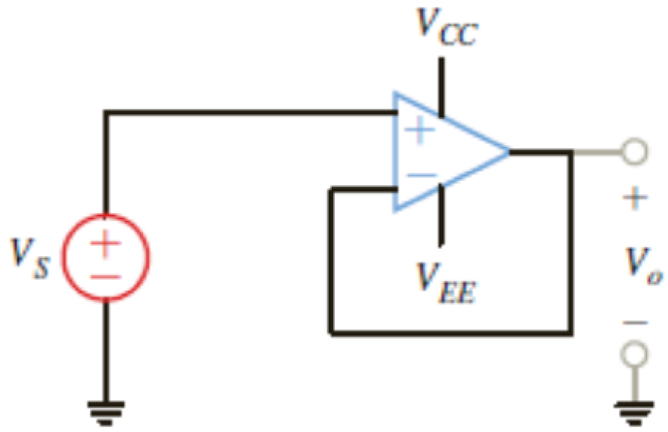
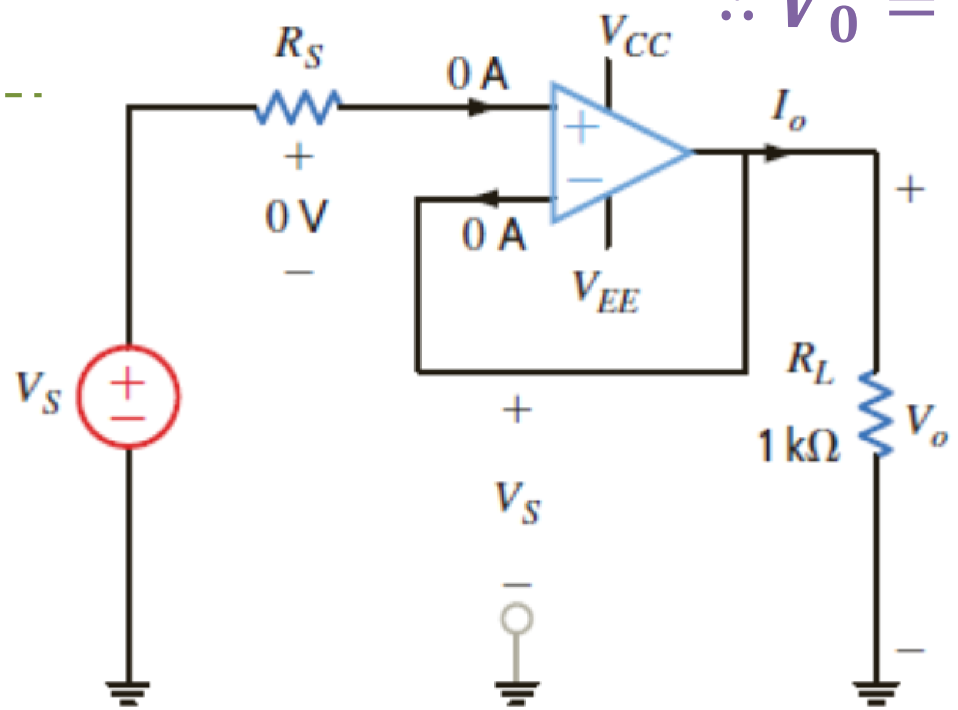
Ideal Op-Amp Circuit Analysis

- Stablish ideal op-amp conditions on the circuit schematic
  1) $i_+ = i_- = 0$
  2) $v_+ = v_-$
- Write nodal equations at the op-amp input terminals
- Solve for the input/output relationship

$$\therefore V_0 = V_s$$

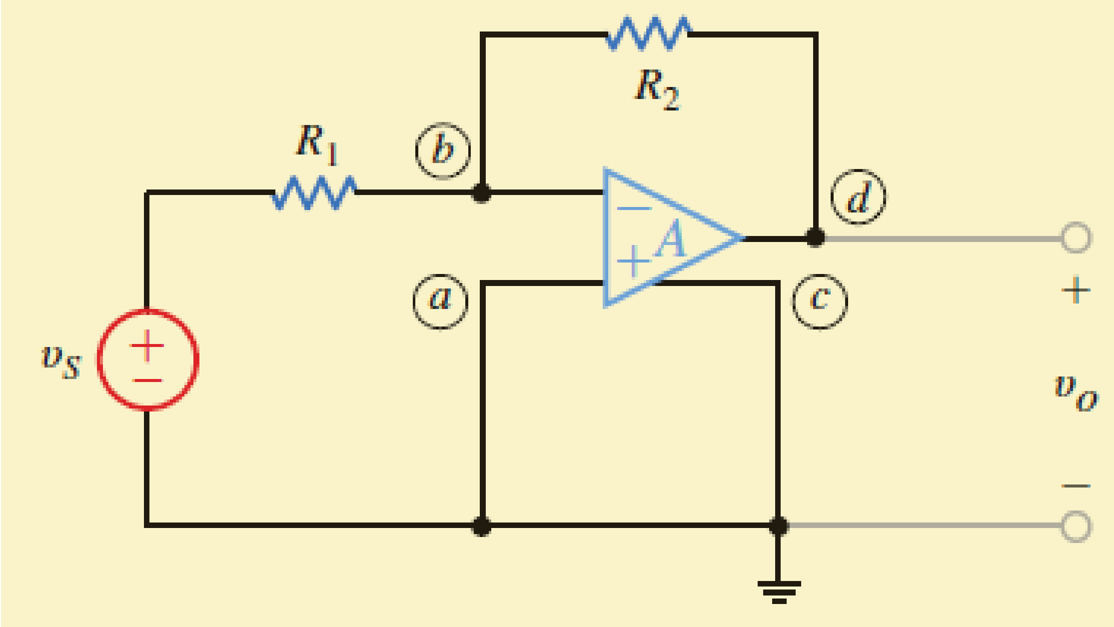
Unity Gain Buffer - Revisited





Example 4.2

Determine the gain v_0/v_s of the basic inverting op-amp configuration using both the non-ideal ($R_i=\infty$, $R_o=0$) and the ideal models.



$$\frac{V_0}{V_s} = -\frac{R_2}{R_1}\left[\frac{1}{1+\frac{1}{A_0}\left(1+\frac{R_2}{R_1}\right)}\right]$$

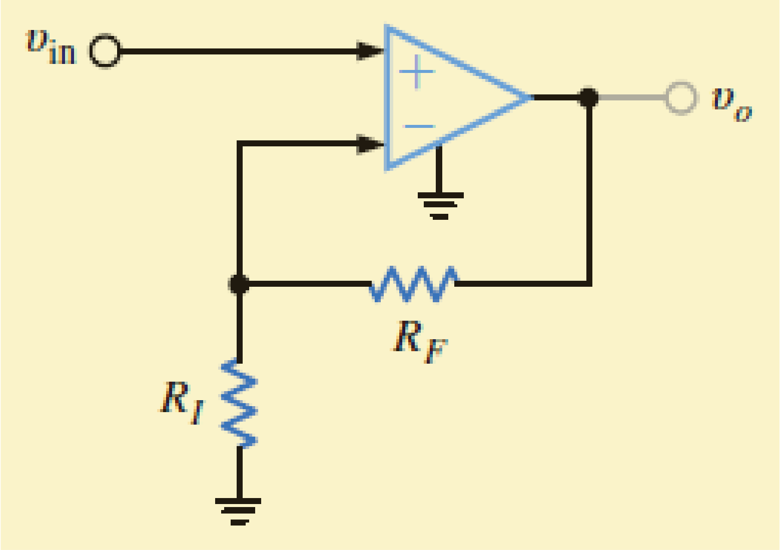
$$for\ \ A_0 = \infty\ \ \rightarrow \frac{V_0}{V_s} \approx -\frac{R_2}{R_1}$$

Example 4.3

Determine the gain v_0/v_s of the basic non-inverting op-amp configuration both the non-ideal ($R_i=\infty$, $R_o=0$) and the ideal models. Determine the expression for the gain error (GE).

$$\frac{V_0}{V_s}=\left[1+\frac{R_F}{R_1}\right]\left[\frac{1}{1+\frac{1}{A_0}\left(1+\frac{R_F}{R_1}\right)}\right]$$

$$for \quad A_0=\infty \quad \rightarrow \frac{V_0}{V_s}\approx 1+\frac{R_F}{R_1}$$

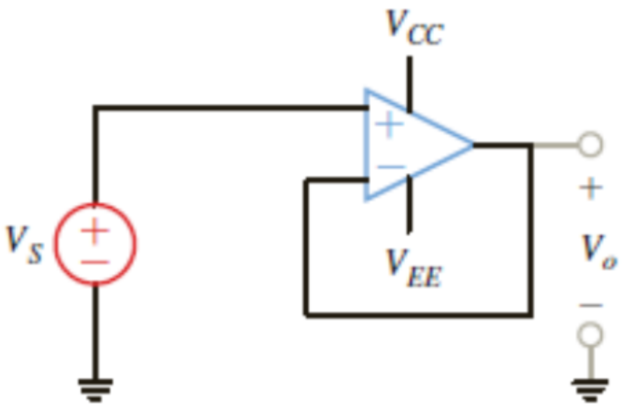


$$GE=\left[\frac{A_{v_{ideal}}-A_v}{A_{v_{ideal}}}\right]\cdot 100=\left[\frac{1}{1+A_0\left(\frac{R_1}{R_1+R_F}\right)}\right]\cdot 100$$

$$for \quad A_0=\infty \quad \rightarrow GE\approx 0$$

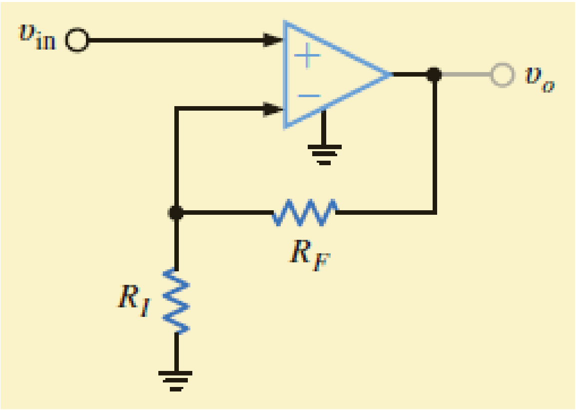
Op-Amp Amplifiers

- **Unity – Gain Amp.**



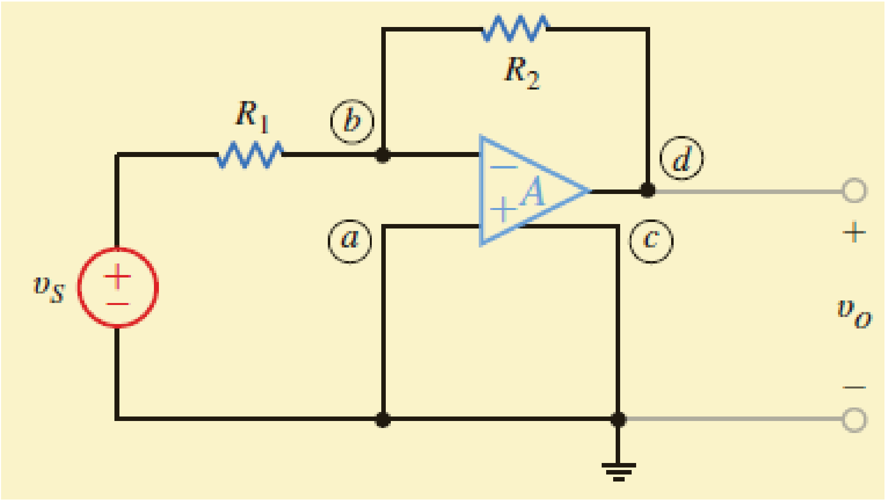
$$\frac{V_0}{V_s} \approx 1$$

- **Non-Inverting Amp.**



$$\frac{V_0}{V_s} \approx 1 + \frac{R_F}{R_I}$$

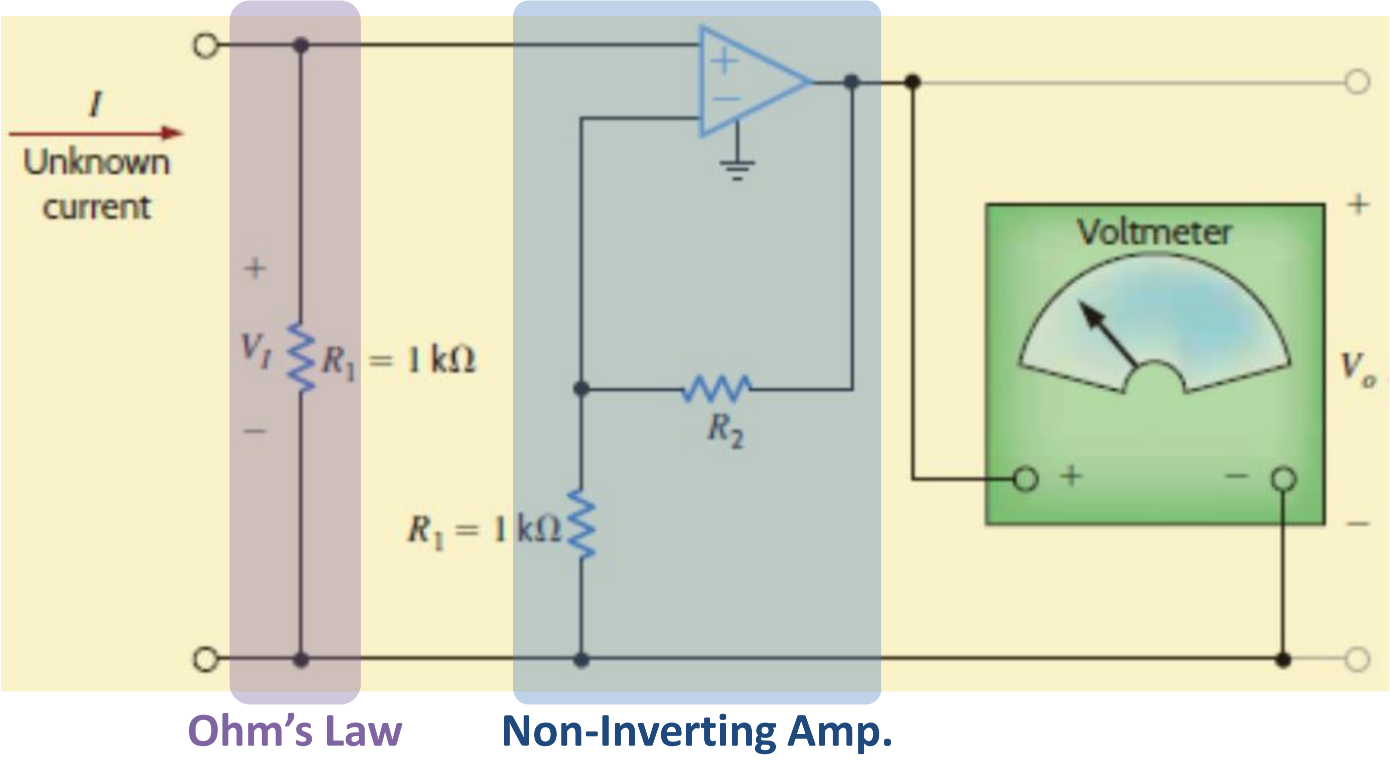
- **Inverting Amp**



$$\frac{V_0}{V_s} \approx -\frac{R_2}{R_1}$$

Example 4.7

The provided circuits is an electronic ammeter. It operates as follows: the unknown current, I, through R_I produces a voltage, V_I. V_I is amplified bye the op-amp to produce a voltage, V_o, which is proportional to I. The output voltage is measure with a simple voltmeter. Find the value of R_2 such that 10V appears at V_o for each milliamp of unknown current.



$$\frac{V_0}{I} = \frac{10}{1m} = 10k\Omega$$

$$V_0 = \left[1 + \frac{R_2}{1k}\right] V_I$$

$$V_I = [1k] \cdot I$$

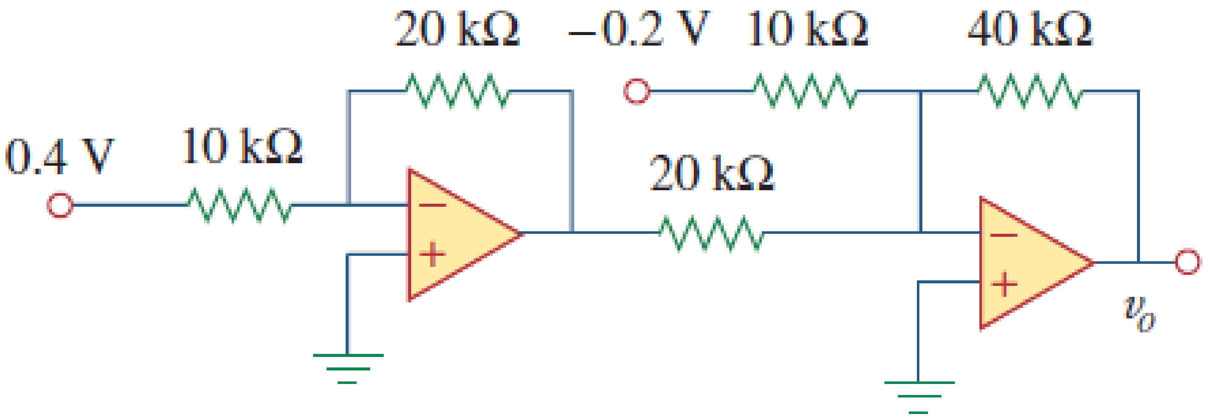
$$\therefore V_0 = [1k + R_2] \cdot I$$

$$\frac{V_0}{I} = [1k + R_2] = 10k\Omega$$

$$\therefore R_2 = 9k\Omega$$

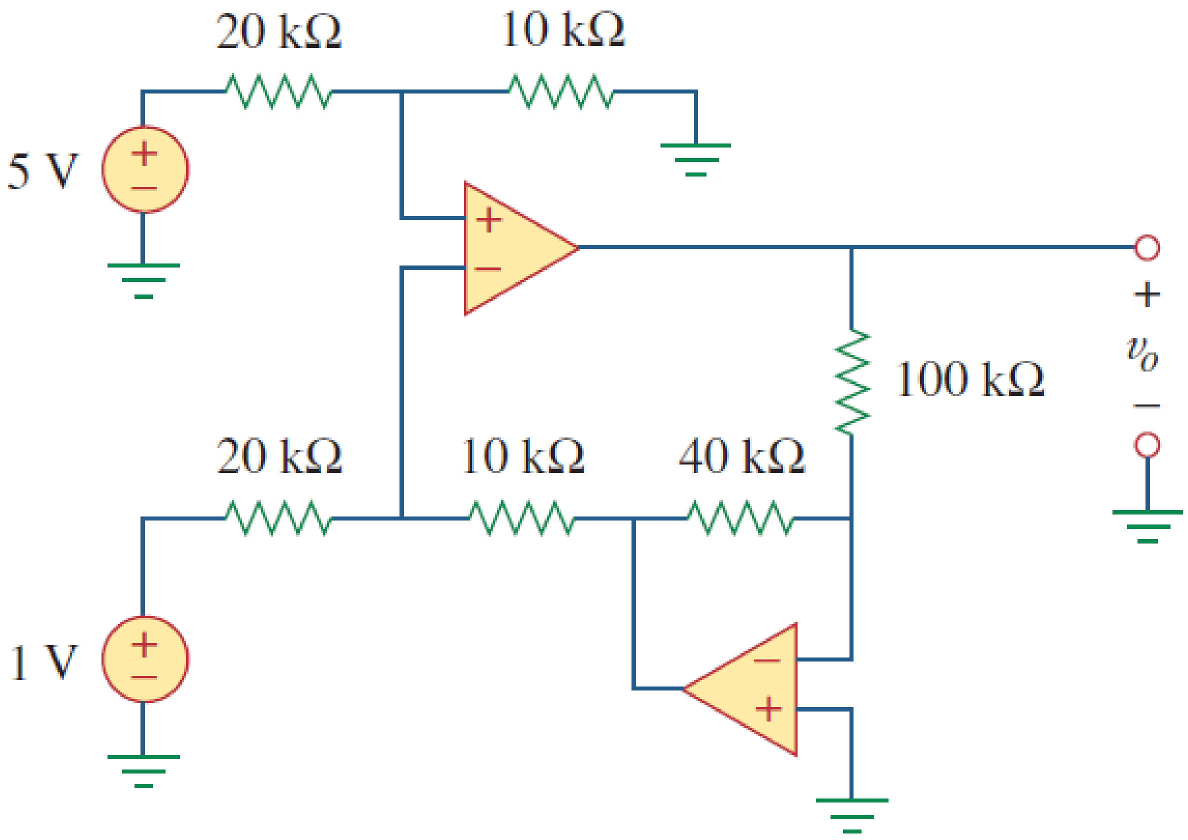
Problem

Determine v_0 in the circuit provided.



Problem

Determine v_0 in the circuit provided.

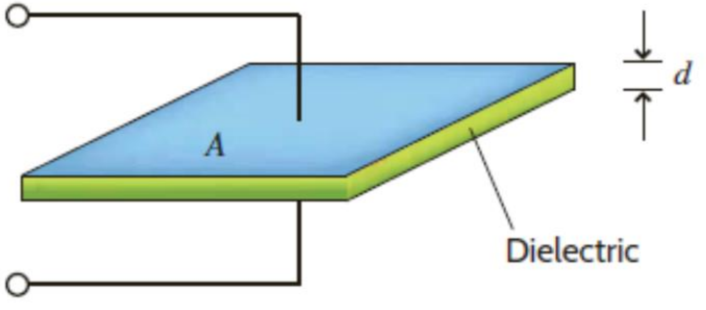


Capacitance and Inductance → Chapter #5

- **Inductor / Capacitor Model → voltages, currents, powers, stored energy**
- **Concept of Continuity → inductor: current, capacitor: voltage**
- **Circuit Analysis with DC Sources**
- **Equivalent Inductance /Capacitance → series & parallel**

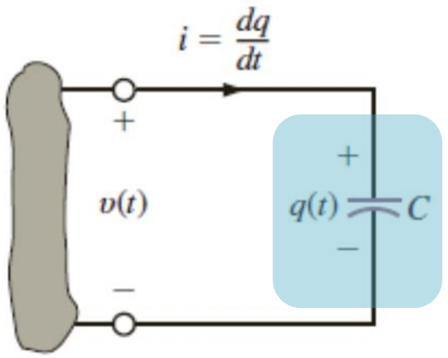
Capacitor

… a circuit element that consists of two conducting surfaces separated by dielectric material



(a)

Simplified Capacitor



(b)

Symbol

Typical Capacitors

Capacitance (C) → $C = \frac{\varepsilon_0 A}{d}$ ← permittivity of free space (ε_0)

↓

Unit → farads (F) = coulombs per volts

$$q = C \cdot v \qquad i = C \cdot \frac{dv}{dt}$$

$$v(t) = v(t_0) + \frac{1}{C} \cdot \int_{t_0}^{t} i(x)dx$$

$$p(t) = C \cdot v(t)\frac{dv(t)}{dt}$$

$$w_c(t) = \frac{1}{2}C \cdot v(t)^2$$