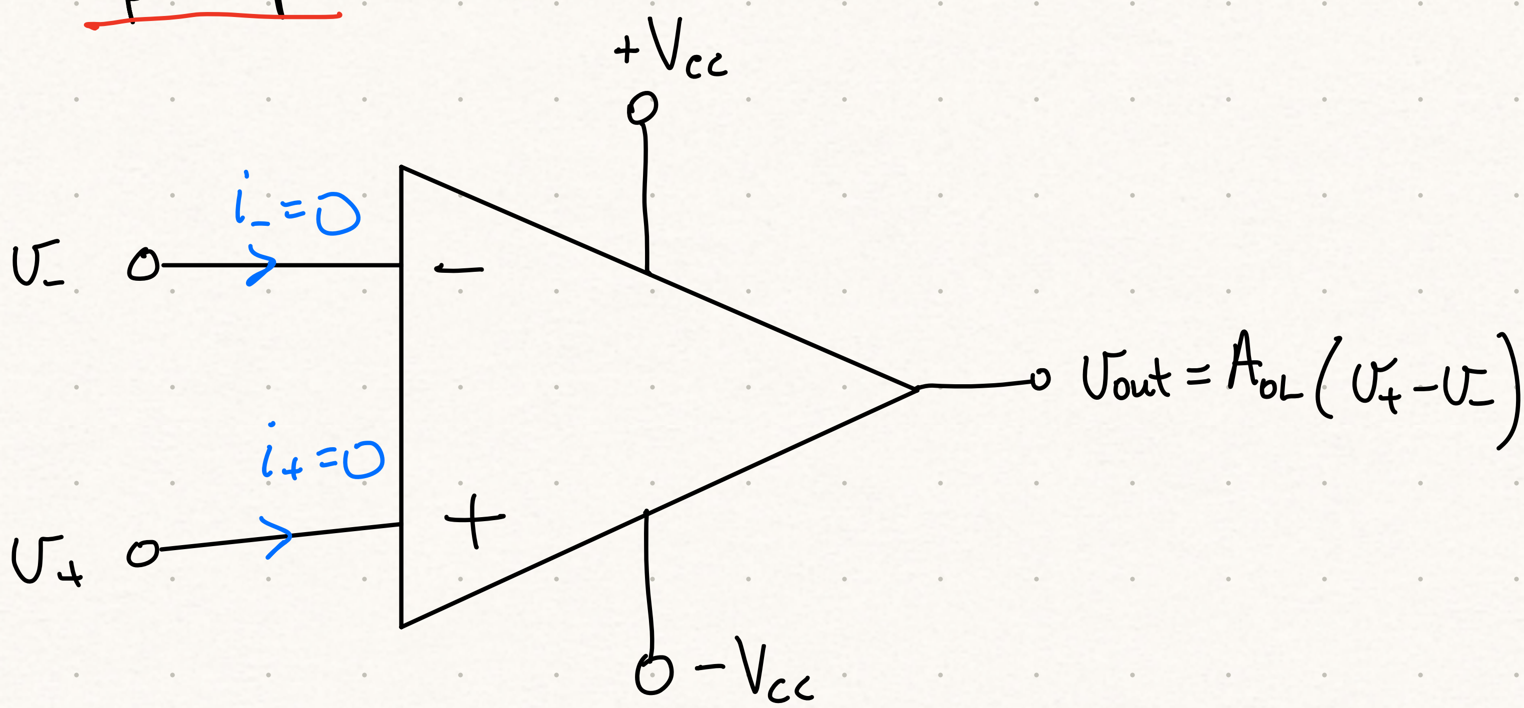
PHYS 231

Oct. 17, 2025

The PHYS 231 Class on Friday, Oct. 24 is cancelled. In its place, I will record a 50-minute lecture and post it to the course website.

Last Time:

Op Amps



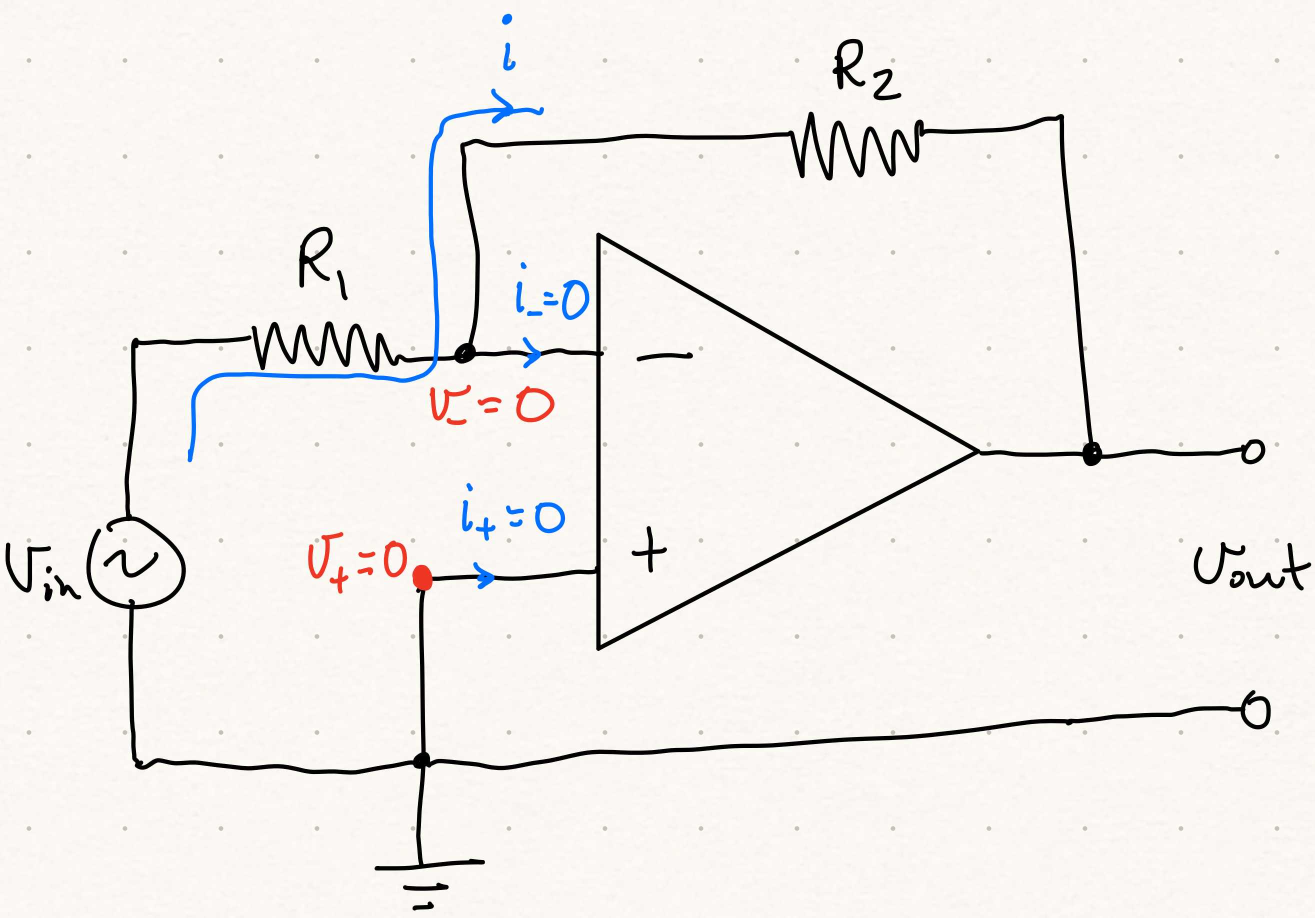
Golden Rules:

① No current into or out of op amp inputs $\Rightarrow$ $i_+ = i_- = 0$

② When using negative feedback, the voltage difference across op amp inputs is zero.

$$\Rightarrow v_+ = v_-$$

Inverting Amplifier



1. $v_{in} - iR_1 = v_- = 0 \Rightarrow i = \frac{v_{in}}{R_1}$

2. $\cancelto{0}{v_-} - iR_2 = v_{out}$

$$\boxed{\therefore v_{out} = -\left(\frac{R_2}{R_1}\right) v_{in}}$$

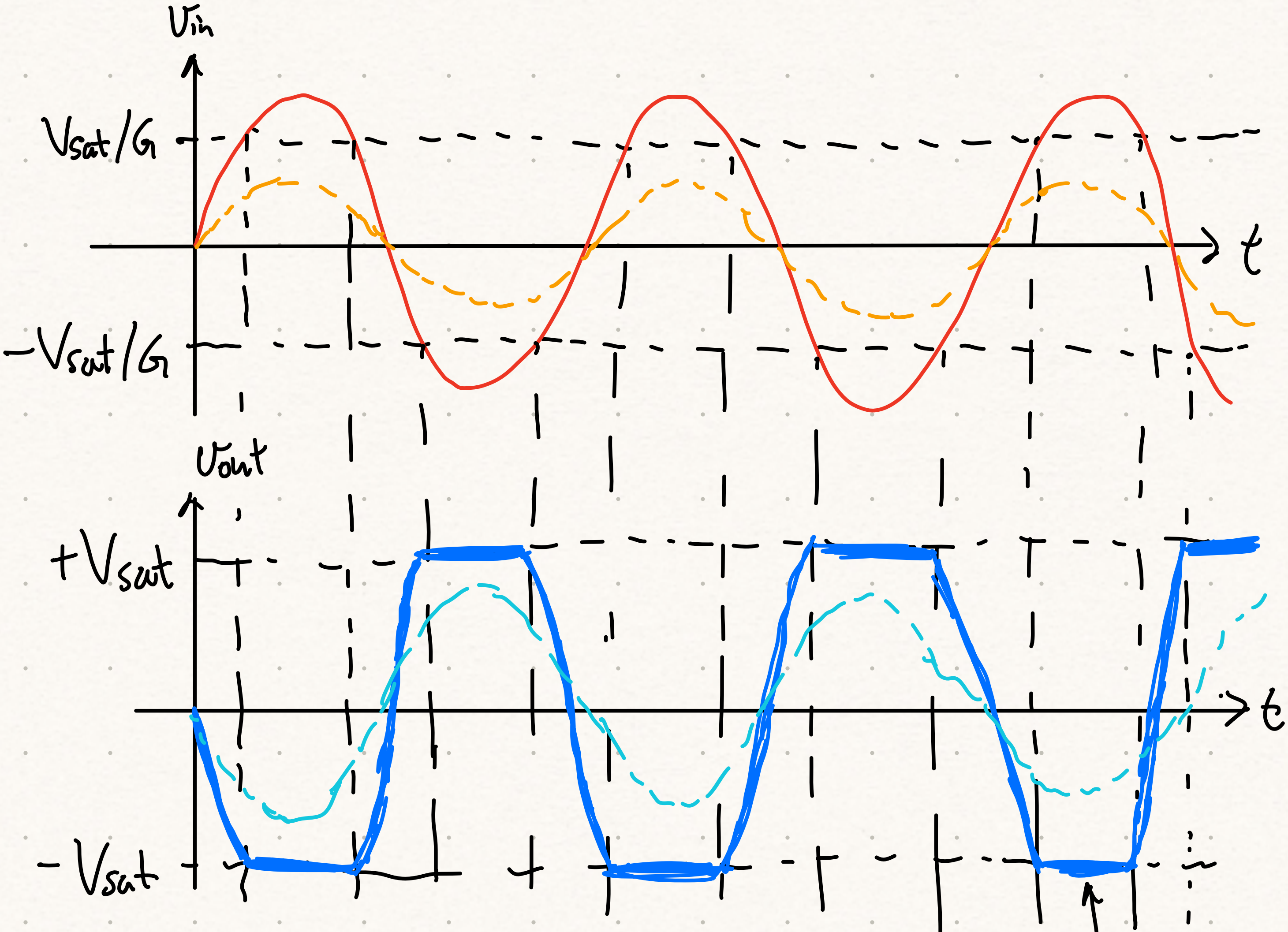
In Lab #5, you will use $R_2 = 100\,k\Omega$
$R_1 = 1\,k\Omega$

$\Rightarrow G = -100$ amp. w/ a gain of -100.
inverting.

Recall that the op amp can output a maximum of $\pm V_{sat} \approx V_{cc} - 1\,V = 14\,V$ for $V_{cc} = 15\,V$.

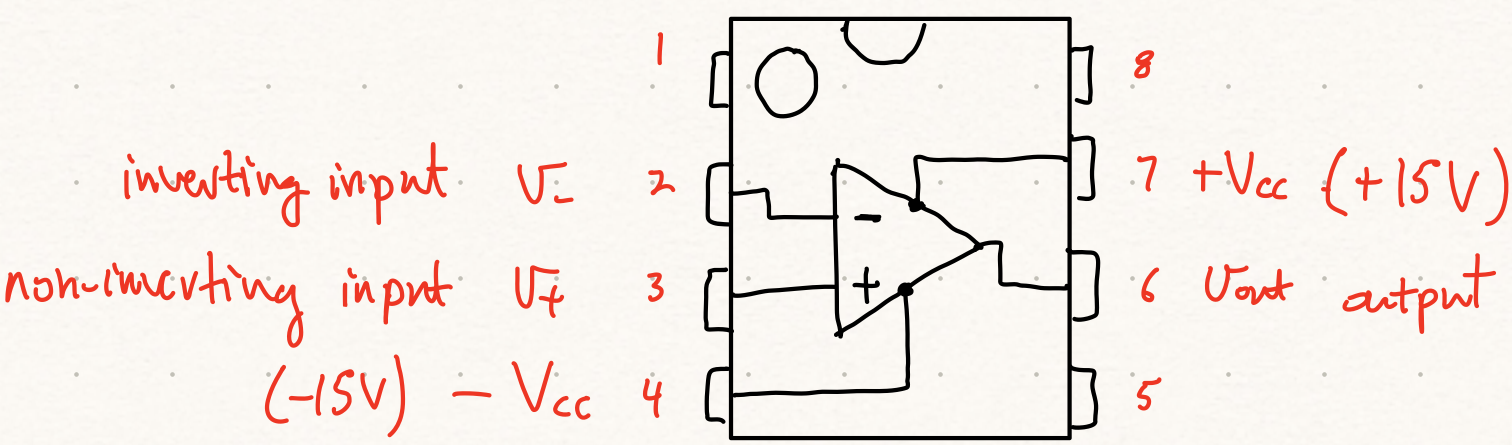
$\therefore v_{out,\,max} = \pm V_{sat}$.

To avoid saturating the output, we need to keep $v_{in} \leq \frac{V_{sat}}{G} \approx 140\,mV$.



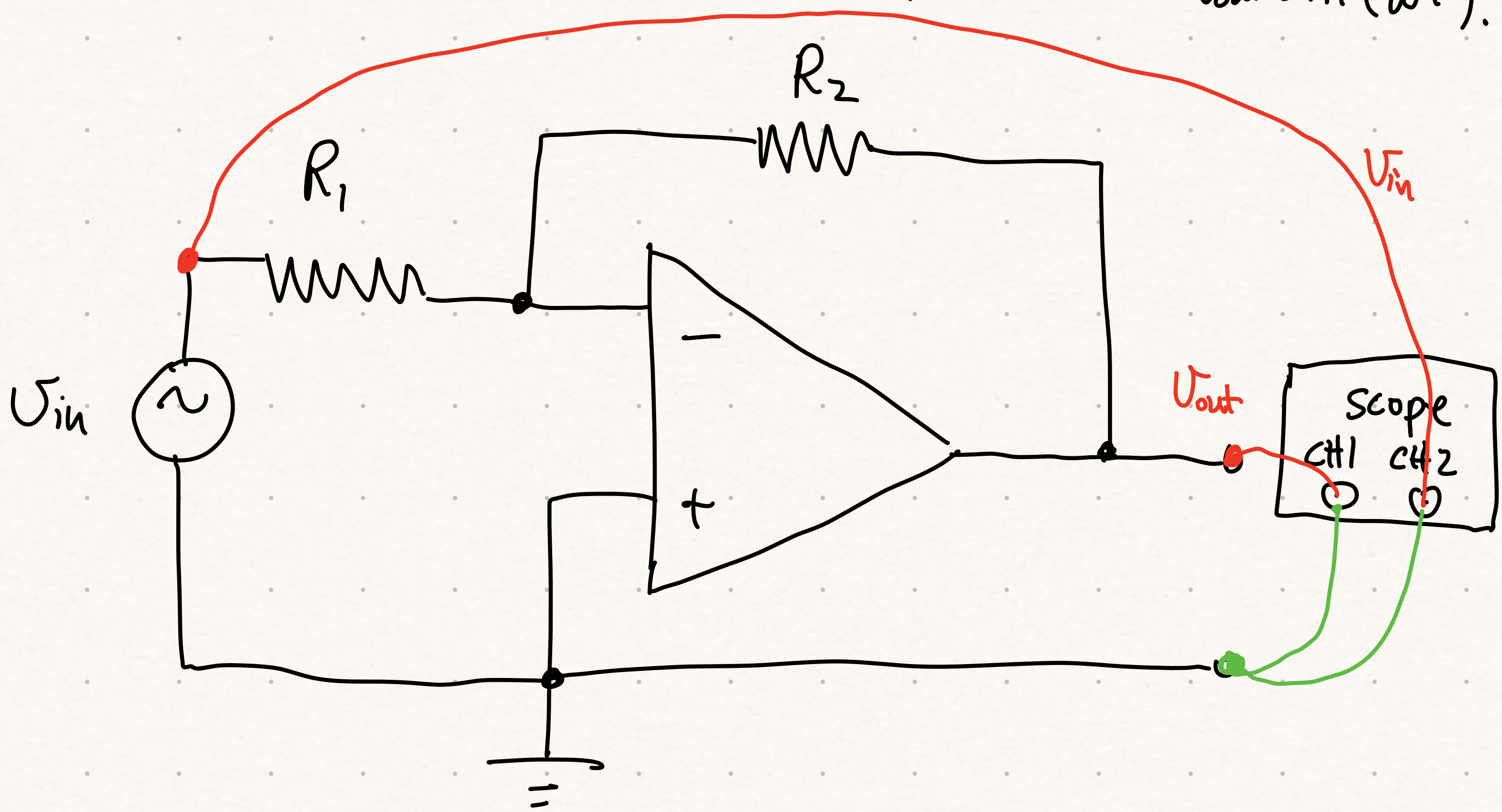
Saturated or clipped op amp output.

Op amps come packaged as "integrated circuits" (ICs) or a "chip".



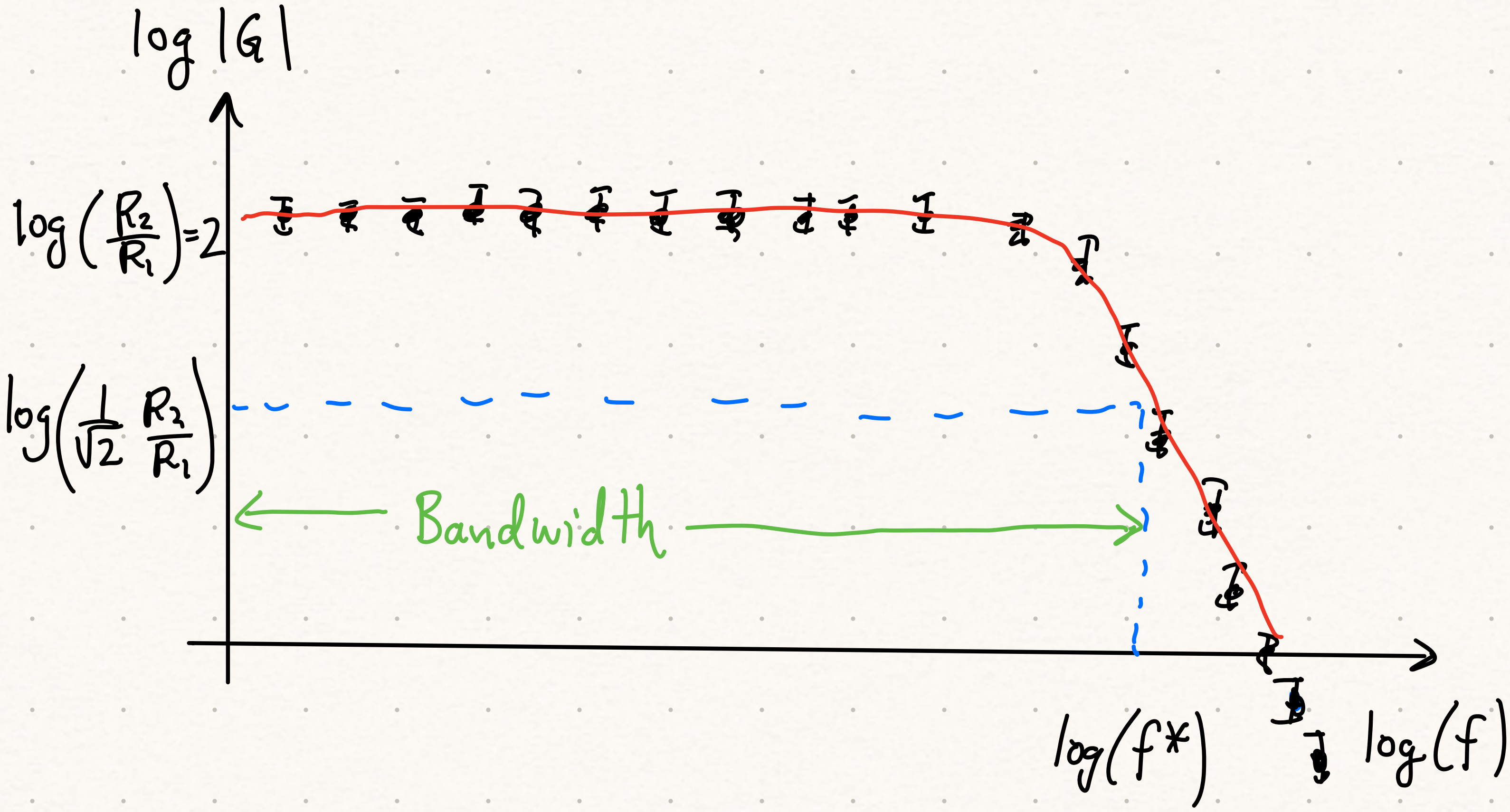
We will not use pins 1, 5, 8.

In Lab #5, we will use a fcn generator to provide $v_{in} = V_0 \sin(\omega t)$. Meas. v_{in} & $v_{out} = -V_{out} \sin(\omega t)$.



Meas. amplitude of v_{in} (V_0) and amp. of v_{out} (V_{out}) as a fcn of freq. f.

Take the ratio $\frac{V_{out}}{V_0} = G$ to determine the circuit's gain vs freq.



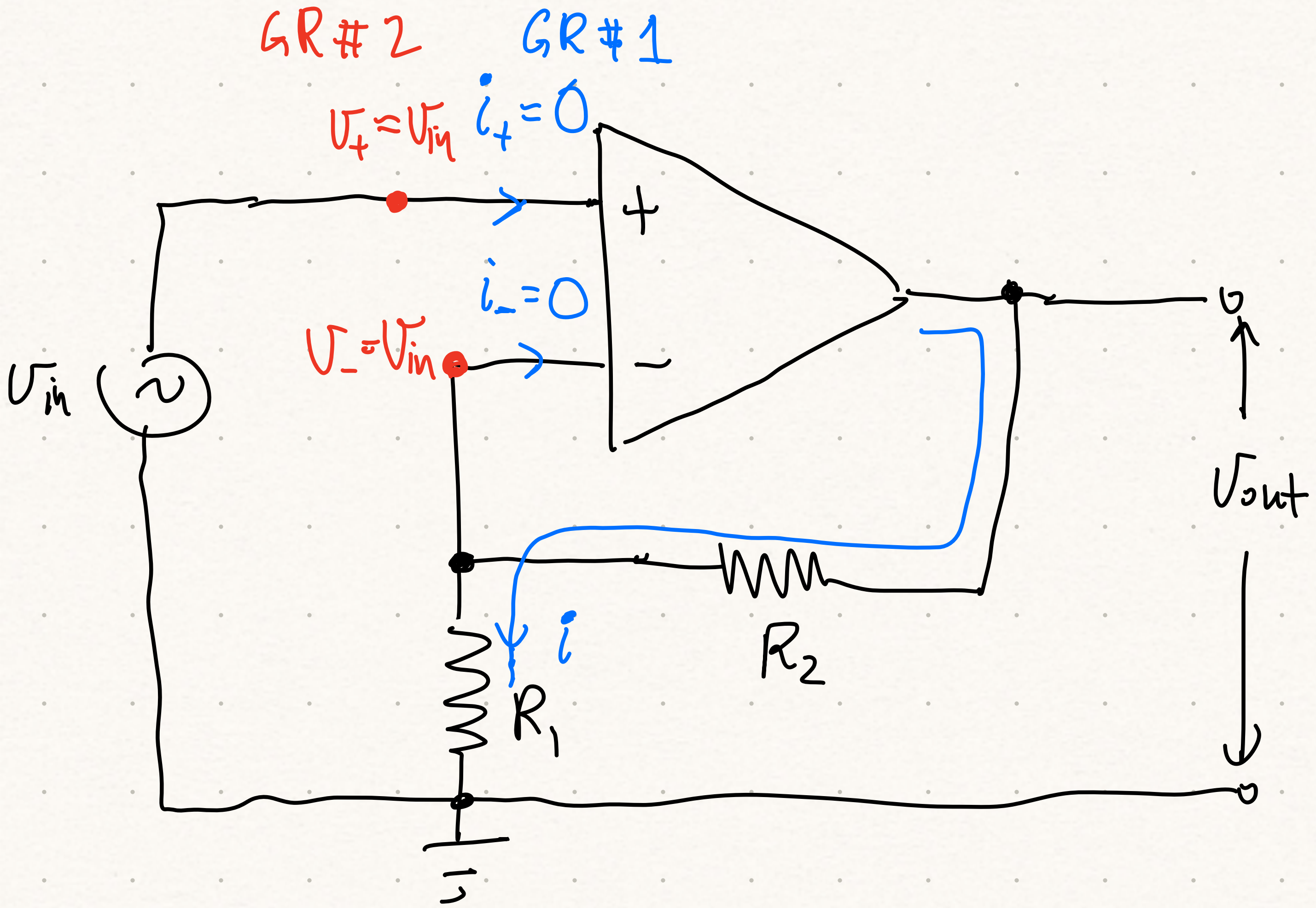
At low enough freq., the $|G| = \frac{V_{out}}{V_0}$ is const, or indep. of freq.

However, as freq is increased, eventually reach a point at which the gain decreases.

We define the "bandwidth" of the amplifier as the freq. f^* at which the gain falls to $\frac{1}{\sqrt{2}}$ of the low-freq. gain $G = \frac{R_2}{R_1}$.

The bandwidth (BW) $0 < BW < f^*$ defines the useful freq. range over which the amplifier works well.

Another op amp amplifier. → Non-inverting amp.



∴ Track volt. changes from v_- to gnd.

$$v_- - iR_1 = 0$$

$$\therefore\ v_{in} - iR_1 = 0 \implies \boxed{i = v_{in}/R_1}$$

Track changes in volt. from V_{out} to gnd.

$$V_{out} - i(R_1 + R_2) = 0$$

$$\therefore V_{out} = i(R_1 + R_2)$$

$$\therefore V_{out} = \frac{V_{in}}{R_1}(R_1 + R_2) = \left(1 + \frac{R_2}{R_1}\right) V_{in}$$

$$\boxed{\therefore \frac{V_{out}}{V_{in}} = G = \left(1 + \frac{R_2}{R_1}\right)}$$

No negative sign.
$\therefore$ non-inverting.

Here, the minimum possible gain is 1.
We cannot use the non-inverting amp to decrease the amp. of V_{in} @ V_{out}.