Amplifiers

- An *amplifier* creates a replica signal with a greater amplitude:
  - Higher voltage

  or

  - Higher current

  and/or

  - Higher power

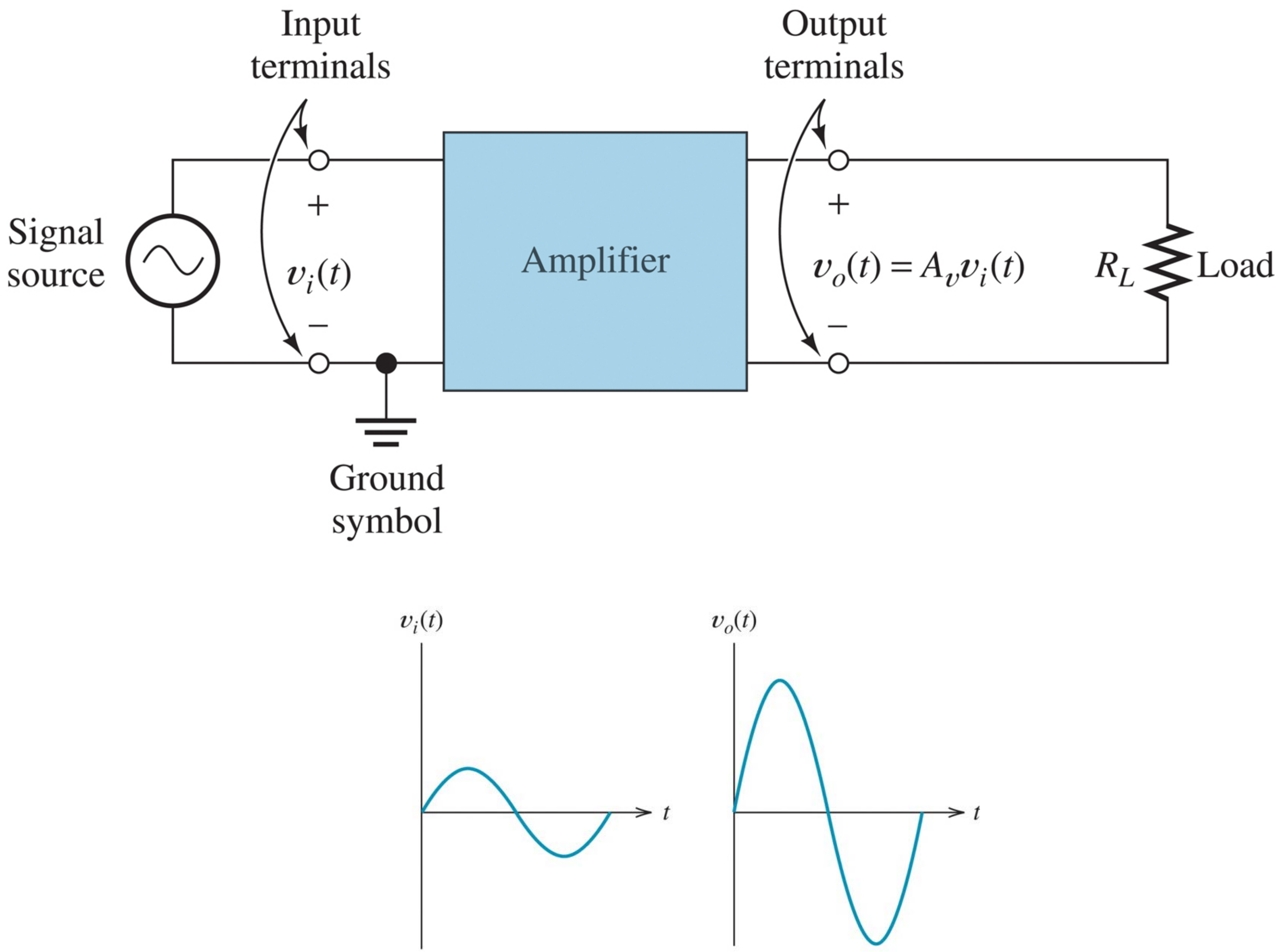
Amplifiers (cont.)

- Voltage amplifier:

$$v_o(t) = A_v\, v_i(t)$$

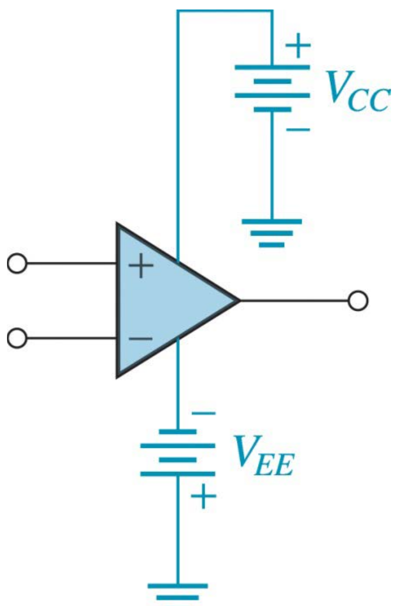
- The *voltage gain* is A_v .
- The voltage gain can be a positive number or a negative number.
  - *Inverting* amp has a negative gain
  - *Non-Inverting* amp as a positive gain

Voltage Amplifier



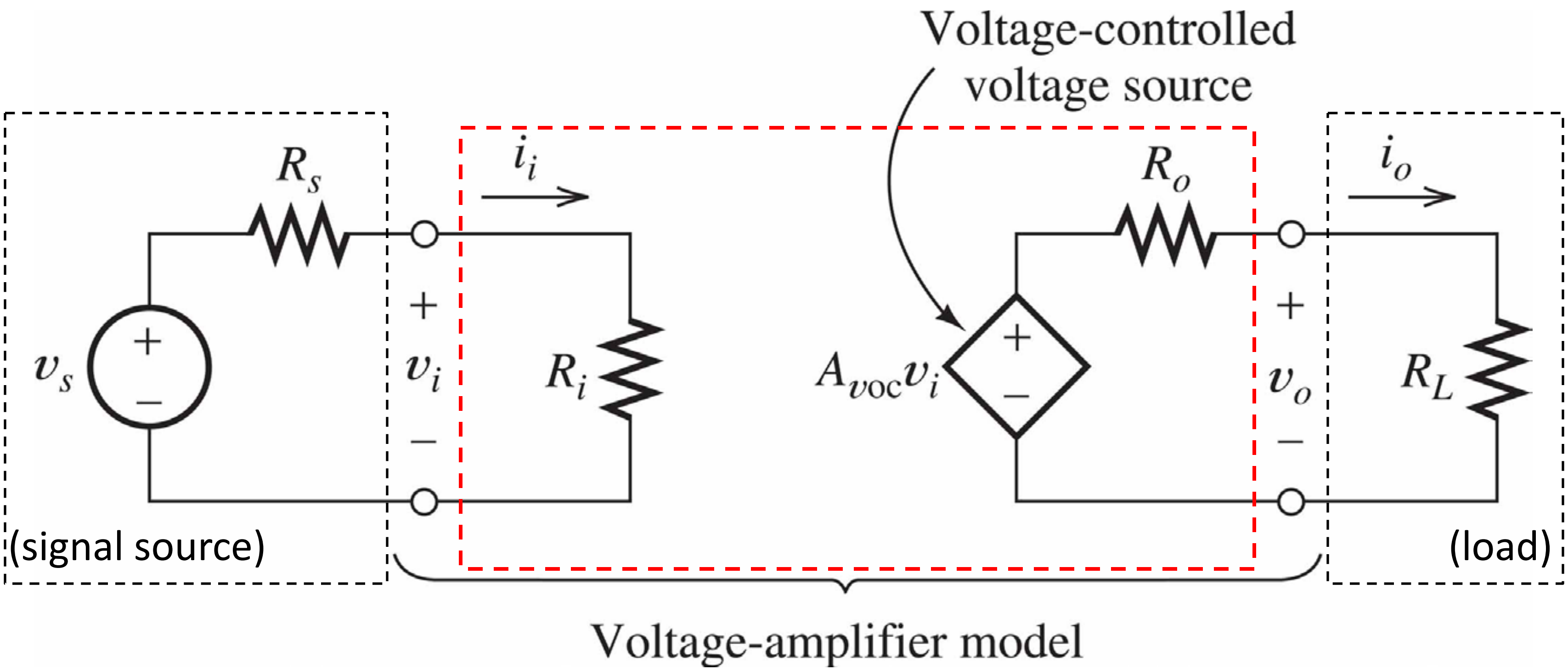
Amplifiers (cont.)

- An amplifier requires a DC power source: the amp needs energy, because the power delivered to the load is greater than the power from the signal source itself.



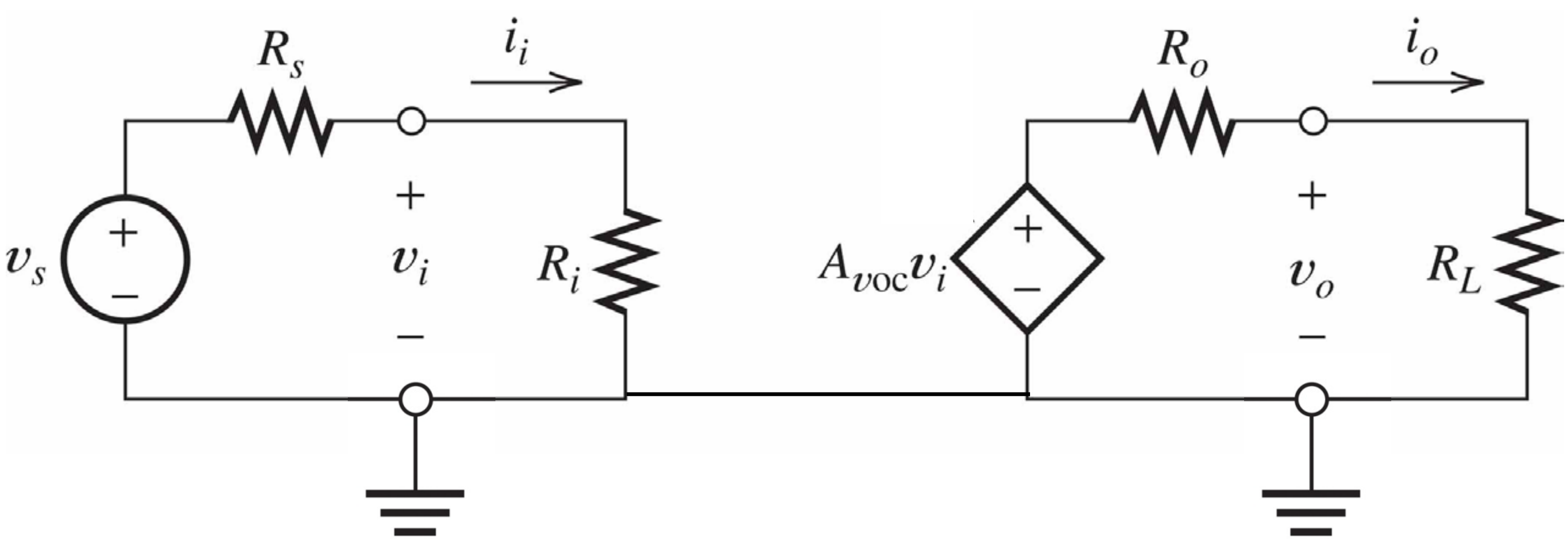
Amplifiers (cont.)

- A realistic voltage amplifier model includes a *big* input resistance R_i (ideally infinite) and a *small* output resistance R_o (ideally zero).



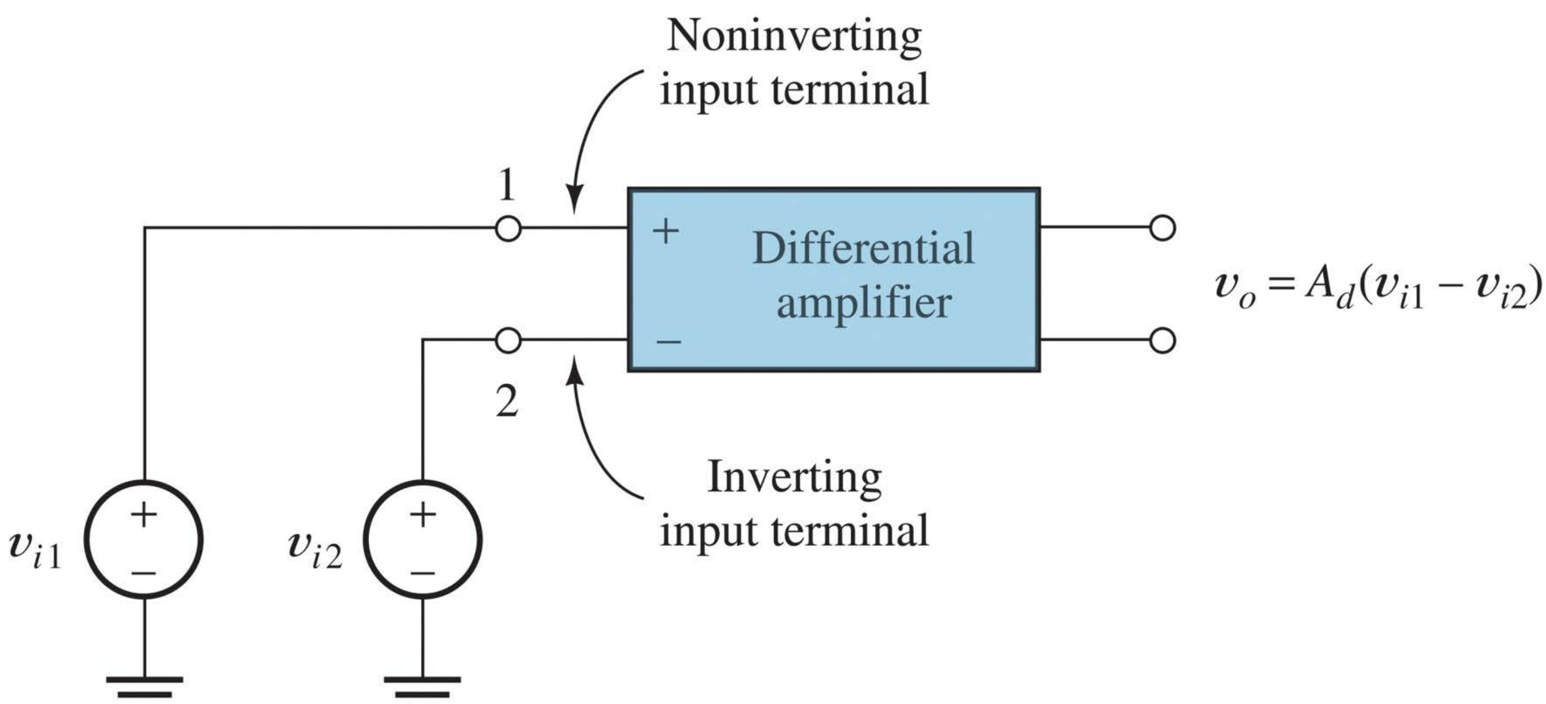
Single-ended vs. differential

- Some amplifiers have a common ground between the input and the output. We call these “single-ended”



Single-ended vs. differential (cont.)

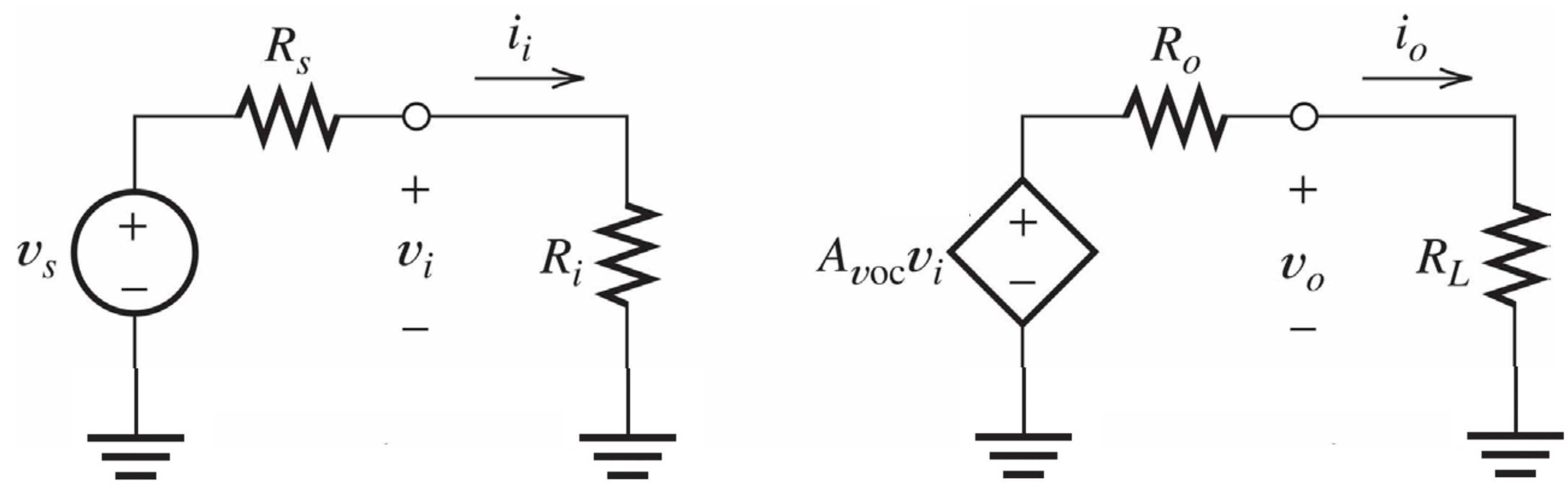
- Some amplifiers amplify the *difference* between the voltages presented to its input pins, neither of which is grounded. These are called *differential* amplifiers.



Node and ground notation

- So far in this course we have been writing circuit diagrams with explicit loops.
- For voltage amplifiers, a convenient shorthand notation is to depict a circuit in terms of its nodes and ground, rather than showing all the circuit loops.
- All of the circuit ground points are implicitly connected.

Node and ground (cont.)



The “Operational” Amplifier

- The “op amp” is a differential input, single-ended output voltage amplifier.
- The op amp has:

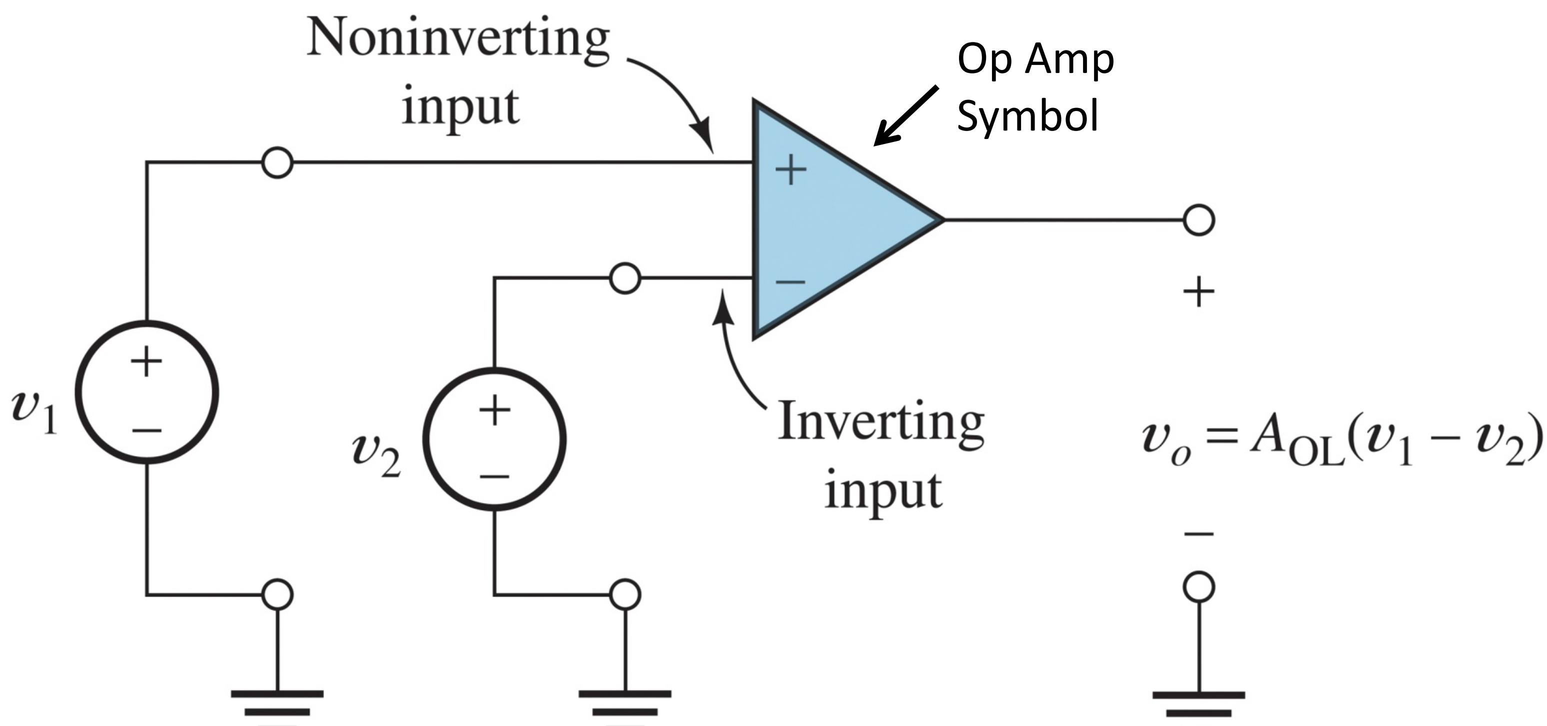
  very high input resistance

  very low output resistance

  very high voltage gain

The Ideal Op Amp

- A "perfect" op amp would have infinite input resistance, zero output resistance, and voltage gain A_{OL} (open loop) approaching infinity.



Negative Feedback

- NOTE that if the op amp's output voltage is a finite value, the differential input voltage will be tiny. In other words, since:

  $A_v = V_o/V_{in}$

  If $A_v \rightarrow$ infinity and V_o is finite,

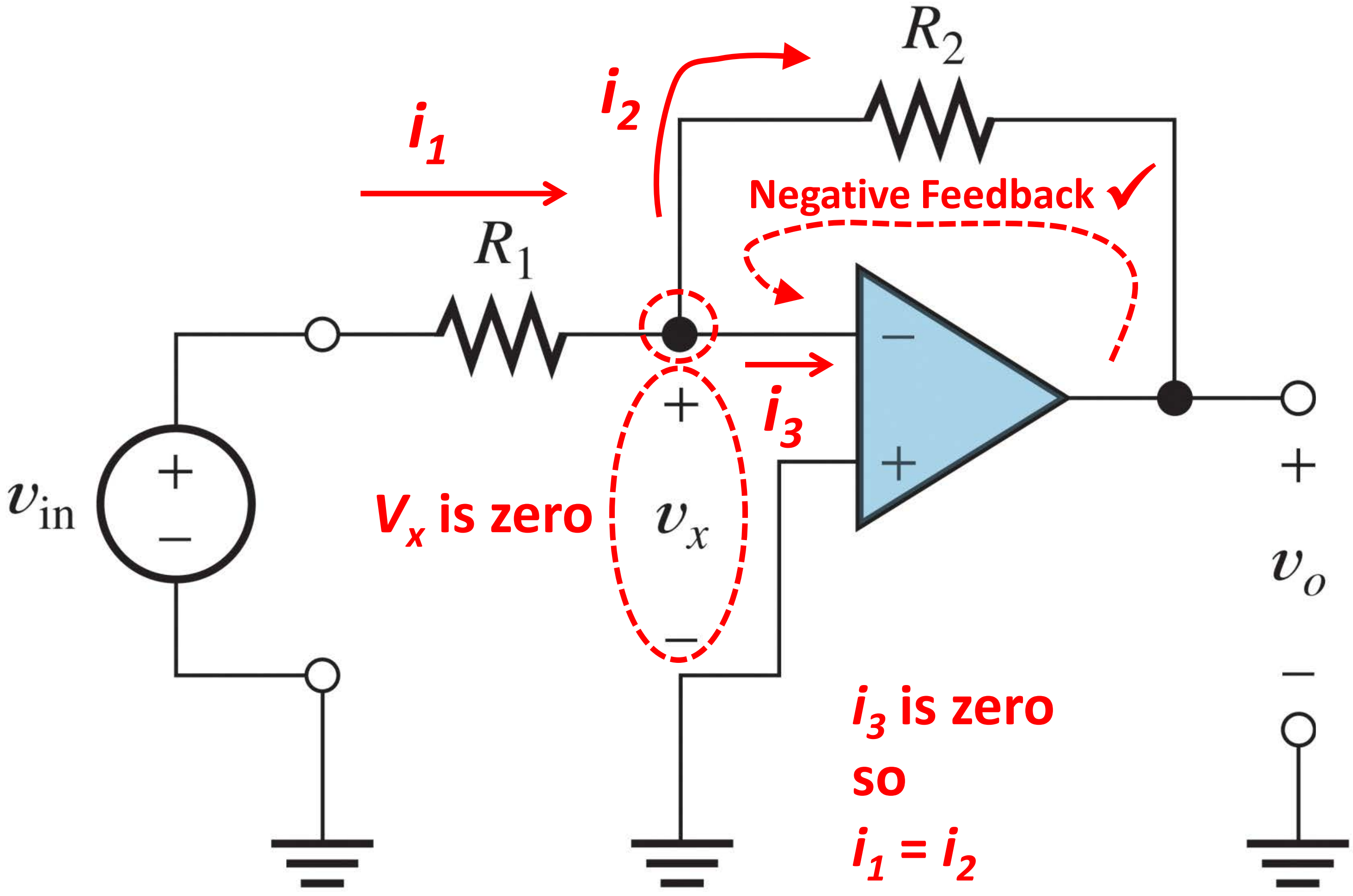
  V_{in} must be REALLY small ($V_{in} \rightarrow 0$)

- Most op amp circuits have deliberate feedback from the output back to the *inverting* input. This is called *negative feedback.*

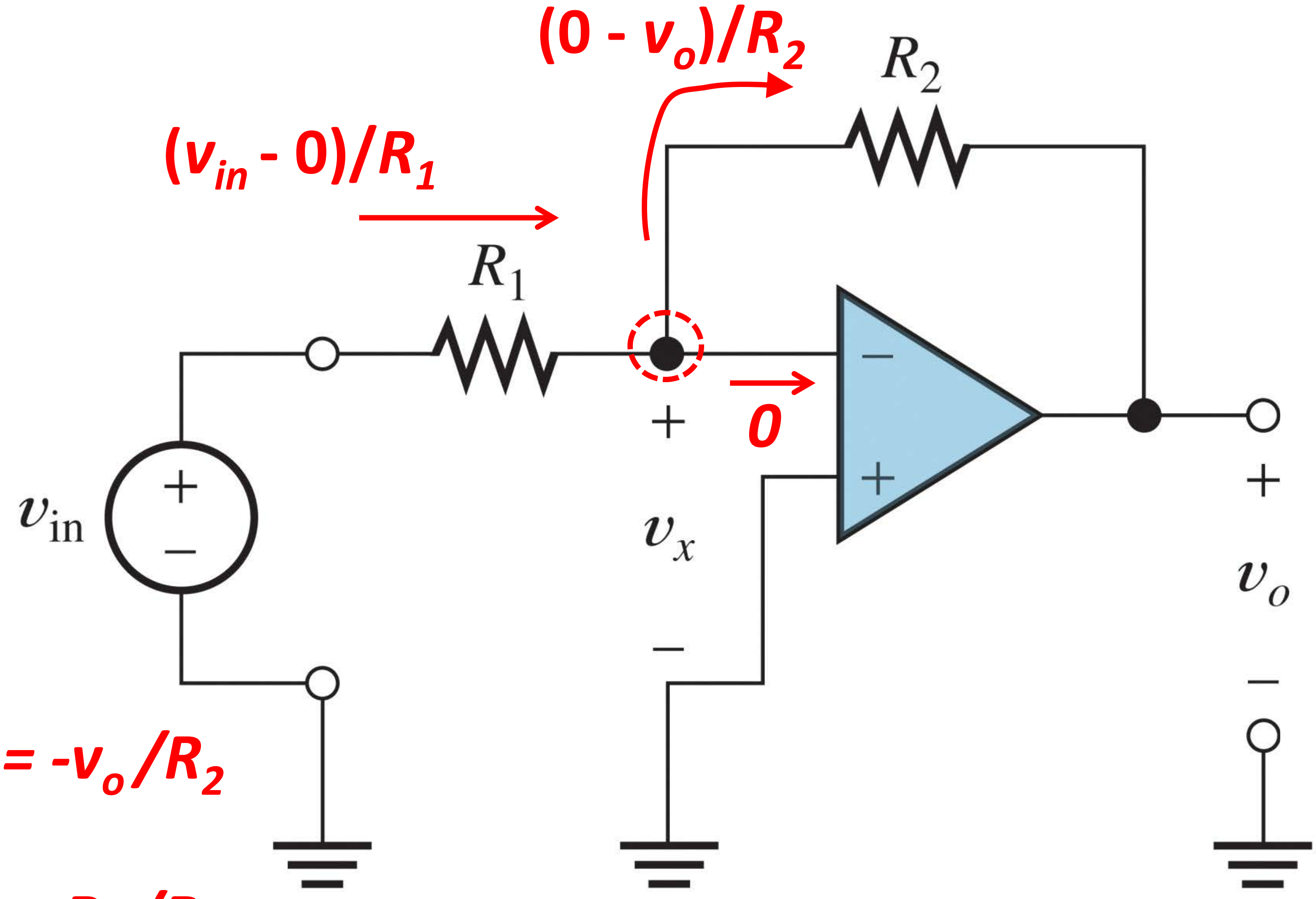
Negative Feedback (cont.)

- "Ideal" op amp assumptions if negative feedback is present:
  1. Differential input voltage is zero, so + input and – input are the same voltage
  2. Input current is zero
  3. Then analyze circuit using regular techniques to find voltage gain v_o / v_i

Ideal Op Amp Example



Ideal op amp (cont.)



$V_{in}/R_1 = -v_o/R_2$

$V_o/v_{in} = -R_2/R_1$

Ideal Op Amp Summary

- High open-loop gain and negative feedback forces differential input voltage to be zero
- High input resistance forces input current to be zero
- Use these assumptions to analyze the closed-loop gain