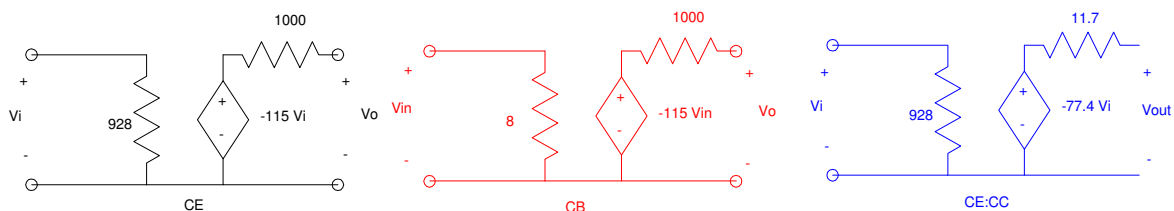# Multi-Stage Amplifiers.

The shopping list of amplifiers you have to play with are as follows:

For a multi-stage amplifier, add these as needed to get what you want.

In general:

- CE amplifiers are good for increasing the gain.
- CB amplifiers are good for te first stage if you need a low input impedance.
- CC amplifiers are good for the last stage if you are driving a low-impedance load, such as an 8-Ohm speaker.

Foe example, design an amplifier to connect a phonograph to an 8-Ohm speaker. Assume the phonograph is a current source with

$$I_{in} = 1\mu A \text{ ground to peak}$$

and a 100 Ohm output impedance. Assume the load is an 8-Ohm speaker, which should be driven with at least

$$I_{out} > 100mA \text{ (0.8V) ground-to-peak.}$$

Since the input is a current source, use a CB amplifier for the first stage. The 8 Ohm input impedance allows the current to flow without too much resistance.

Since the output is an 8-Ohm speaker, make the last stage a CE:CC amplifier. The 11.7 Ohm output impedance isn't desirable (you'd rather have it be zero ohms), but it's the best we have for now.

Add in a bunch of CE amplifiers in the middle until you get enough gain.

Assume for a start you have a single CE amplifier in the muiddle. The 2-port model is then:
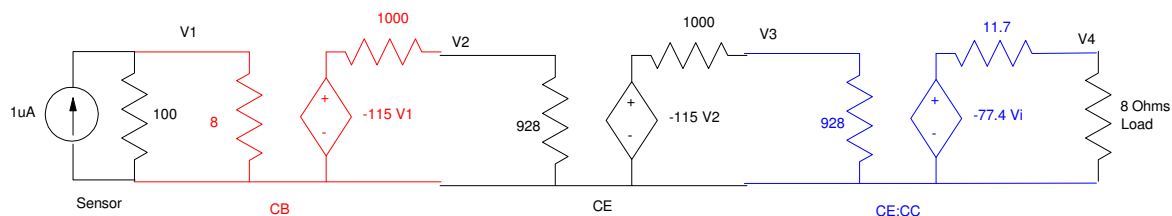
The voltages are then:

$$V_1 = (100 \| 8) 1\mu A = 7.41 \mu V$$

$$-115 V_1 = -851.8 \mu V$$

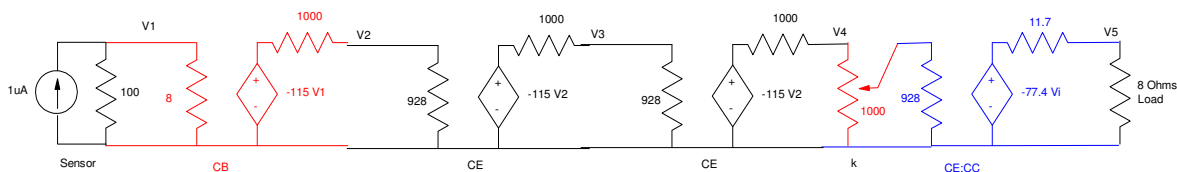$$V_2 = \left(\frac{928\Omega}{928\Omega + 1000\Omega} \right)(-851.8\mu V) = -410.0\mu V$$

$$-115 V_2 = 47.15 mV$$

$$V_3 = \left(\frac{928\Omega}{928\Omega + 1000\Omega} \right)(47.15 mV) = 22.69 mV$$

$$-77.4 V_3 = -1.756 V$$

$$V_4 = \left(\frac{8\Omega}{8\Omega + 11.7\Omega} \right)(-1.756 V) = -0.713 V$$

So, you have 0.713V across the 8 Ohm load. If that isn't enough, you can add another CE amplifier in the middle as well as a resistor to adjust the gain:

To adjust the gain, you could add a resistor in series with the 1000 Ohms resistor, or, you could add a potentiometer. The potentiometer allows you to adjust the gain down to zero. The resistor in series is less expensive.