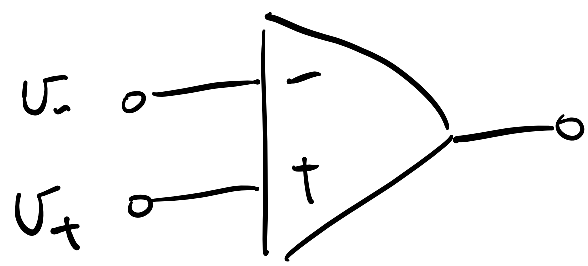
PHYS 231 – Nov. 1, 2023

Last Time: Op Amps



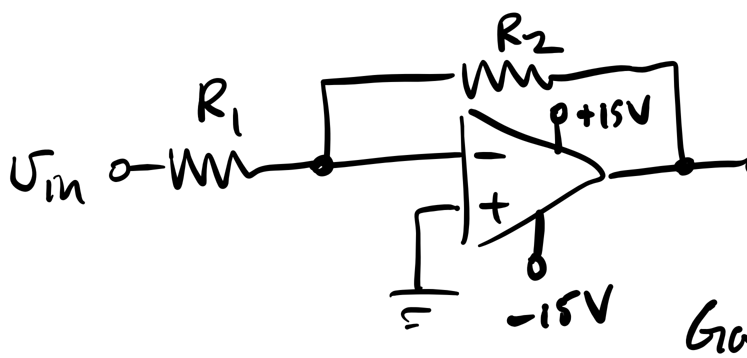
$V_{out} = A_{OL}(V_+ - V_-)$

Golden Rules:

1. Current into/out of op amp inputs is zero. $\Rightarrow i_+ = i_- = 0$

2. When using negative feedback, $V_+ = V_-$.

Inverting Amplifier (Lab #5).



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

Gain: $G = -R_2/R_1$

Tommorrow's Lab:

Build inverting amplifier using

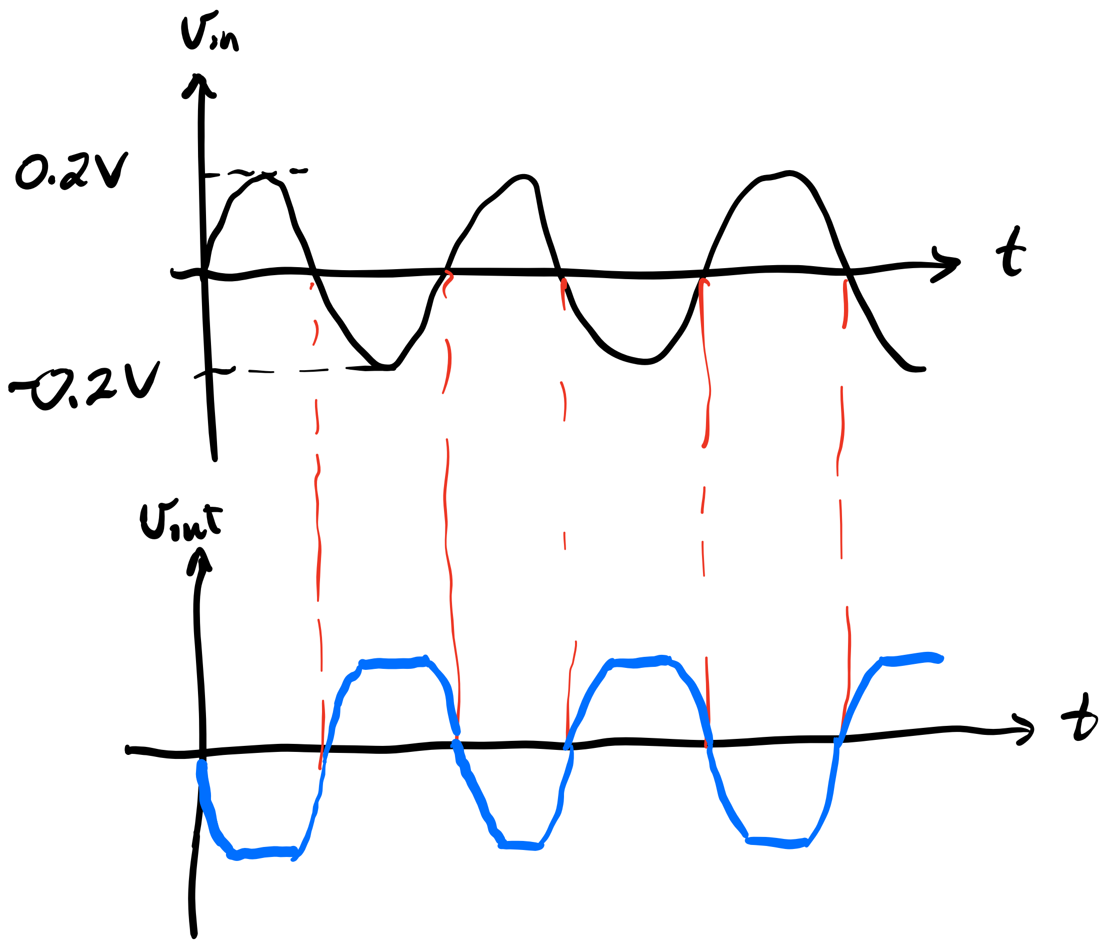
$R_1 = 1k\Omega$

$R_2 = 100k\Omega$.

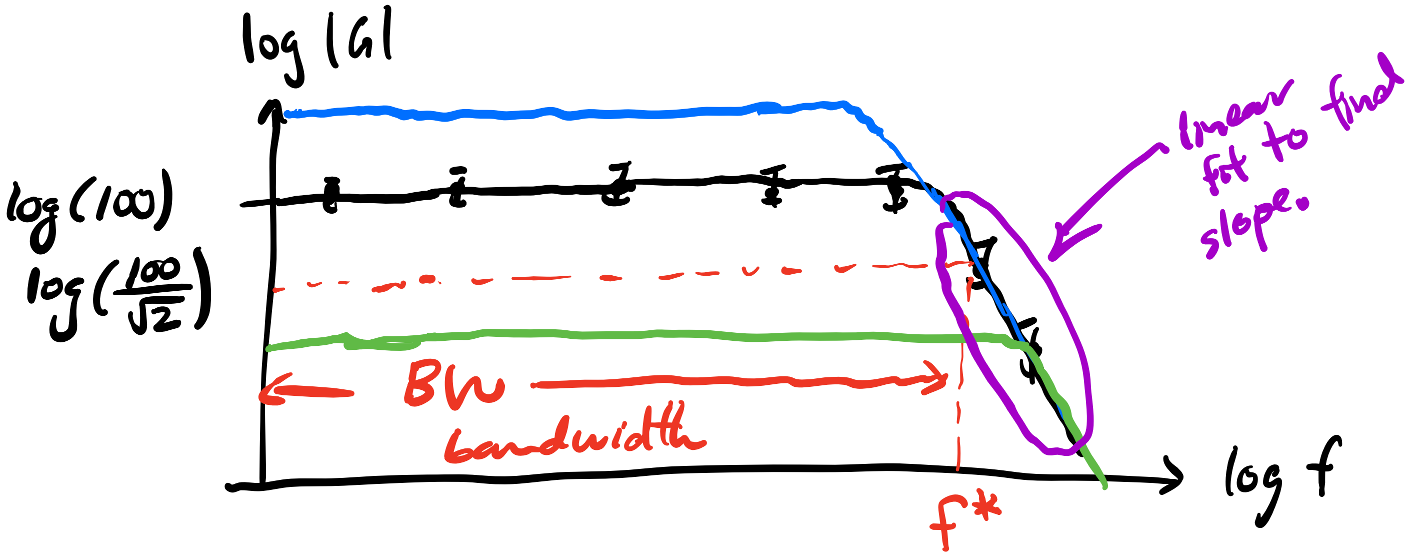
$v_{in} = V_0 \sin(\omega t)$

v_{out} is meas. w/ osc.

Limitations:



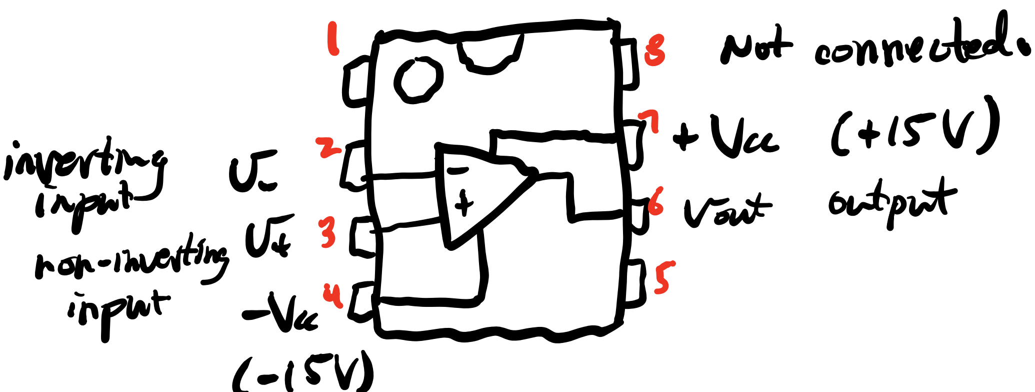
- Meas. $|G|$ vs f.
- Plot $\log|G|$ vs $\log f$.

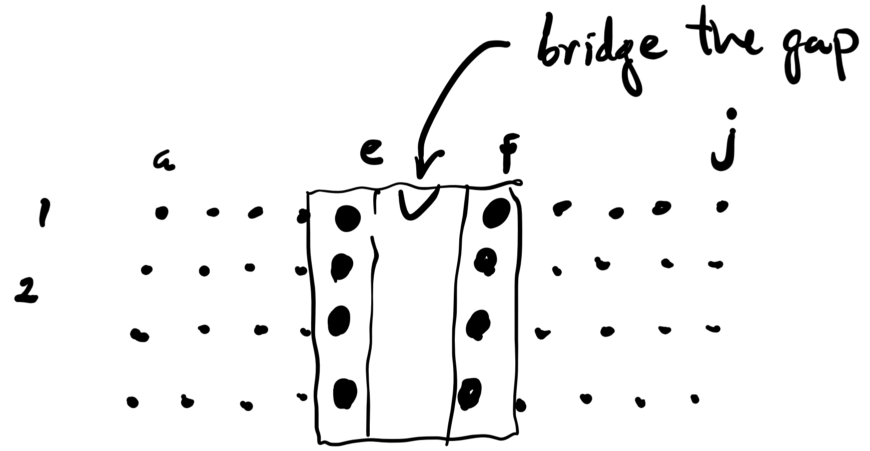


Inverting amplifier has a gain-bandwidth product that is const.

$$|G| \cdot BW = C \quad (\text{const})$$

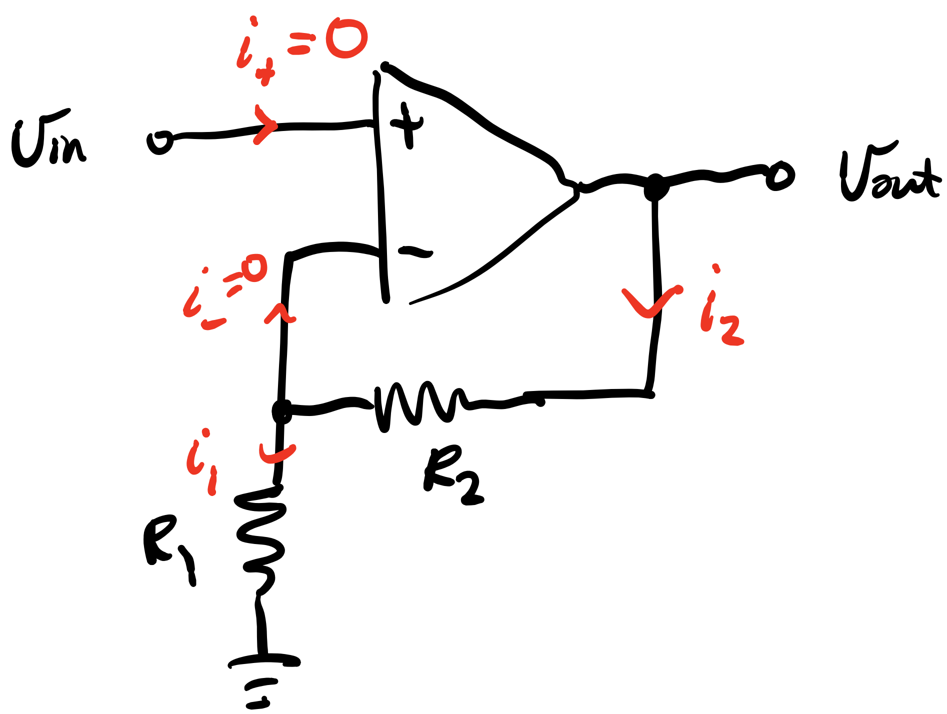
LM741 op amp that you'll use comes on a chip (IC's) Integrated circuits.





More Op amp applications:

1. Non-inverting amplifier



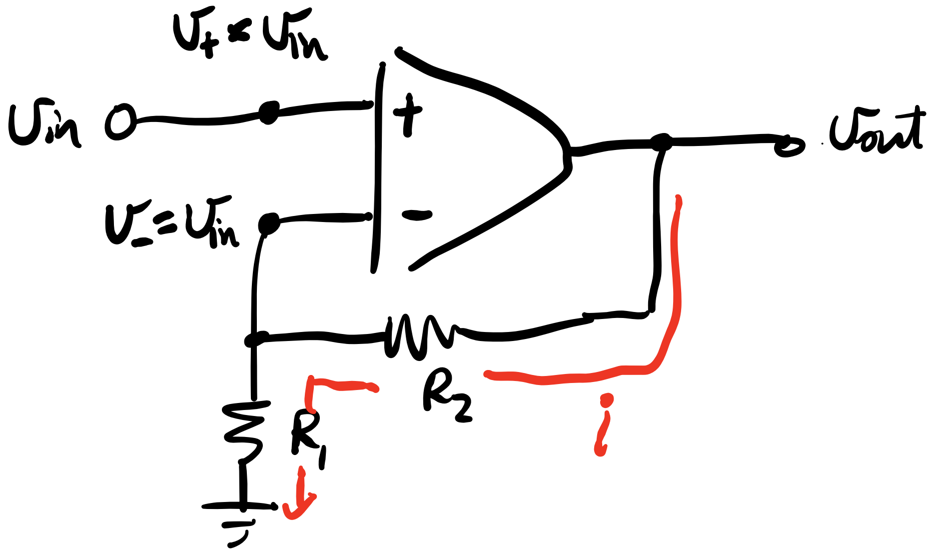
Apply op amp Golden rules.

Sum rule $\quad i_2 = i_1 + i_- \to 0$

First Golden rule: $\quad i_- = 0.$

$i_+ = 0$

$$i_2 = i_1 \equiv i$$



2nd Golden Rule: $\quad V_+ = V_-$

Since $V_+ = V_{in}$

require $V_- = V_{in}$

Start from V_- & work towards gnd.

$$\underbrace{V_-}_{V_{in}} - iR_1 = 0 \quad \Rightarrow \quad \boxed{i = \frac{V_{in}}{R_1}}$$

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

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

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

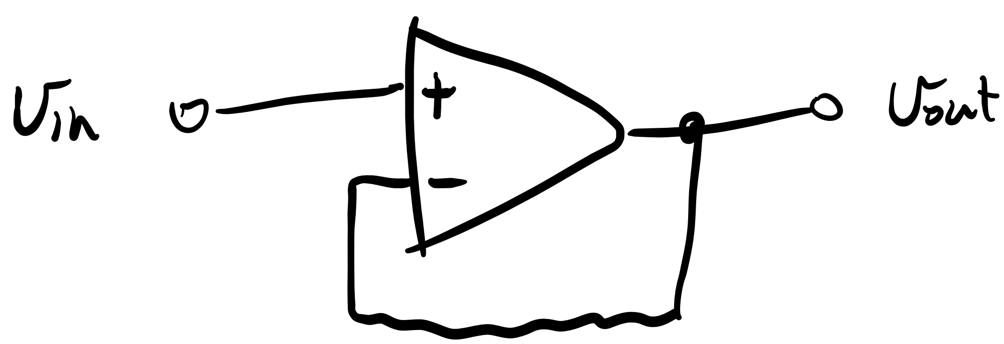
$$\boxed{\frac{V_{out}}{V_{in}} = G = \left(1 + \frac{R_2}{R_1}\right)}$$

non-inverting amplifer gain.

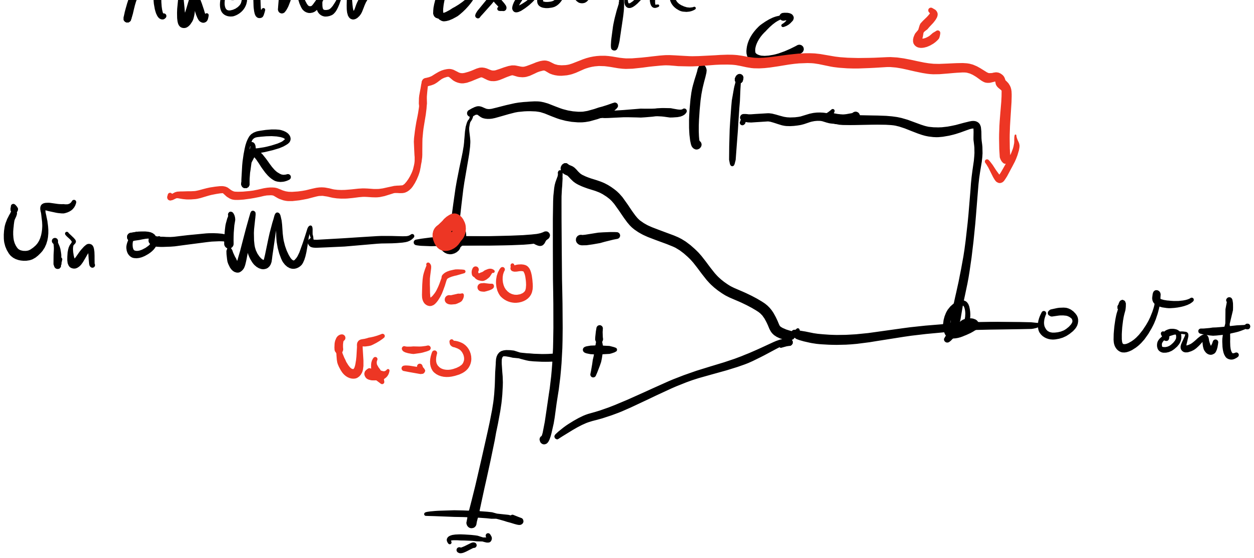
Minimum possible gain of 1

(take $R_2 = 0$, $R_1 \to \infty$).

Buffer Circuit ($R_2 \to 0$, $R_1 \to \infty$)



Another Example:



From v_{in} to v_-

$$v_{in} - iR = v_- = 0$$

$$i = \frac{v_{in}}{R}$$

From v_- to v_{out}

$$v_- - v_c = v_{out} \quad (v_- \rightarrow 0)$$

$$v_{out} = -\frac{q}{C}$$

$$C = \frac{q}{v_c}$$

$$\therefore \; v_c = \frac{q}{C}$$

know $i = \frac{dq}{dt}$

$$q = \int i \, dt$$

$$v_{out} = -\frac{1}{C}\int i \, dt$$

$$v_{out} = -\frac{1}{C}\int \frac{v_{in}}{R} \, dt$$

$$\boxed{v_{out} = -\frac{1}{RC}\int v_{in} \, dt}$$

If Put in $v_{in} = \text{const}$

$$v_{out} = -\frac{1}{RC} v_{in} t$$