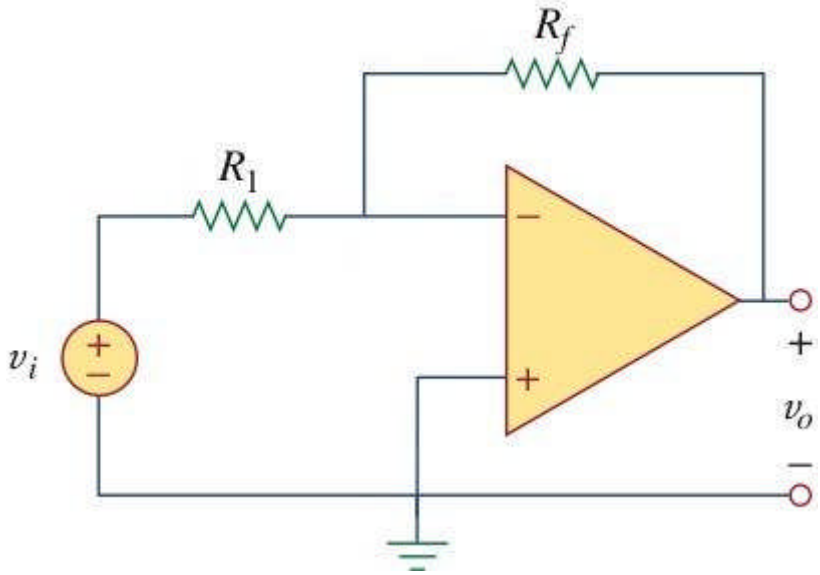
Lesson 10:
Operational Amplifiers 2

Inverting amplifier

- Calculate the output voltage v_o.

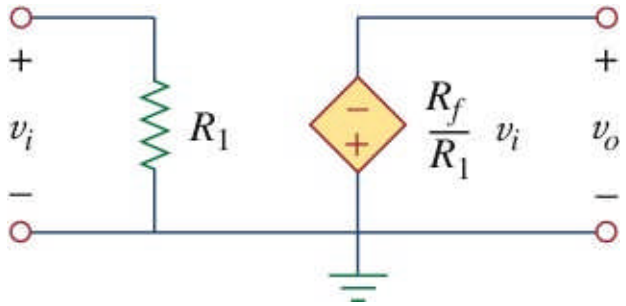


Inverting amplifier

- The inverting amplifier reverses the polarity of the signal while amplifying it.

$$v_o = -\frac{R_f}{R_1} v_i$$

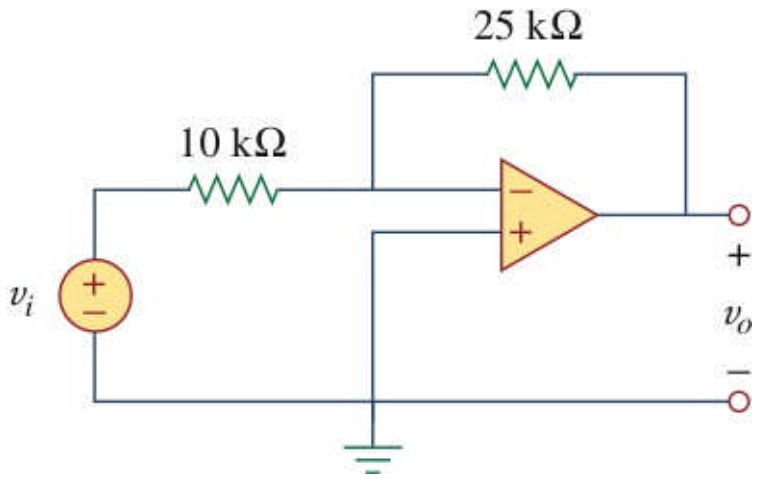
- The closed-loop voltage gain $A_v = v_o/v_i = -R_f/R_1$



Equivalent circuit for inverting amplifier

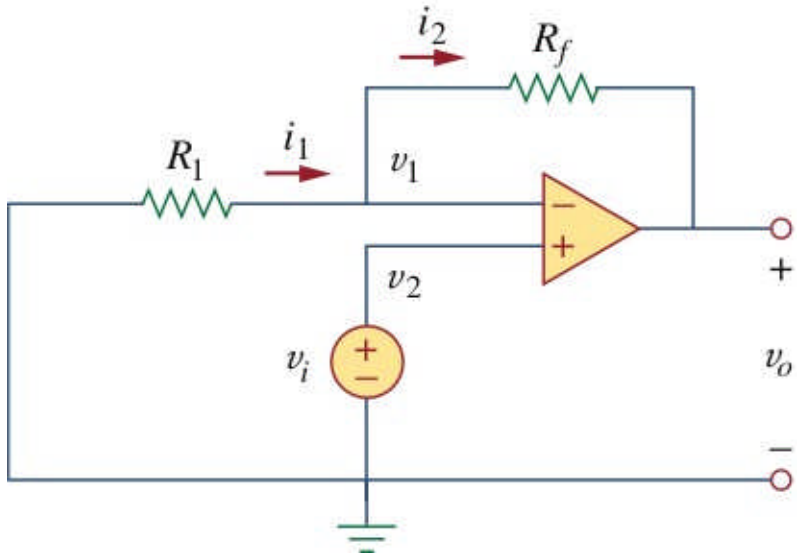
Example Problem 1

If $v_i = 0.5$ V calculate (a) the output voltage v_o, and (b) the current in the 10-kΩ resistor.



Non-inverting amplifier

- Calculate the output voltage v_o.



Non-inverting amplifier

- The non-inverting amplifier provides positive voltage gain.

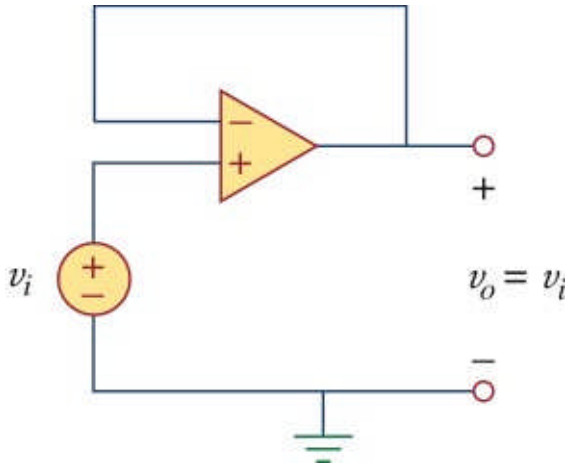
$$v_o = \left(1 + \frac{R_f}{R_1}\right) v_i$$

- The voltage gain $A_v = v_o/v_i = 1 + R_f/R_1$

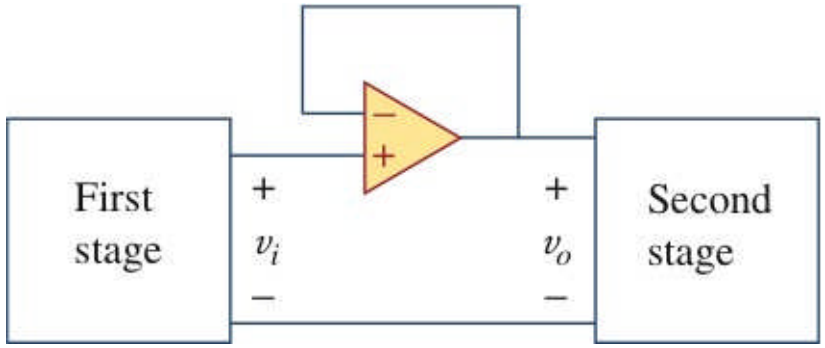
Voltage follower

- Using a non-inverting amplifier with $R_f = 0$ and $R_1 = \infty$, the voltage gain $A_v = v_o/v_i = 1$.

- This is known as a voltage follower and is often used as a buffer between multistage amplifiers.

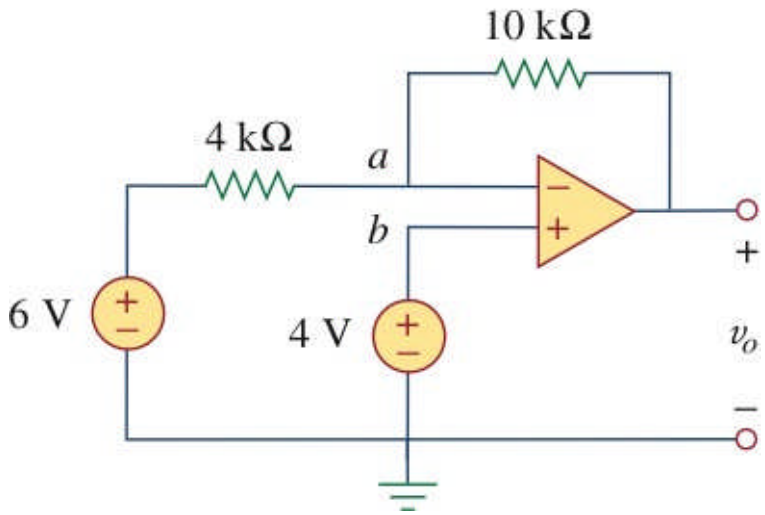


Voltage follower



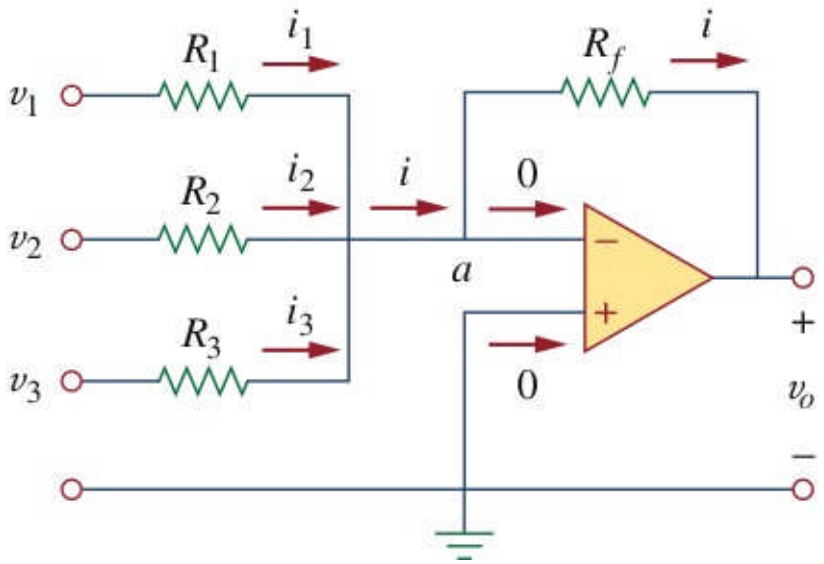
Example Problem 2

Calculate the output voltage v_o.



Summing amplifier

- Calculate the output voltage v_o.



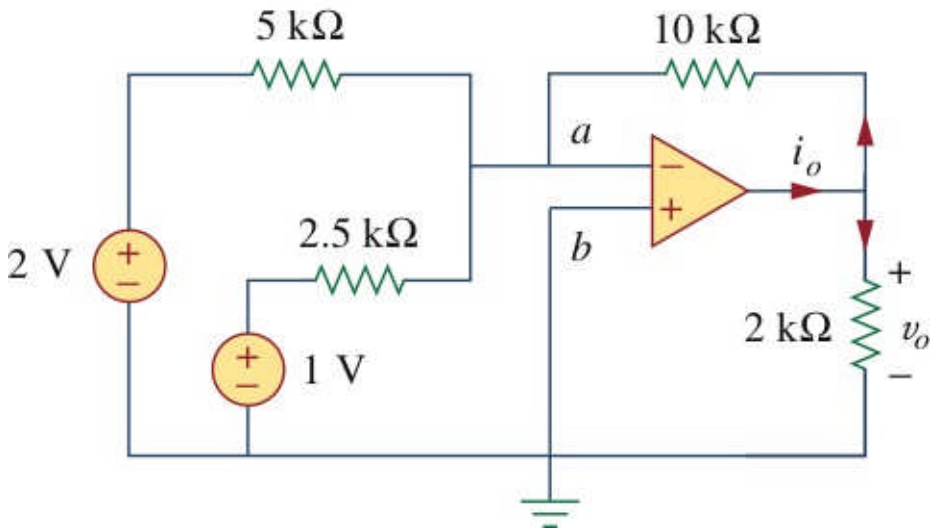
Summing amplifier

- The summing amplifier combines several inputs and produces an output that is the weighted sum of the inputs.

$$v_o = -\left(\frac{R_f}{R_1} v_1 + \frac{R_f}{R_2} v_2 + \frac{R_f}{R_3} v_3 + \cdots + \frac{R_f}{R_n} v_n \right)$$

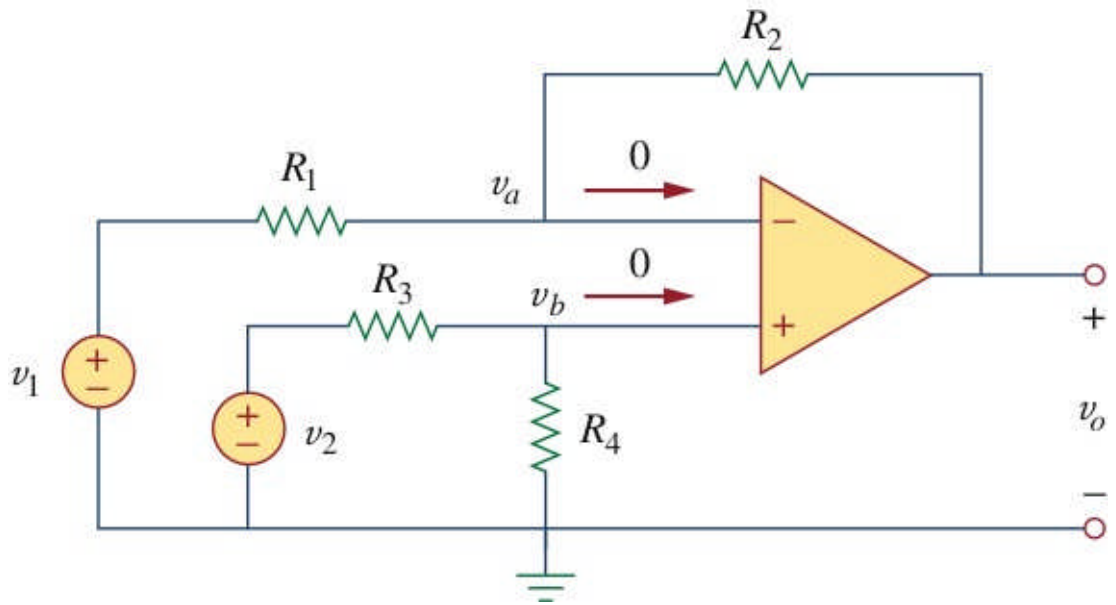
Example Problem 3

Calculate v_o and i_o.



Difference amplifier

- Calculate the output voltage v_o.



Difference amplifier

- The output voltage is given

$$v_o = \frac{R_2(1+R_1/R_2)}{R_1(1+R_3/R_4)}v_2 - \frac{R_2}{R_1}v_1$$

- The difference amplifier must meet the condition that $v_o = 0$ when $v_1 = v_2$.
  - What values of R_1, R_2, R_3, and R_4 make this true?

Difference amplifier

- The condition is met when

$$\frac{R_2}{R_1} = \frac{R_3}{R_4}$$

and the output becomes

$$v_o = \frac{R_2}{R_1}(v_2 - v_1)$$

Example Problem 4

Design an op amp circuit with inputs v_1 and v_2 such that $v_o = -5v_1 + 3v_2$.