amp as ideal, meaning we remove it and replace the output with a source called v_o and assume a 0V drop across the +, − inputs.

After that, we take v-loops on the left and right that pass thru the 0 V drop across the +, − inputs. We also take current sums at nodes.



For the v-loops, we have:

$$v_s - i_1 R_1 + 0V - i_4 R_4 = 0V$$ (on

$$+ i_4 R_4 - 0V - i_2 R_2 - i_2 R_3 - v_o = 0V$$ (on

Note: we use Ohm's law to write v-drop in terms of currents.

For current sums at nodes we have (for node to right of R_1):

$$-i_1 + i_2 + 0A = 0A \quad \text{or} \quad i_1 = i_2$$

↑ no current into op-amp

For node above R4:

$$-i_s + i_4 + 0A = 0A \quad \text{or} \quad i_4 = i_s$$

↑ no current into op-amp

Substituting into v-loop eq'ns, we have

$$v_s - i_2 R_1 - i_s R_4 = 0V$$

and $i_s R_4 - i_2 R_2 - i_2 R_3 = v_o$.

The first eq'n gives $i_2 = \dfrac{v_s - i_s R_4}{R_1}$.

Using this in the 2nd eq'n gives

$$v_o = i_s R_4 - \left(\frac{v_s - i_s R_4}{R_1}\right)\left(R_2 + R_3\right)$$

or $$v_o = i_s R_4 \left(1 + \frac{R_2 + R_3}{R_1}\right) - v_s \frac{R_2 + R_3}{R_1}$$