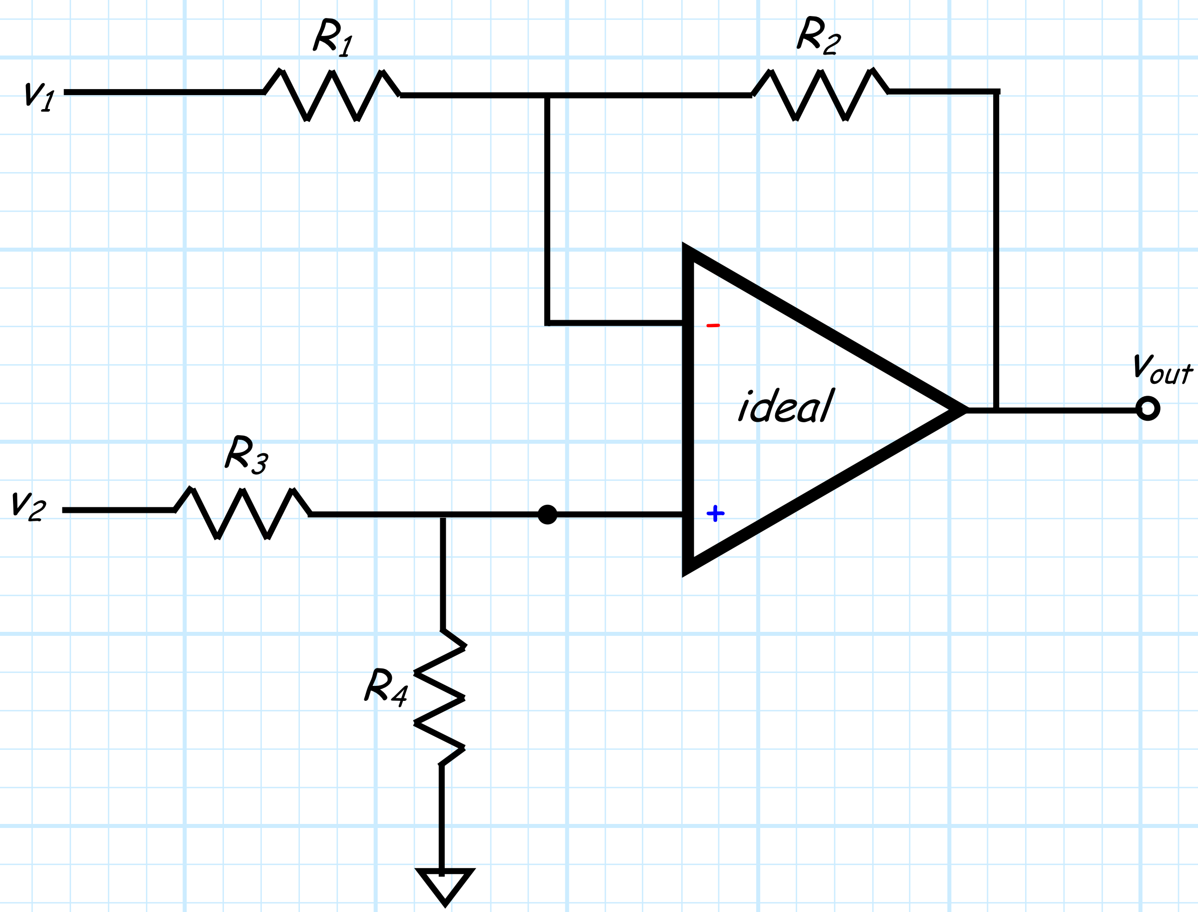
Superposition and Op-Amp Circuits

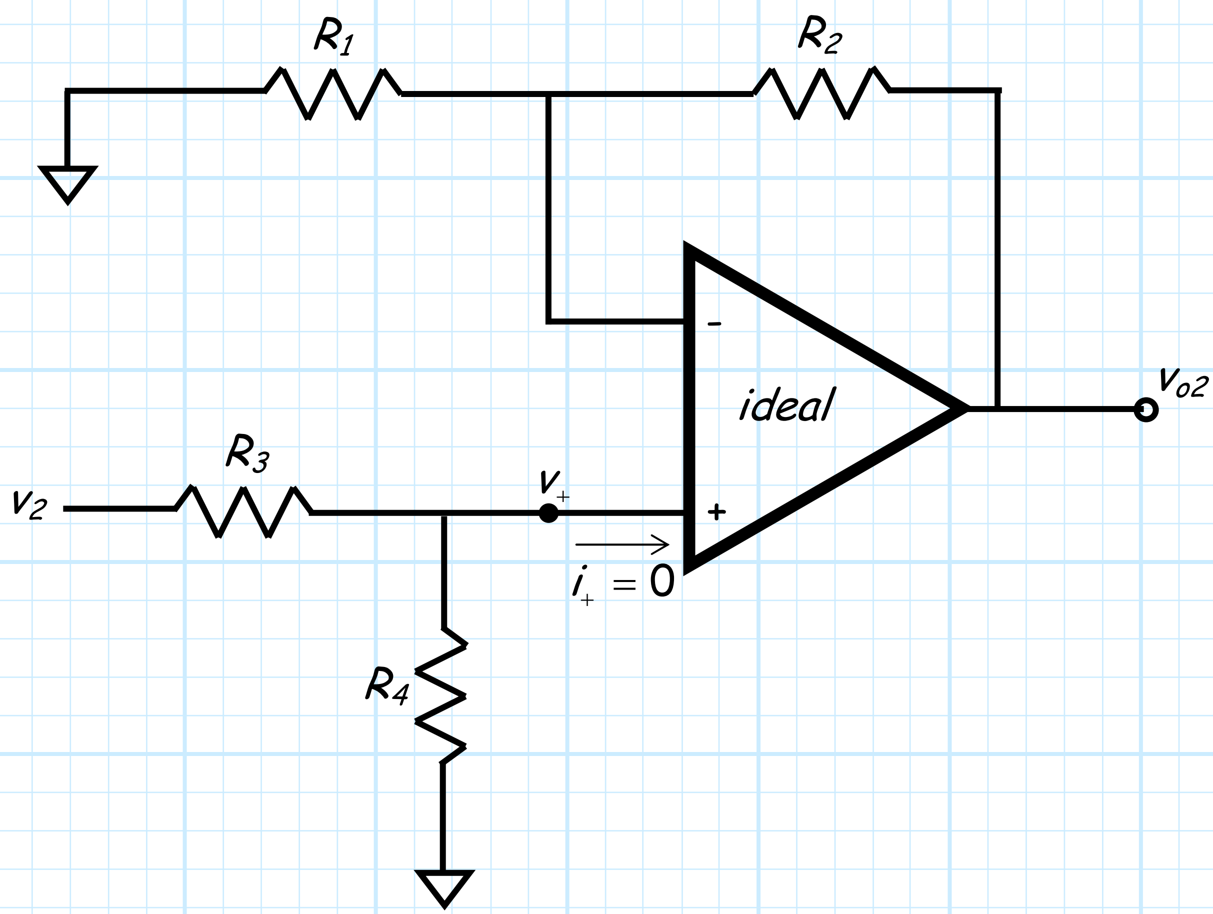
Consider **this** op-amp circuit, with two input voltages (v_1 and v_2):



Apply superpostion

The **easiest** way to analyze this circuit is to apply **superposition**! Recall that op-amp circuits are **linear**, so superposition applies.

Our **first step** is to set all sources to zero, **except** v_2—in other words, set $v_1 = 0$ (connect it to ground potential):

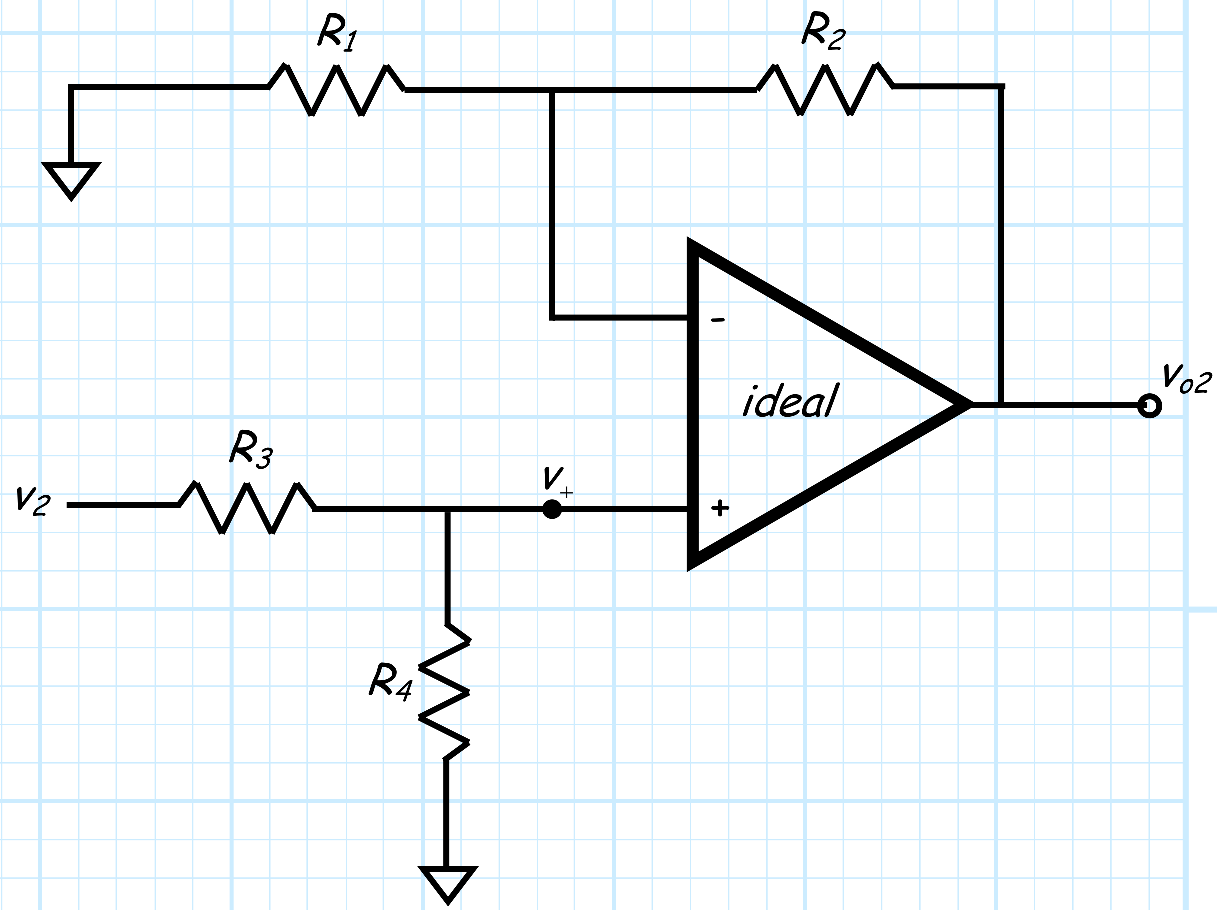


$v_1 = 0$

Since the current into the non-inverting input of the op-amp is **zero** ($i_+ = 0$), it is evident that:

$$v_+ = \frac{R_4}{R_3 + R_4} v_2$$

Likewise, the remainder of the circuit is simply the **non-inverting amplifier**, where:



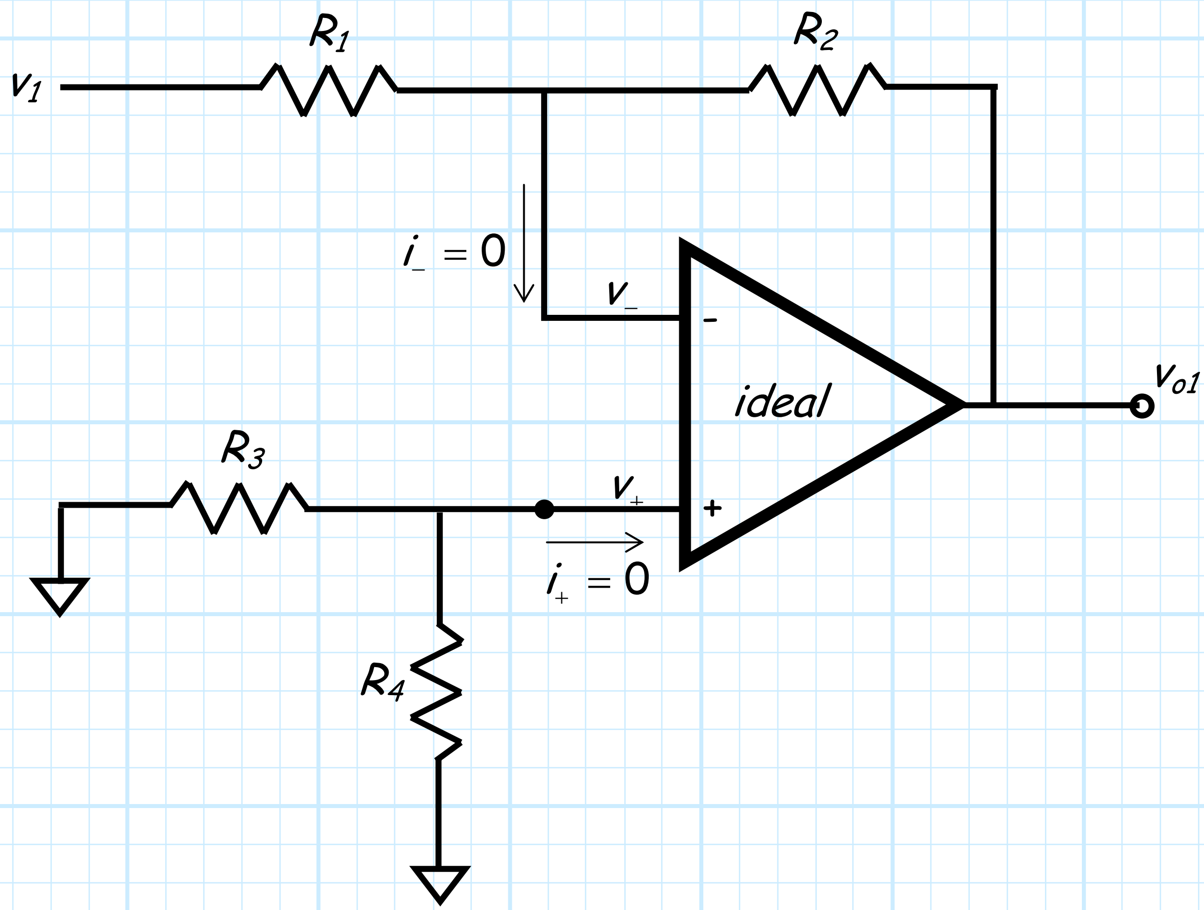
$$v_{o2} = \left(1 + \frac{R_2}{R_1}\right) v_+$$

Combining these two equations, we get:

$$v_{o2} = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right) v_2$$

$v_2 = 0$

Now for the **second step**. Turn off all sources except v_1—in other words set v_2 =0:

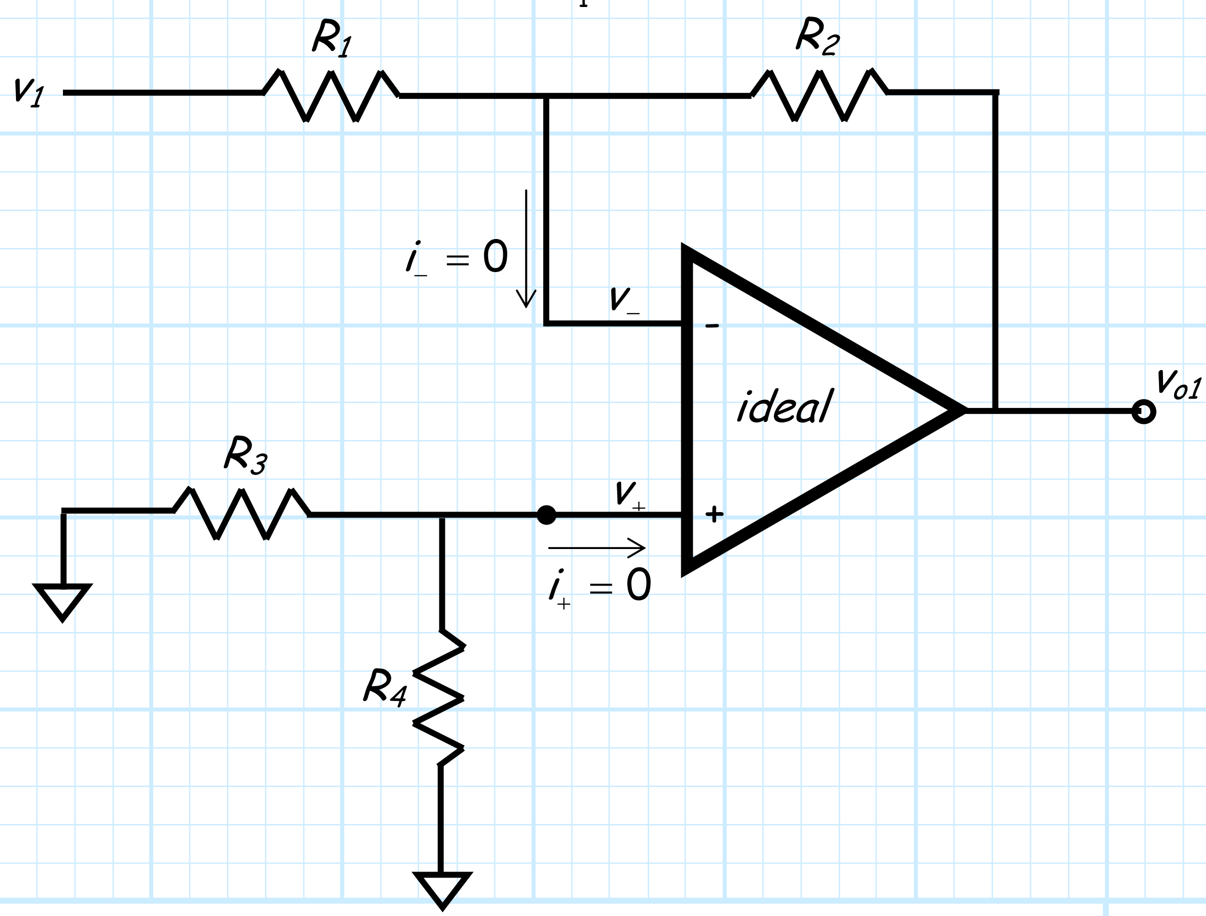


An inverting amp

It is evident that the since the current into the non-inverting terminal of the op-amp is **zero**, the voltage v_+ is likewise **zero**.

Thus, the circuit above is simply an **inverting amplifier**, where:

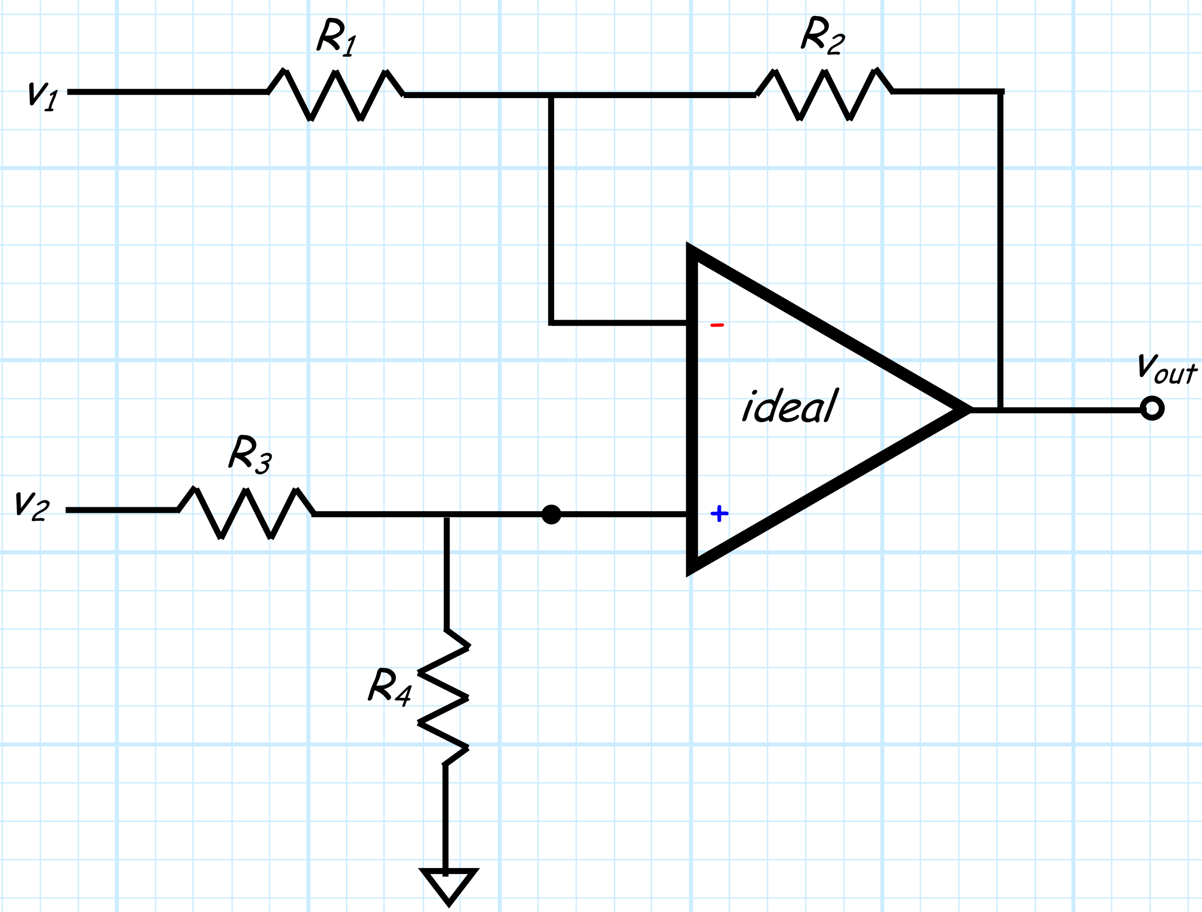
$$v_{o1} = -\frac{R_2}{R_1} v_1$$



And the result

There are **no** more sources in this circuit, so that we can conclude from **superposition** that the output voltage is the sum of our two, single-source solutions:

$$v_{out} = v_{o1} + v_{o2} = \left(1 + \frac{R_2}{R_1}\right)\left(\frac{R_4}{R_3 + R_4}\right) v_2 - \left(\frac{R_2}{R_1}\right) v_1$$



Note this circuit is effectively a **weighted difference amplifier**.