Superposition and Op-Amp Circuits

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

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):

![Circuit Diagram](image-url)
\[ v_1 = 0 \]

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:

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