ME 412: Active components
- powered devices that change behavior when powered.

- A key example: the transistor. The name is concatenation of "Transfer" and "Resistor".

- A type of controlled resistor.

Transistors function like valves: modulate current with an input.
Transistors are 3-pole devices:

bipolar junction transistor (BJT):

\[ I_c = \beta I_B \]

\[ I_E = I_c + I_B \]

npn:

"Collector"

"Base"

"Emitter"

Rules of transistors: 2 types npn, pnp.
(reverse the polarities of these rules for pnp-type)

1. Collector must be "more positive" than the emitter

2. Base-Emitter & Base-Collector junctions behave like diodes:
4. $I_c \sim I_b$, where $I_c = h_{ce} I_b = \beta I_b$

$\beta$ typ. $>100$. * $\beta$ is typically not a precise value, even for same part #s

* No design should rely on $\beta$'s value

* Diodes are non-linear passive devices. AoE P3.44.
Re-state rule #41: Small base current $\rightarrow$ large collector current.

\[ I_c = \beta I_b \]

\[ I_E = I_c + I_B = (1+\beta)I_B \approx I_c. \]

Diodes $\rightarrow$ transistor:
* CURRENT SOURCE:

\[ V = 5.6V \]

\[ V = 0.6V \]

\[ V = 5V \]

\[ 1mA \to 5.1k \]

\[ V = IR \]

\[ I_E = \frac{5V}{5.1k} \approx 2mA. \]
Thought Experiment: Suppose $V_+ = 20V$, load is variable resistor $50k\Omega$ (trim pot).

- What happens as we vary the value of $R_{load}$ from $0$ to $50k\Omega$?
- Does the behavior denote from "Ideal curve" or not?

Ideal behavior breaks when $R_{load} > \frac{14V}{1mA} = 14k\Omega$. 
EMITTER AMPLIFIER:

1. Apply Signal $\Delta V_b$

2. $\Delta V_b \rightarrow \Delta V_{E}$
   $\Rightarrow \Delta I_E$; Small $R_E \Rightarrow 1g \cdot \Delta I_E$
   (Recall Ohm's Law: $\Delta I_E = \frac{\Delta V_E}{R_E}$)

3. $\Delta I_C \approx \Delta V_{out}$
   (1g, $R_C \approx 1g \cdot \Delta V_{out}$)

* Emitter-Follower:

Why do we use this? "Rose-colored lens" effect.

$V_{out} = V_{in} - 0.6V$
A closer look at the Emitter-Follower:

1. $\Delta V_m$, $\Delta V_{out}$ are the same
2. $\Delta I_I$, $\Delta I_E$ are very different

Generalized Ohm: \[ \frac{\Delta V}{\Delta I} = Z \]

1. "Looking into" converter from output side: load "sees" $\Delta I_E$ from $\Delta V_m$

$R_{eff} = \frac{\Delta V_m}{\Delta I_E} = \frac{\Delta V_m}{\beta DI_B} \approx \frac{R_b}{100}$
2. Looking into the transistor from the base, the 'sees' the 1kΩ load as:

\[ R_{eq} = \frac{\Delta V_E}{\Delta I_B} = \frac{\beta \Delta V_E}{\Delta I_E} = \beta R_{load} \approx 100 \text{ } R_{load} \]

A different transistor device: The switch. (How computer & logic works)

V+ = 5V

* Binary response:
  - Lamp (non-linear resistor) on or off
  - Purposefully over-driven, 100x Ic
  - To obtain rigid Ic
  - Uce is kept low. (All power goes thru lamp)
All laboratories today: BJT, FET. (More common).

Lab exercises

\[ A_{0\delta E} \approx 98 - 102 \] Eqs. - Model: §2.10 & 2.11.