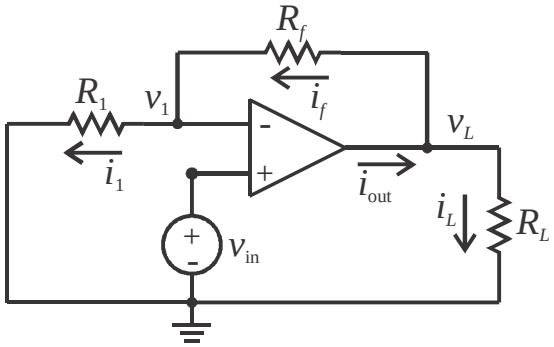
Design a non-inverting amplifier to supply a 1 kΩ load with 10 V when 1 V is input while ensuring i_{out} < 18 mA. Then, determine all labeled currents and voltages when 1 V is input.



Non-inverting Amplifier

- Using (5.11), $v_L = v_o = \left(1 + \frac{R_f}{R_1}\right) v_i$ and the requirement that the output be 10 V when the input is 1 V, we get

$$A_v = \frac{v_o}{v_i} = 1 + \frac{R_f}{R_1} = \frac{10\,\text{V}}{1\,\text{V}} = 10 \quad \Rightarrow \quad \frac{R_f}{R_1} = 9\,.$$

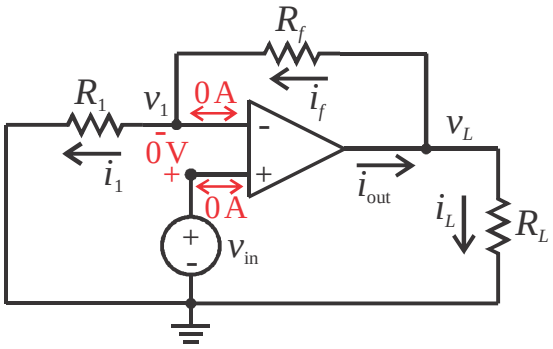
- When the output is 10 V and given that the load is 1 kΩ, the load current is

$$i_L = \frac{v_L}{R_L} = \frac{10}{1000} = 10\ \text{mA}\,.$$

- Using KCL at the output node and applying the requirement that i_{out} < 18 mA, we find that

$$i_{out} = i_f + i_L \quad \Rightarrow \quad i_f \le 18 - 10 = 8\ \text{mA}\,.$$

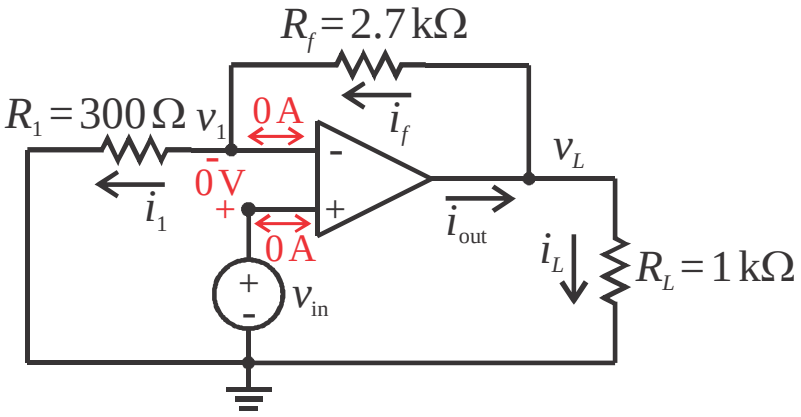
- Applying the ideal op-amp assumptions (see circuit below), $v_{in} = v_1 = 1\text{V}$.



- Then, by Ohm's Law

$$i_f = \frac{v_L - v_1}{R_f} = \frac{10 - 1}{R_f} \le 8\ \text{mA} \quad \Rightarrow \quad R_f \ge 1125\,\Omega$$

- With the above information in mind and looking at the available leaded resistors in EP 336, **select** R_f = 2.7 kΩ and R_1 = 300 Ω. This yields the circuit



Now, we can calculate all the currents and voltages for our non-inverting amplifier design when the input is 1 V.

Check gain-

$$A_v = \frac{v_o}{v_i} = 1 + \frac{R_f}{R_1} = 1 + \frac{2700}{300} = \underline{10}\,.$$

Given $v_i = v_{\text{in}} = 1\text{ V}$ -

$$v_o = A_v v_i = 10(1\text{ V}) \quad \Rightarrow \quad v_o = \underline{v_L = 10\text{ V}}$$

By ideal op-amp assumption-

$$v_{\text{in}} = \underline{v_1 = 1\text{V}}$$

Using Ohm's Law-

$$i_L = \frac{v_L}{R_L} = \frac{10\text{ V}}{1000\,\Omega} \quad \Rightarrow \quad \underline{i_L = 10\text{ mA}}$$

$$i_f = \frac{v_L - v_1}{R_f} = \frac{10-1}{2700} \quad \Rightarrow \quad \underline{i_f = 3.\overline{3}\text{ mA}}$$

$$i_1 = \frac{v_1 - 0}{R_1} = \frac{1-0}{300} \quad \Rightarrow \quad \underline{i_1 = 3.\overline{3}\text{ mA}}$$

Using KCL at the output node-

$$i_{\text{out}} = i_f + i_L = 3.\overline{3}\text{ mA} + 10\text{ mA} \quad \Rightarrow \quad \underline{i_{\text{out}} = 13.\overline{3}\text{ mA}}\,.$$

Design meets all specifications!