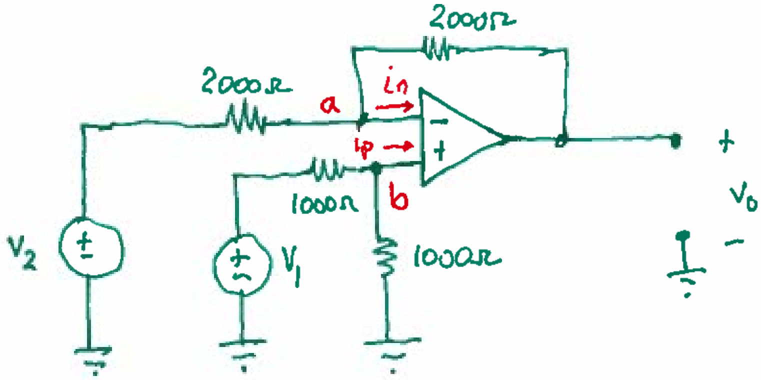
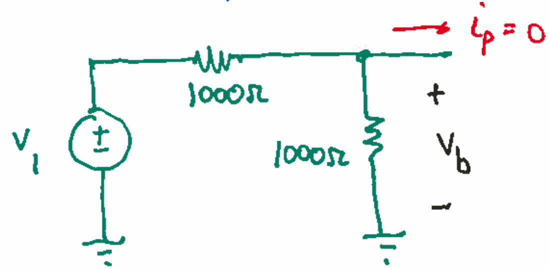
Example 2: a differential amplifier – solve for V_o Friday, March 4, 2016



Start with what we know for sure. At the op-amp's '+' terminal, by our previous analysis.



Since $i_p = 0$, resistors are in series, → voltage divider.

This means $V_a = V_b = \dfrac{1000}{1000+1000} V_1 = \frac{1}{2} V_1$ (1)

At node a:

$$\frac{V_a - V_2}{2000} + \frac{V_a - V_o}{2000} + \cancel{i_n}^{\,0} = 0$$

(x 2000) $V_a - V_2 + V_a - V_o = 0$

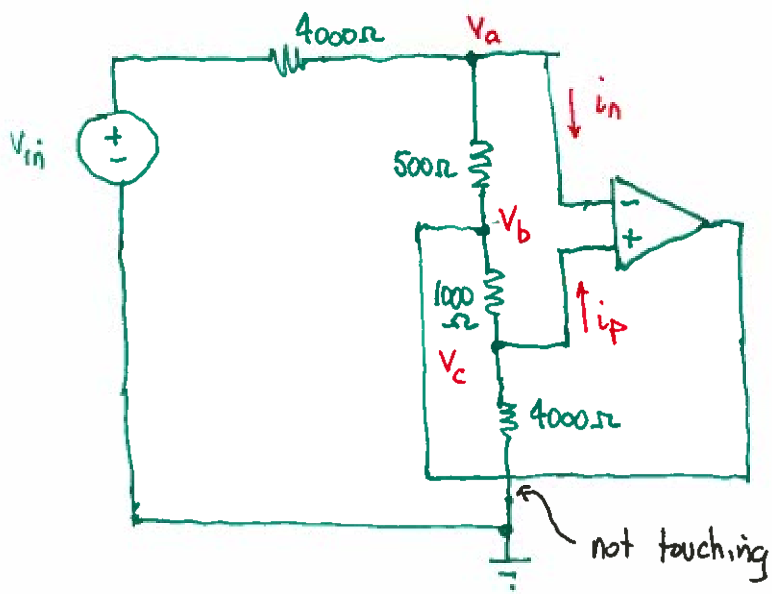
So $V_o = 2V_a - V_2$

Substitute equation (1)

$$V_o = 2\left(\tfrac{1}{2}V_1\right) - V_2$$

$$V_o = V_1 - V_2$$

Example 3: A more tricky example!



Find V_a.

As always, the most interesting things happen at the op-amp's input terminals.

Node a: $\frac{V_a - V_{in}}{4000} + \cancel{i_n}^{0} + \frac{V_a - V_b}{500} = 0 \qquad (1)$

From the summing-point constraints, we also know $V_a = V_c$.
We have two unknowns: V_a, V_b

Node c: $\frac{V_c - V_b}{1000} + \cancel{i_p}^{0} + \frac{V_c}{4000} = 0$

so $\frac{V_a - V_b}{1000} + \frac{V_a}{4000} = 0$

(x 4000) $4V_a - 4V_b + V_a = 0$

$5V_a = 4V_b$, so $V_b = \frac{5}{4} V_a \qquad (2)$

Substitute into (1)

$$\frac{V_a - V_{in}}{4000} + \frac{V_a - \frac{5}{4} V_a}{500} = 0$$

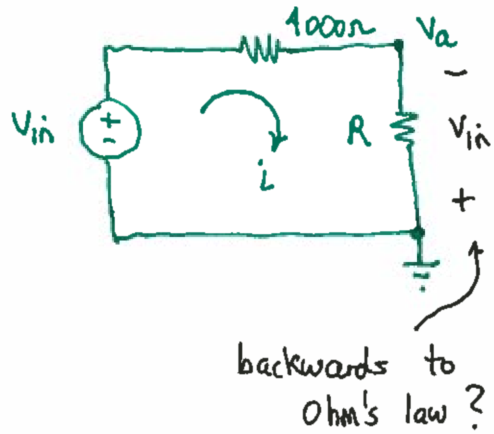
(x 4000) $V_a - V_{in} + 8V_a - 8\left(\frac{5}{4} V_a\right) = 0$

$$V_a(1+8-10) = V_{in}$$

$$\therefore\ V_a = -V_{in}$$

(Notice we didn't need to write an equation at b.)

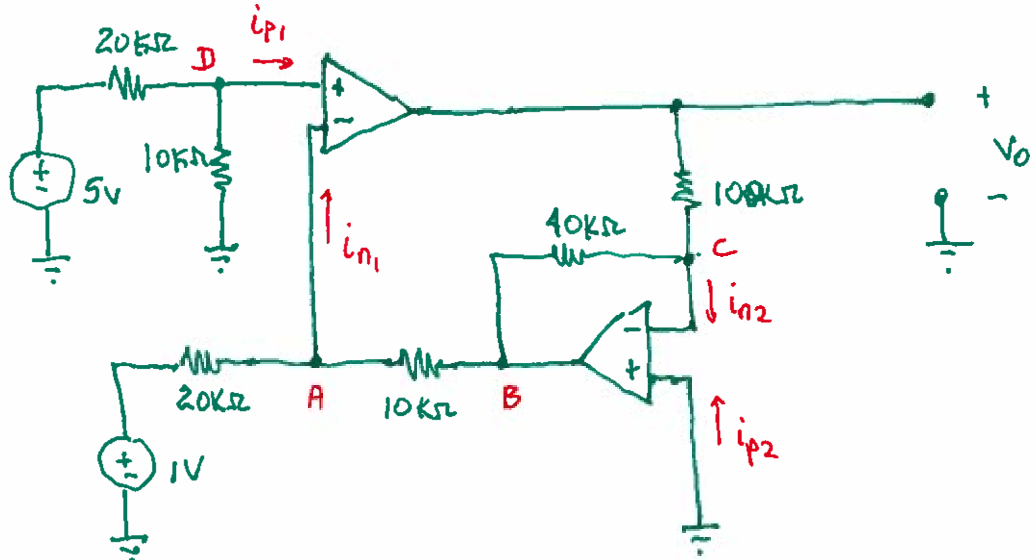
The op-amp circuit is emulating a negative resistance!



$$i = \frac{V_{in} - (-V_{in})}{1000} = \frac{2V_{in}}{4000}$$

$$\text{and } R = \frac{V_a}{i} = -\frac{V_{in}}{i} = \frac{-V_{in}}{\left(\frac{2V_{in}}{4000}\right)} = -2000\Omega$$

Example 4: Trickier still – a two op-amp problem



Find V_o.

What the summing-point constraints give us:

Upper op-amp: $i_{n_1} = 0$, so we have a simple voltage divider