IEEE’s Hands on Practical Electronics (HOPE)

Lesson 5: Amplifiers
Last Week

- Capacitors – an electrical device that can store energy
This Week

• Amplifiers!!!
Amplifiers

- Turn a small (quiet) signal into a big (loud) one!
- Gain: a measure of the ability to increase the power or amplitude of an input signal
Examples?
Operational Amplifiers

• “Op amps”

\[ \text{Output} = A^* (V_p - V_n) \]
Operational, but Practical?

• Example:
  – $A \sim 10^6$
  – Let $V_p = 10\text{V}$, $V_n = 5\text{V}$
• What's $V_{out}$?
• Does this make sense?
“Railing”

- $V_{ss} \leq V_{out} \leq V_{cc}$
- In other words, you can't output more voltage than you put in
- Conservation laws exist in electronics as well!
- Input = 5V → Output = 5MV defies conservation of charge
“Railing”

- \( V_p = \sin(t) \), \( V_n = 0 \), \( A = 10^6 \), \( V_{cc} = 5V \), \( V_{ss} = -5V \)
- \( V_{out} = 10^6\sin(t) \) ?
- Not quite...
- This is an example of one type of “distortion”
- In this case, the op-amp acts as a comparator
Op Amps SUCK

• Just kidding, op amps rule
• “Tame the beast” with “negative feedback”
• Rids Vout of any dependence on A
Negative Feedback

• Subtracting the output from the input to stabilize the output

• “[The] feedback signal, when subtracted from the original input, will act to reduce the original input, by "too large" an amount. This "too small" input will be amplified again by the "too large" open-loop gain, creating a signal that is "just right". The net result is a flattening of the amplifier's gain.” [Wikipedia]
Negative Feedback

- Applies a portion of output voltage to inverting input
Ideal Op Amps: Golden Rules

- For any op amp, there is NO CURRENT flowing into the device.
- For an op amp in a negative feedback configuration, $V_p = V_n$. 
Inverting Amplifier

- What's Vout?
- KCL + Ohm's Law + Ideal Op Amp Rules!
- What's the gain (Vout / Vin)?
Lab

• Grab a worksheet!
• Grab a partner (or two or whatever)!
• Let us know when you finish the first part and we'll come test it.
• Note that capacitors have polarity: the shorter lead corresponds to the side of the capacitor that goes to ground.