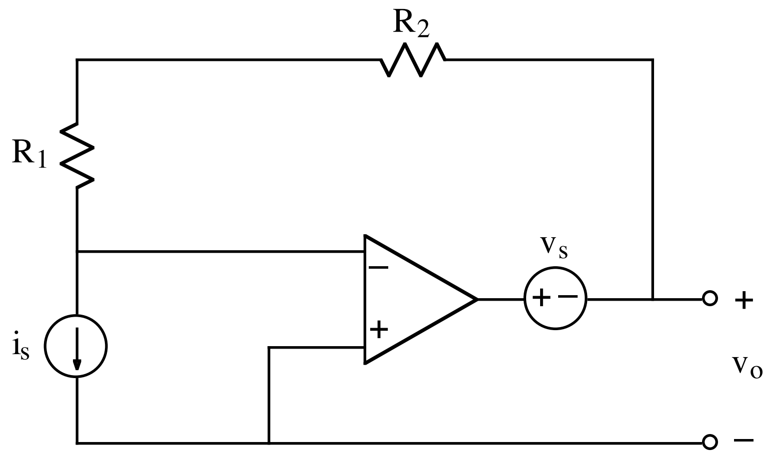
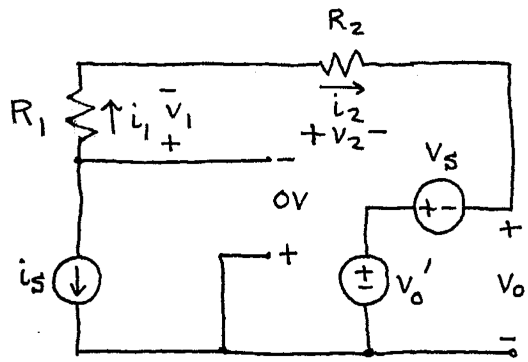
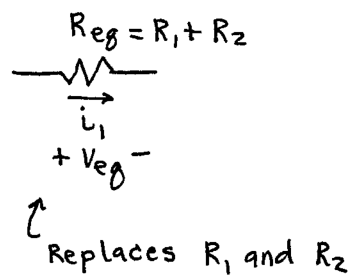
Ex:



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, and R_2.

sol'n: We assume a 0V drop across the + and − inputs of the op-amp, and we replace the op-amp output with a src called v_o'.





We may combine R_1 and R_2 into one resistor: $R_{eq} \equiv R_1 + R_2$.

R_{eq} carries current i_1 and has v-drop $v_{eq} = i_1 R_{eq}$.

We now look for v-loops, including those passing thru the 0V drop across the op-amp inputs.

The only v-loop not containing an i-src is on the right side.

$$-0V - v_{eq} + v_S - v_o' = 0V$$

If we ignore dangling wires, we have no nodes where three or more wires are connected.

Thus, we have no i-sum eq'ns for nodes.

We look for components in series that carry the same current.

$$i_1 = -i_S$$

Finally, we use Ohm's law for R_{eq}:

$$v_{eq} = i_1 R_{eq}$$

Since $i_1 = -i_S$, we have

$$v_{eq} = -i_S R_{eq}.$$

Using our earlier v-loop eq'n, we can solve for v_o':

$$v_o' = -v_{eq} + v_S = i_S R_{eq} + v_S$$

We use a v-loop to find v_o from v_o':

$$+v_o' - v_s - v_o = 0\,V$$

or $$v_o = v_o' - v_s$$

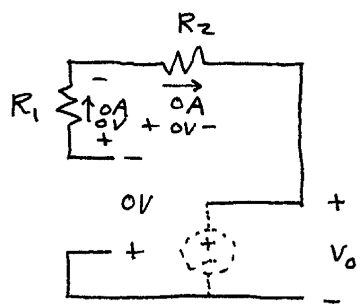
or $$v_o = i_s R_{eq} + v_s - v_s$$

or $$v_o = i_s R_{eq}$$

Consistency check:

Let $i_s = 0\,A$. Then no current flows in R_1 and R_2. Thus, there is no v-drop across R_1 and R_2.

We have a simple v-loop thru v_o:



$$-0V - 0V - 0V - v_o = 0V$$

Thus $v_o = 0V$.

Plugging $i_s = 0A$ into $v_o = i_s R_{eq}$ gives $v_o = 0$ ✓