Monday, March 7, 2016

$$V_D = \frac{10K}{10K + 20K} \times 5 = \frac{5}{3} V$$

[or node equation : $\frac{V_D - 5}{20K} + \frac{V_D}{10K} + \cancel{i_{A1}}^{0} = 0$]

This must also be the voltage at A : $V_A = \frac{5}{3} V$.

Also, we know $V_C = 0 V$. We have two unknown voltages : V_B, V_o

Op-amp's input terminals always most important. Write an equation at node A, where we know $V_A = \frac{5}{3} V$.

$$\frac{V_A - 1}{20K} + \cancel{i_{n1}}^{0} + \frac{V_A - V_B}{10K} = 0$$

$$V_A - 1 + 2V_A - 2V_B = 0$$

$$3V_A - 2V_B = 1$$

But $V_A = \frac{5}{3} V$, so $\left(\frac{5}{3}\right)3 - 2V_B = 1$

$$5 - 2V_B = 1$$

$$\therefore V_B = 2V$$

One more node of interest : V_C !

$$\frac{V_C - V_o}{100K} + \frac{V_C - V_B}{40K} + \cancel{i_{n2}}^{0} = 0$$

With $V_B = 2$, $V_C = 0$

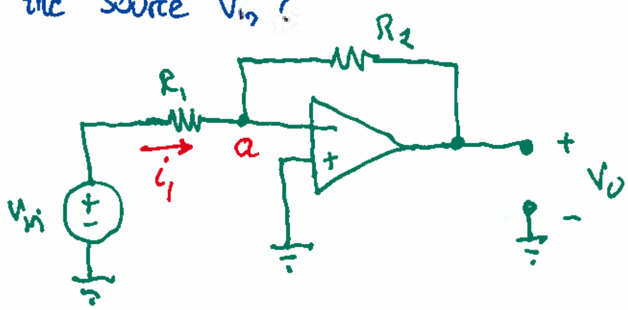
$$\frac{-V_o}{100K} - \frac{2}{40K} = 0$$

$$V_o = \frac{-2(100K)}{40K}$$

$$\boxed{V_o = -5V}$$

Input resistance of op-amp circuits

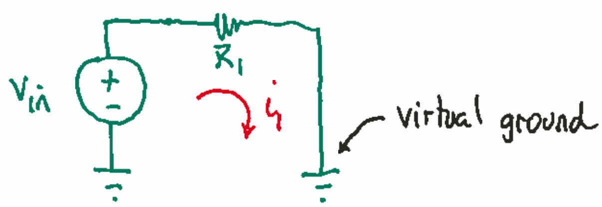
Consider an inverting amplifier. What is the resistance "seen" by the source V_{in}?



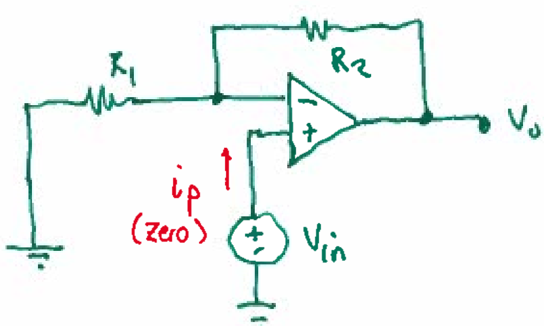
Recall that $V_a = 0$ due to the virtual short circuit

We have $i_1 = \frac{V_{in}}{R_1}$

so the source "sees" a resistance of R_1



Now how about non-inverting

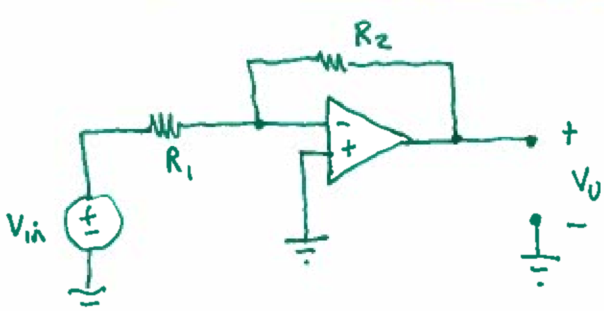


$i_p = 0$

So $R_{in} = \frac{V_{in}}{i_p} = \infty$

open-circuit!

Another application of op-amps – comparators



We showed

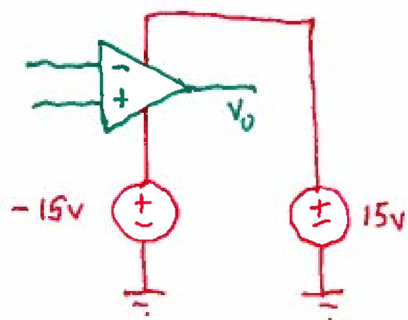
$$V_o = -\frac{R_2}{R_1} V_{in}$$

Closed-loop gain $A_v = -\frac{R_2}{R_1}$

Resistor R_2 is a critical component here

- provides the required "negative feedback" to allow this circuit to operate.

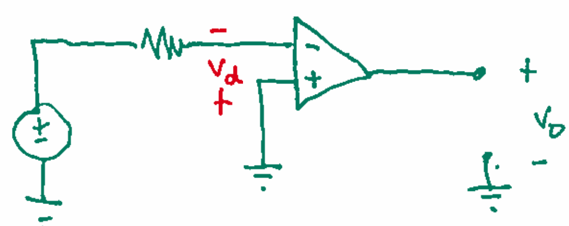
Also recall that the op-amp itself requires an external power source to operate.



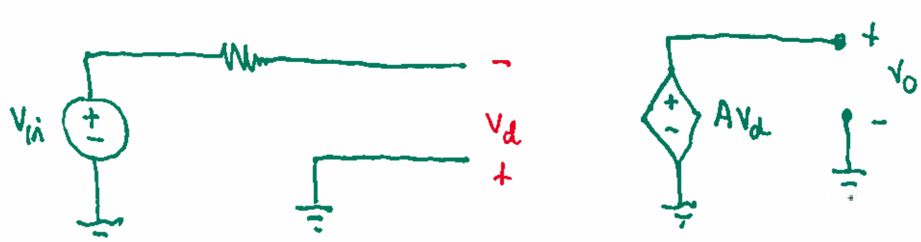
- with external power sources as shown, V_0 is allowed to be any voltage in range

$$-15 \leq V_0 \leq 15.$$

Now suppose that R_2 is not there.



This now means that we are running the op-amp "open-loop". Using the ideal model,



We have

$$V_d = -V_{in}, \quad \text{so} \quad V_o = -A V_{in}$$

"open-loop" gain

→ big number! (ideally ∞)

If $V_{in} < 0$, $V_o = +$ [huge number]

$V_{in} > 0$, $V_o = -$ [huge number]

Here, [huge number] is limited by the external power sources, so

$$\left.\begin{array}{ll} \text{If } V_{in} < 0, & V_o = +15\text{ V} \\ V_{in} > 0, & V_o = -15\text{ V} \end{array}\right\} \text{ only operates at extremes.}$$

This behaviour makes the op-amp very useful as a <u>voltage comparator</u>.