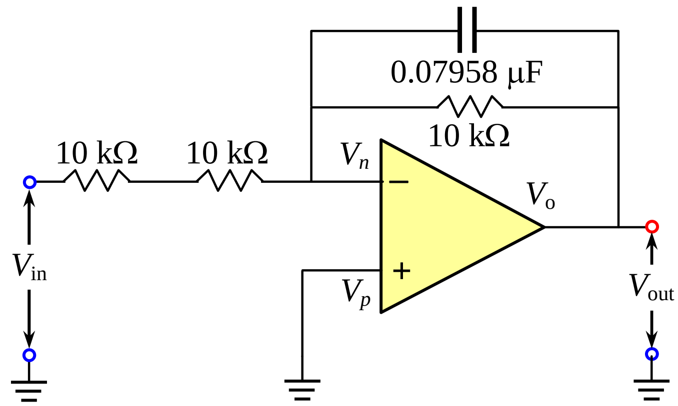
Today, we will:

- Do some more example problems and discussion about op-amp circuits
- Finish reviewing the pdf module: **op-amps (miscellaneous properties: GBP, CMRR)**

Example: Op-amp circuits

Given: Consider the circuit shown.



(***a***) **To do**: What kind of circuit is this?

(***b***) **To do**: Calculate the output voltage V_{out} when the input voltage is 2.0 V DC.

(***c***) **To do**: Calculate the amplitude of the output voltage V_{out} when the input voltage is a pure sine wave with amplitude 1.0 V and frequency 200 Hz.

Recall, from last lecture:

In general, we desire our electronic circuits to have ***very low output impedance*** and ***very high input impedance***.

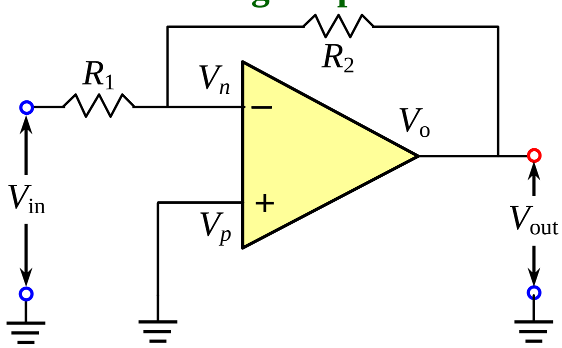
The input impedance of an inverting amplifier op-amp circuit is approximately R_1.

That is one reason why we generally want R_1 to be large (> 1 kΩ as an absolute lower limit).

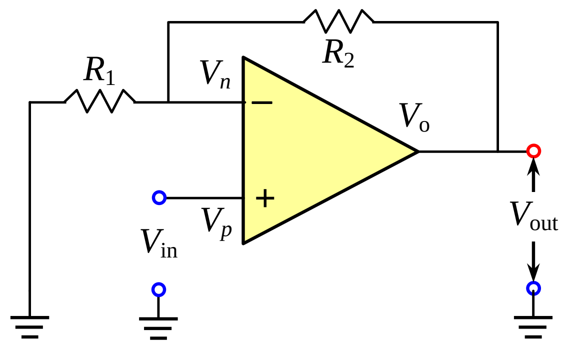
The output impedance of an inverting amplifier op-amp circuit is small, on the order of 1 Ω.

What about a *noninverting* amplifier? What are the input and output impedances?

Inverting Amplifier:

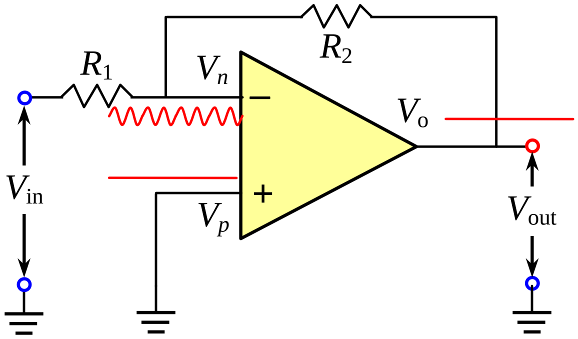


Noninverting Amplifier:

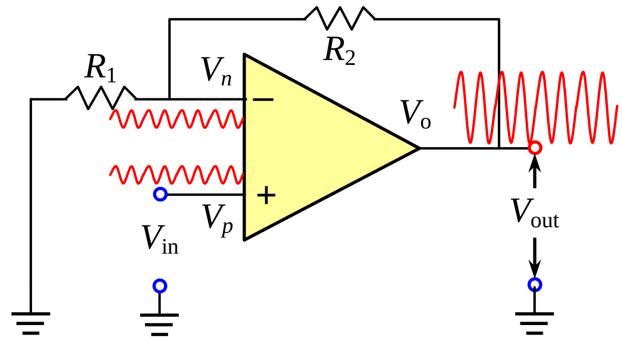


Let's compare the amplification of **common mode noise** for *inverting* and *noninverting* amplifiers (common mode noise amplification).

Inverting Amplifier:



Noninverting Amplifier:



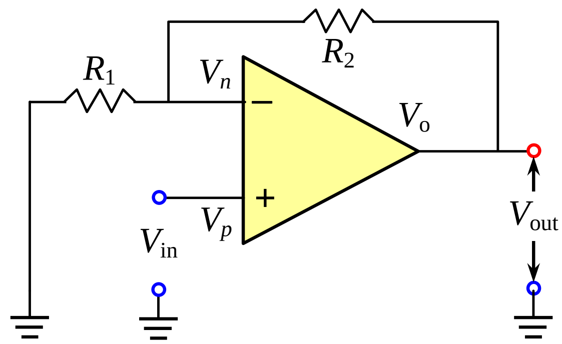
Bottom Line:

- If *input loading* is of primary concern, *noninverting* amplifiers should be used.
- If *noise reduction* and *signal-to-noise issues* are of primary concern, *inverting* amplifiers should be used.

Example: Op-amp circuits with GBP effects

Given: We need to amplify the output of a microphone (music converted into voltage) by a factor of 1000. We construct a noninverting amplifier as sketched, with:

- $R_1 = 1\ \text{k}\Omega$
- $R_2 = 999\ \text{k}\Omega$



To do:
(***a***) Calculate the *theoretical* gain of the circuit (at any frequency) if the op-amp were ideal.
(***b***) Calculate the *actual* gain for a type 741 op-amp, with GBP = 1.0 MHz at the following frequencies of the music:

- f = 20 Hz (lower limit of human hearing)
- f = 261.63 Hz (middle C)
- f = 4000 Hz = 4 kHz (a fairly high note)
- f = 20 kHz (upper limit of human hearing)

(***c***) Suggest a better circuit.

Solution:

Example: Op-amp circuits

Given: We need to build an amplifier with a theoretical gain of 25 (or -25 – sign does not matter). We use a 741 op-amp with GBP = 1.0 MHz (1000 kHz). The resistors we have on hand are 5 kΩ, 10 kΩ, 20 kΩ, 50 kΩ, 100 kΩ, and 200 kΩ (we have several of each).

(*a*) To do: Draw an electrical circuit that will generate the required gain using a non-inverting amplifier. Repeat for an inverting amplifier.

Solution:

Non-inverting:

Inverting:

(***b***) **To do**: For the non-inverting case, calculate the overall gain of the amplifier if the signal being amplified has a frequency of 20 kHz. Repeat for the inverting amplifier.

Solution:

Non-inverting:

Inverting:

(*c*) To do: For the inverting case, suppose we split up the gain into two stages to reduce the effect of the GBP-filtering. Calculate the overall gain of the amplifier if the signal being amplified has a frequency of 20 kHz.

Solution: