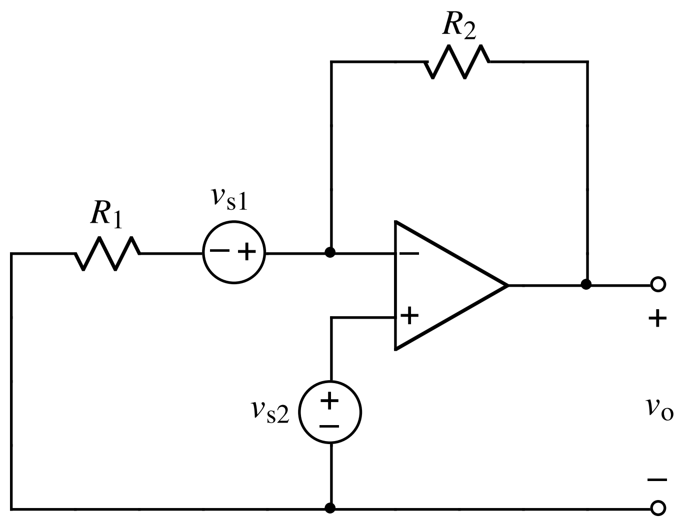
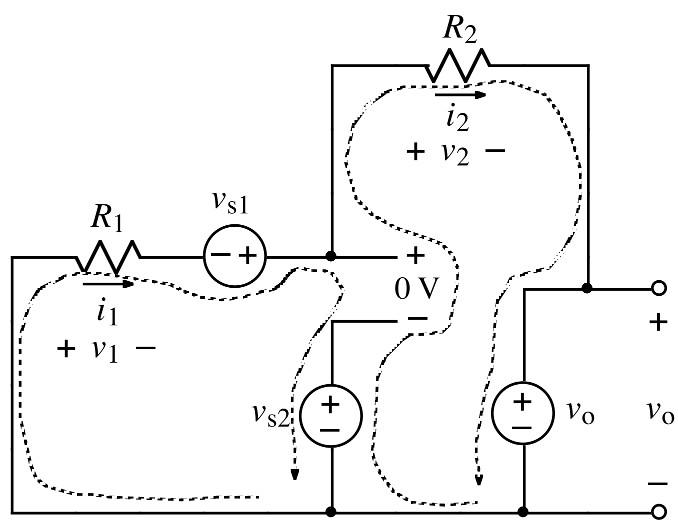
HOMEWORK #4 solution

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_{s1}, v_{s2}, R_1, and R_2.

SOL'N: a) Because we have negative feedback that causes the op-amp to operate in linear mode, we remove the op-amp and find the value of v_o that causes the voltage across the inputs of the op-amp to be zero.



We look for v-loops, such as those shown by dashed lines, that pass thru the 0 V drop across the op-amp inputs. These v-loops yield two equations:

$$-i_1 R_1 + v_{s1} + 0\text{ V} - v_{s2} = 0\text{ V} \qquad (1)$$

and

$$v_{s2} - 0\text{ V} - i_2 R_2 - v_o = 0\text{ V}. \quad (2)$$

A current summation at the minus input of the op-amp yields a third equation:

$$i_1 = i_2 \quad (3)$$

Using this result in equation (2) yields the following result:

$$v_{s2} - i_1 R_2 - v_o = 0\text{ V}$$

or

$$v_o = v_{s2} - i_1 R_2 \quad (4)$$

Solving equation (1) for i_1, we have

$$i_1 = \frac{v_{s1} - v_{s2}}{R_1}$$

Using this expression in equation (4) yields our final answer:

$$v_o = v_{s2} - \frac{(v_{s1} - v_{s2})}{R_1} R_2$$

or

$$v_o = v_{s2}\left(1 + \frac{R_2}{R_1}\right) - v_{s1}\frac{R_2}{R_1}$$