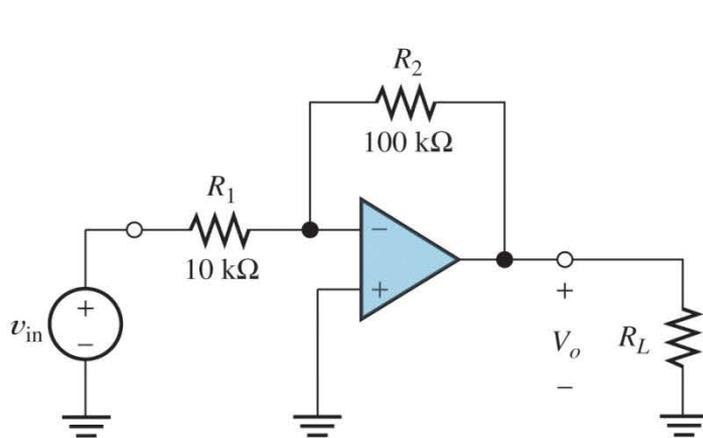# EELE 250:  Circuits, Devices, and Motors
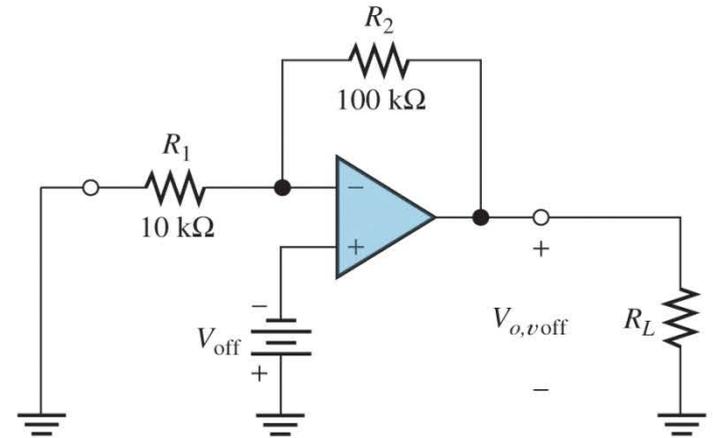
Op Amps (cont.)

# Assignment Reminder

- Read 14.4 - 14.7
- Practice Problems:
  - P14.19, P14.20, P14.22, P14.23, P14.32
- Lab #7 next week. Note that there is a design to be done in the prelab.
- NO D2L Quiz this weekend
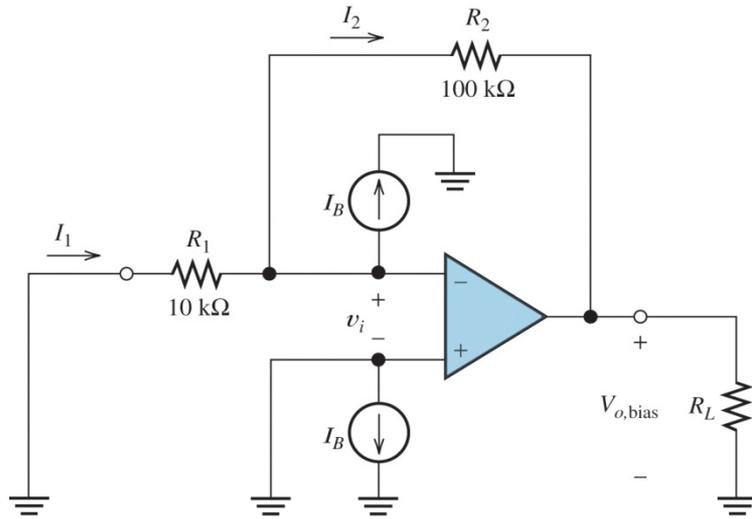- Exam #3:  Friday 15 Nov.

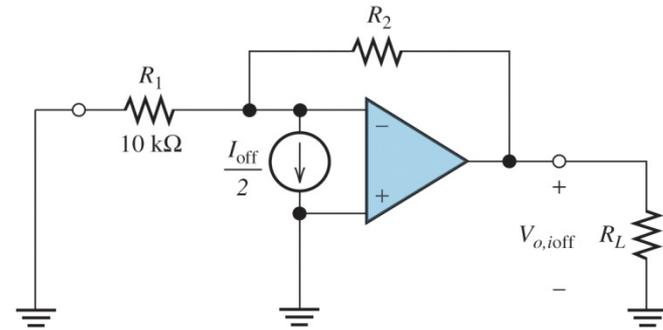# Modeling real op amps



(a) Original circuit

(b) Circuit with $v_{in} = 0$ showing the input offset voltage source

Input offset voltage:  output may not be exactly zero volts  even if input is zero
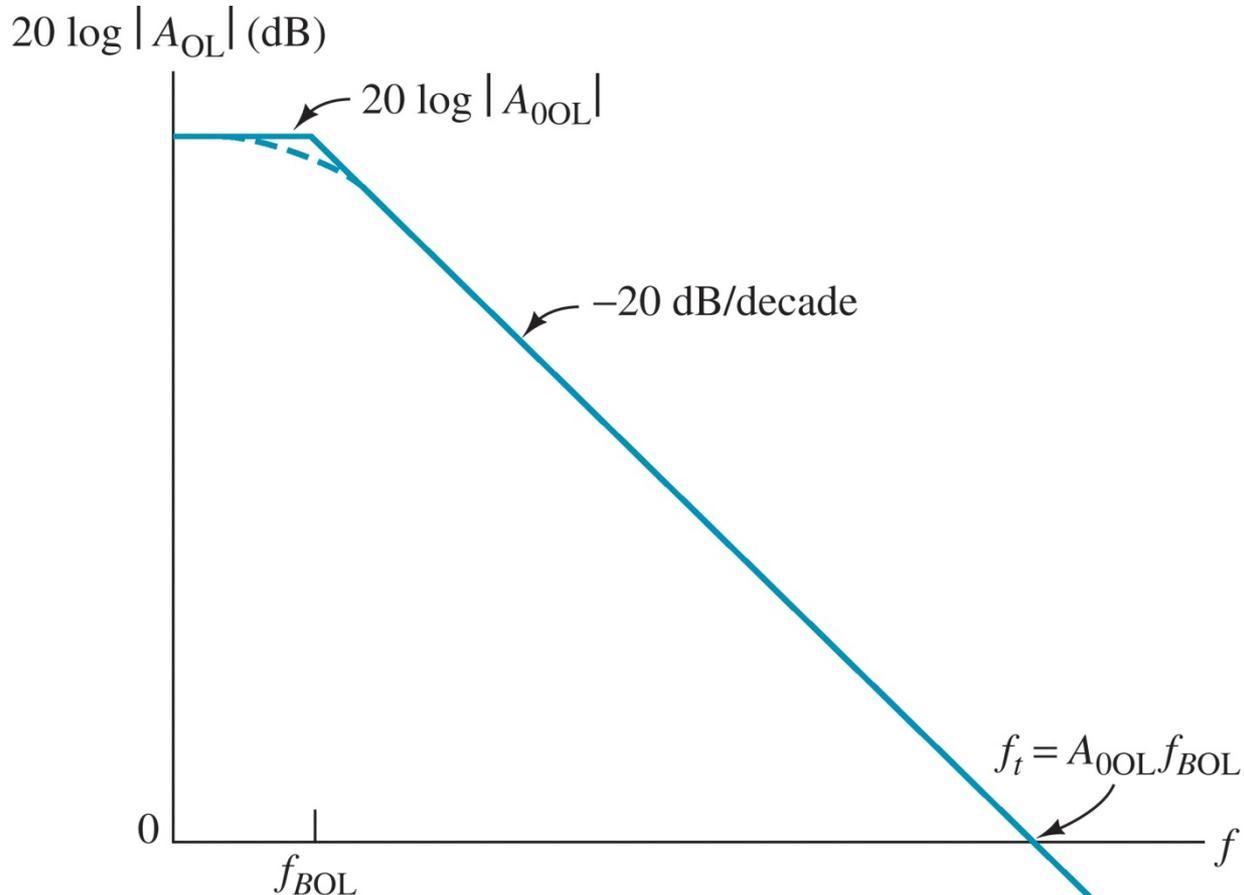
# Modeling real op amps (cont.)



(c) Circuit with bias current sources

(d) Circuit with offset current source

Input bias and offset currents:  current at each input is not exactly zero, and not exactly balanced.

# Frequency Response



Open loop gain decreases as frequency increases, so assumption that $A_{OL}$ is huge does not hold at higher frequencies.

# Output limitations

- Output voltage swing -- clipping
- Output current – clipping or droop
- Slew rate:  limit on dV/dt -- distortion

# Typical specs

| | 741 | OP-27 | LF353 |
|---|---|---|---|
| Input bias current | 1.5 **uA** | 35 **nA** | 50 **pA** |
| Input offset voltage | 6.5 mV | 25 uV | 5 mV |
| Gain  x BW | 1 MHz | 8 MHz | 4 MHz |
| Slew Rate | 0.5 V/usec | 2.8 V/usec | 13 V/usec |
| Max output current | 25 mA | 30 mA | 25 mA |
| Input noise | 20 | 3.8 | 20 |
| Price | $ 0.88 | $ 3.00 | $ 0.66 |