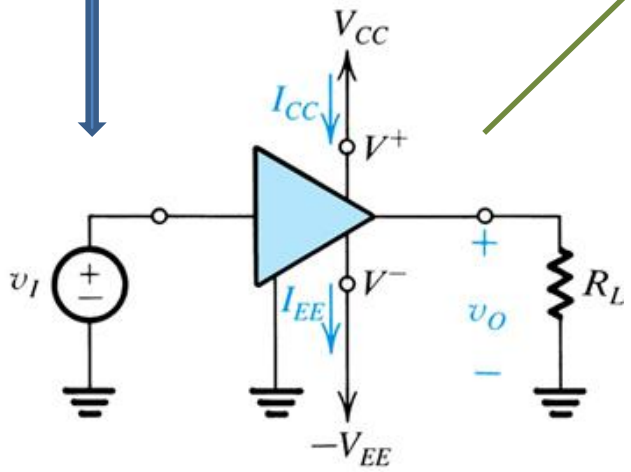
Last Lecture → Chapter 1.2-1.4

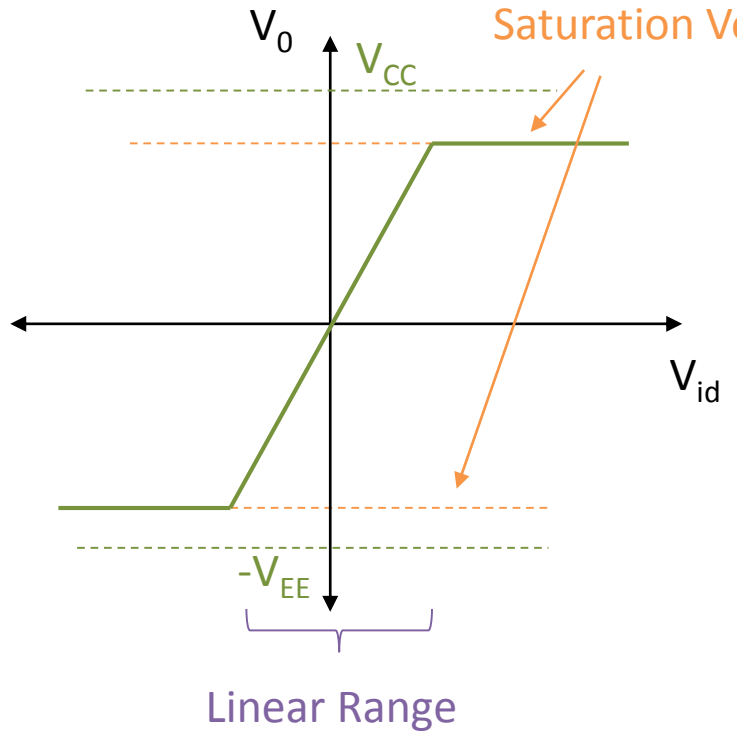
Concepts revisited…

- **Frequency spectrum**
- **Fourier series**
- **Amplifier basics**
  - *conservation of power*
  - *efficiency*
  - *model*



Voltage Gain

$$V_{out}(t) = A_V \cdot V_{in}(t)$$



- **Limited Linear Range**
- **Saturation Voltage**
- **Conservation of power** → $P_{V_I}+P_{V_{CC}}+P_{V_{EE}} = P_L + P_{amp}$
- **Efficiency** → $\eta = \frac{P_L}{P_{in}} = \frac{P_L}{P_{V_I}+P_{V_{CC}}+P_{V_{EE}}}$

Amplifier Circuit Model → Chapter 1.5

… is the description of the amplifier's terminal behavior, neglecting internal operation / transistor design

model of amplifier input terminals

$$\text{input voltage} = v_i = (v_s)\frac{R_i}{R_i + R_s}$$

v_s: source volt. $R_i + R_s$: source and input resistances

model of amplifier output terminals

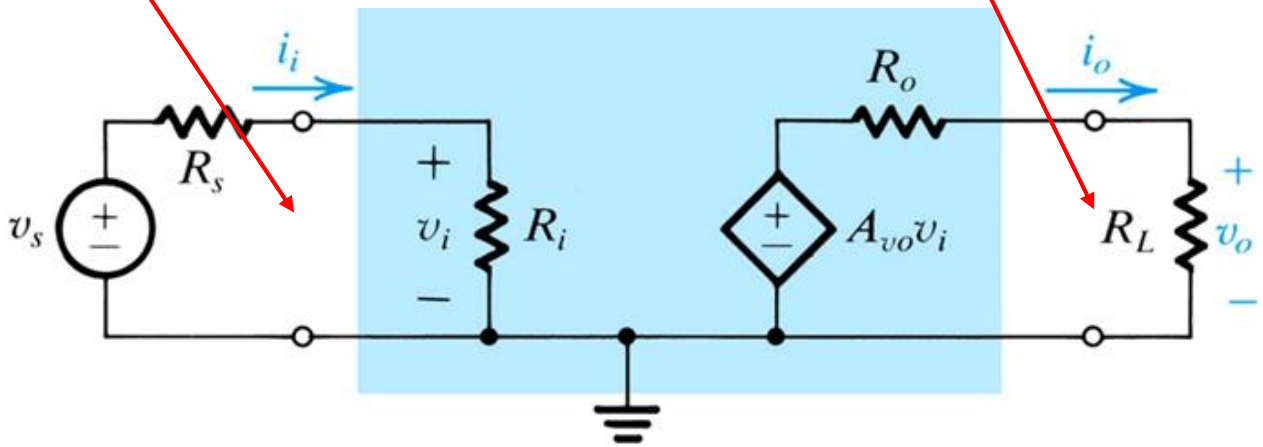
$$\text{output voltage} = v_o = (A_{vo} v_i)\frac{R_L}{R_L + R_o}$$

$A_{vo} v_i$: open-ckt output voltage $R_L + R_o$: output and load resistances

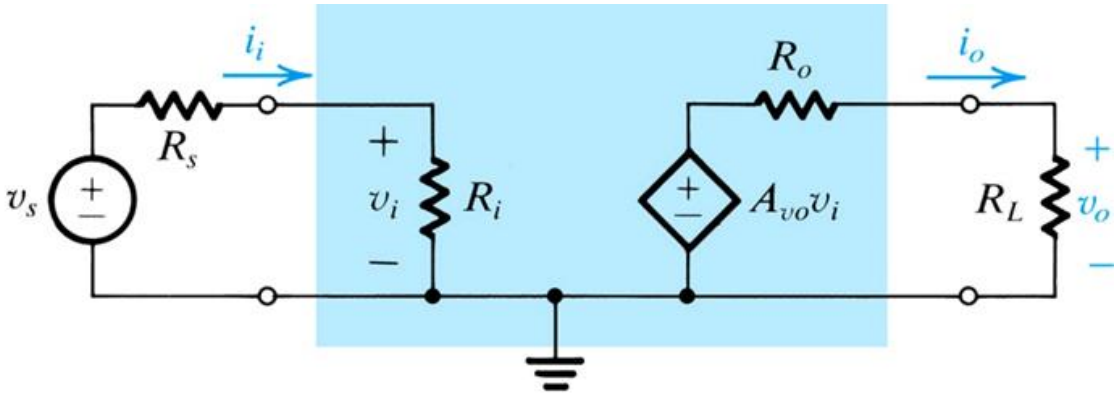
Voltage Gain

$$A_v = \frac{V_0}{V_s} = \underbrace{\left[\frac{V_i}{V_s}\right]}_{A_{v1}}\underbrace{\left[\frac{V_0}{V_i}\right]}_{A_{v2}}$$

Amplifier Circuit Model



Amplifier Circuit Model



Ideal Assumptions…

- $R_i = \infty$ or $R_i >> R_s$
- $R_o = 0$ or $R_o << R_L$

$$v_o = \underbrace{A_{vo} v_s \frac{R_i}{R_i + R_s} \frac{R_L}{R_L + R_o}}_{\text{non-ideal model}} = \underbrace{A_{vo} v_s}_{\text{ideal model}}$$

$$v_o = \underbrace{\left(A_{vo} (v_s) \frac{R_i}{R_i + R_s} \frac{R_L}{R_L + R_o} \right)}_{\text{open-ckt output voltage}} = A_{vo} v_s \frac{R_i}{R_i + R_s} \frac{R_L}{R_L + R_o}$$

Attenuation: $\frac{R_i}{R_i + R_s}$ — source volt.; source and input resistances

Loading: $\frac{R_L}{R_L + R_o}$ — output and load resistances

Gain is not constant, and dependent on input and load resistance!

Cascade Amplifiers

In real life, an amplifier is not ideal an will not have infinite input impedance or zero output impedance…

… cascading of amplifiers, however, may be used to emphasize desirable characteristics.

- **first amplifier** → high R_i, medium R_o
- **last amplifier** → medium R_i, low R_o
- **aggregate** → high R_i, low R_o

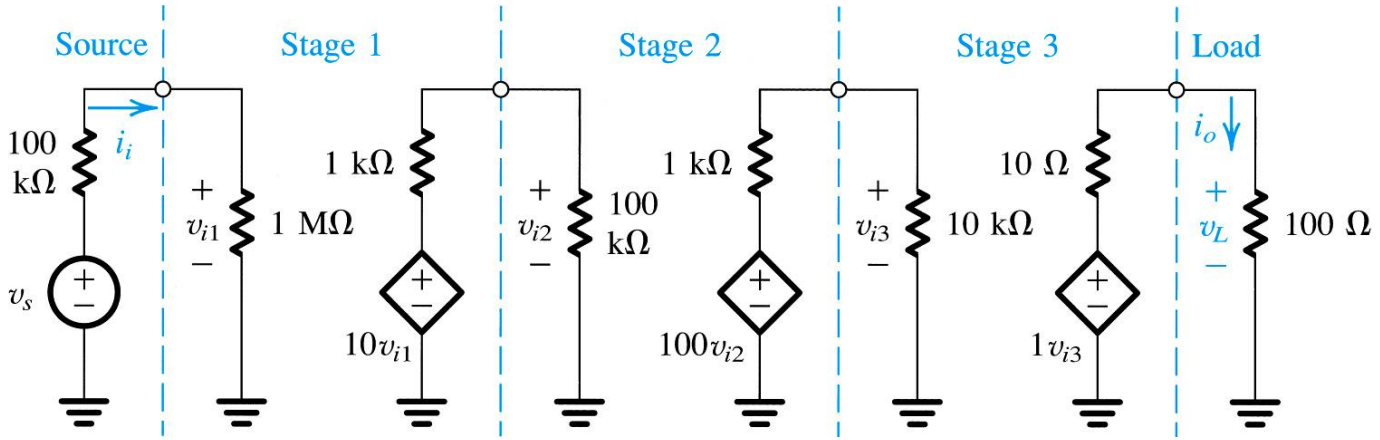
Example 1.3

Examine system of cascaded amplifiers….

a) **What is the overall voltage gain?**

b) **What is the overall current gain?**

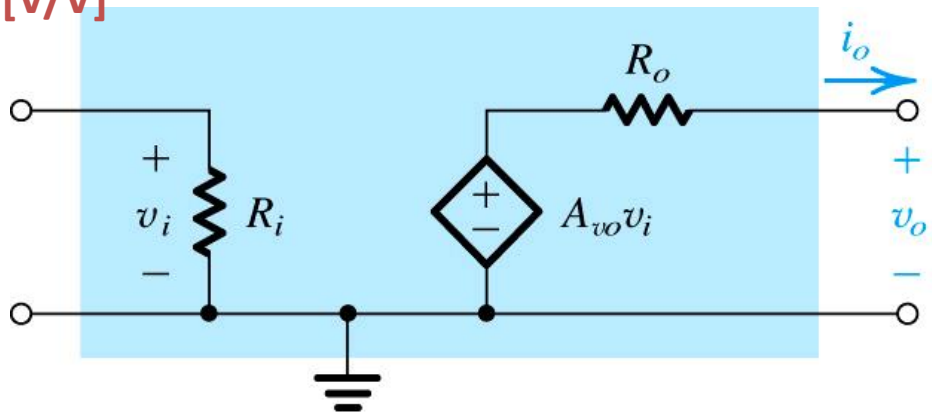
c) **What is the overall power gain?**



Different Types of Amplifiers

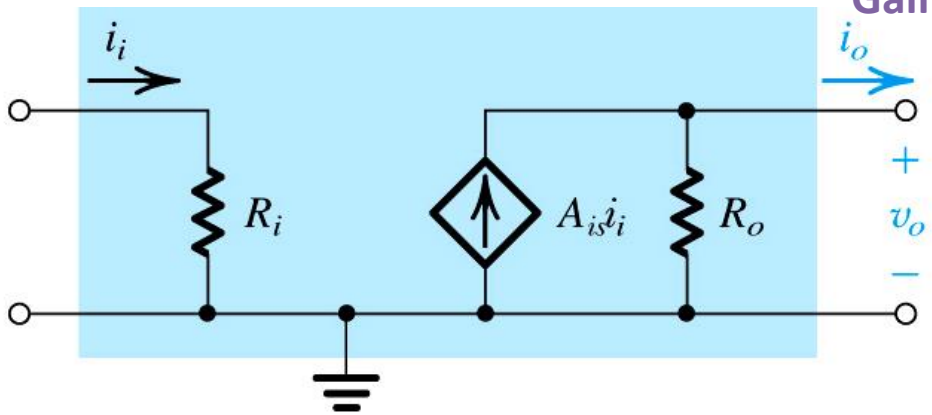
Voltage Amplifier

Gain → A_v [V/V]
$R_i = \infty$
$R_0 = 0$



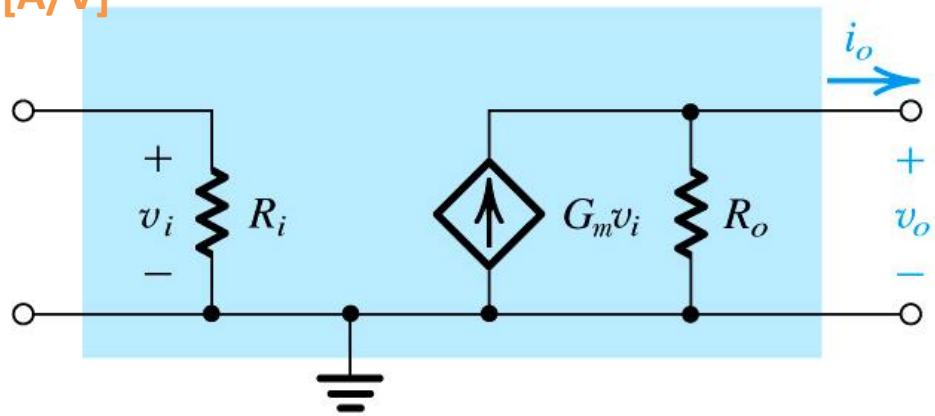
Current Amplifier

Gain → A_i [A/A]
$R_i = 0$
$R_0 = \infty$



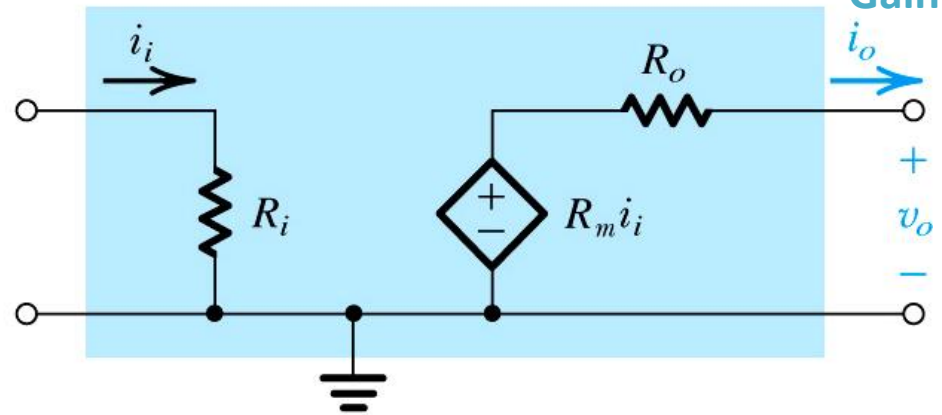
Trans-conductance Amplifier

Gain → A_v [A/V]
$R_i = \infty$
$R_0 = \infty$



Trans-resistance Amplifier

Gain → A_v [V/A]
$R_i = 0$
$R_0 = 0$



Problem D1.49

A designer has available voltage amplifiers with an input resistance of 10kΩ, an output resistance of 2kΩ, and an open-circuit voltage gain of 10V/V. The signal source has a 10kΩ resistance and provides a 10-mV_{rms} signal, and it is required to provide a signal of at least $2V_{rms}$ to a 2kΩ load. How many amplifier stages are required? What is the output voltage actually obtained?