

# ECE 321 - Homework #1

Op Amp Amplifiers, Push-Pull Amplifiers. Due Monday, November 9th

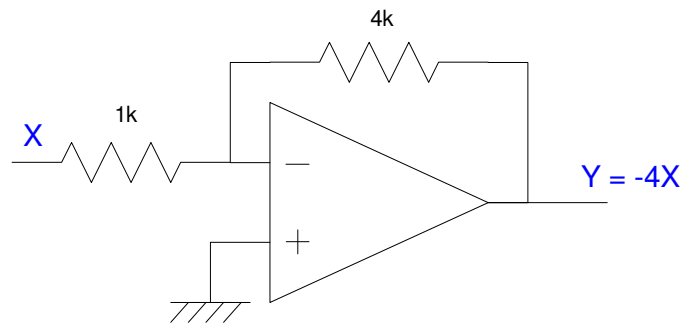
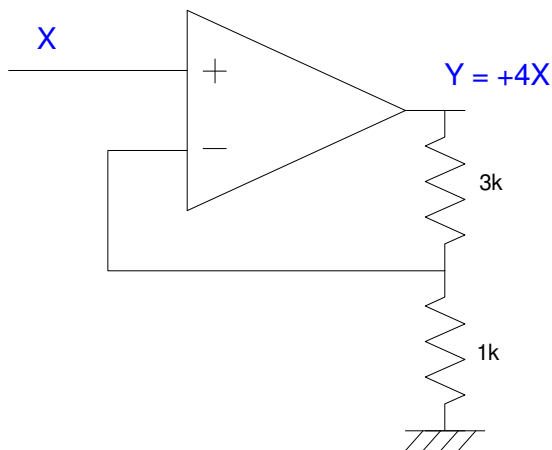
Please make the subject "ECE 321 HW#1" if submitting homework electronically to Jacob\_Glower@yahoo.com (or on blackboard)

## Amplifier:

Design a circuit to implement

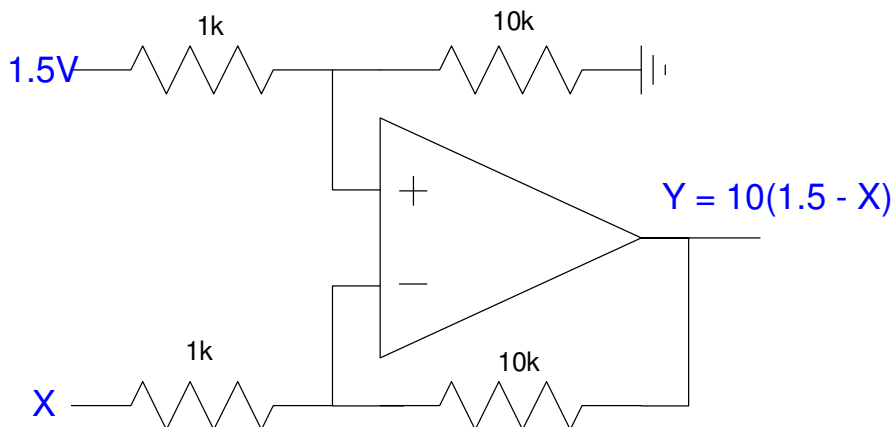
1a)  $Y = +4X$

1b)  $Y = -4X$



1c)  $Y = 15 - 10X$

$$Y = 10(1.5 - X)$$



## Mixer

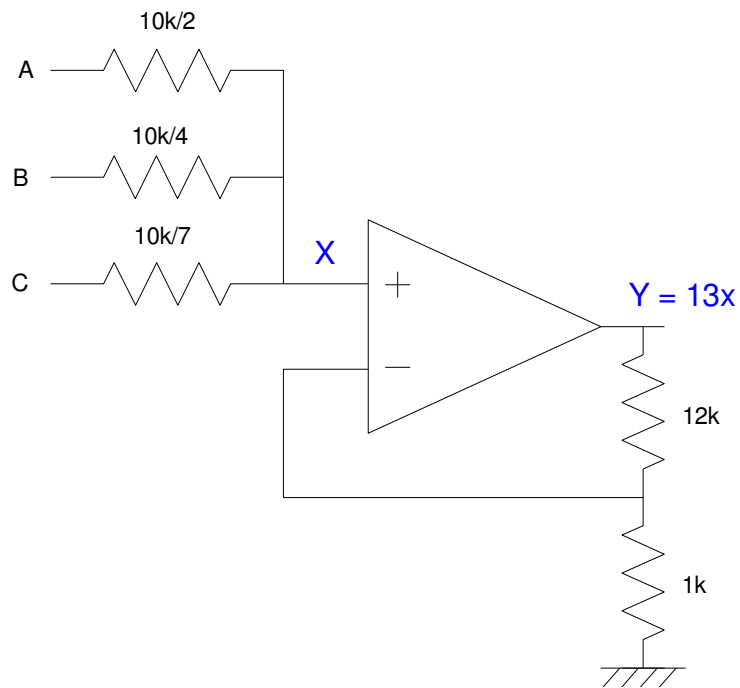
2) Design a circuit to mix three signals together:

- $Y = 2A + 4B + 7C$

Let

$$X = \left( \frac{2A+4B+7C}{13} \right)$$

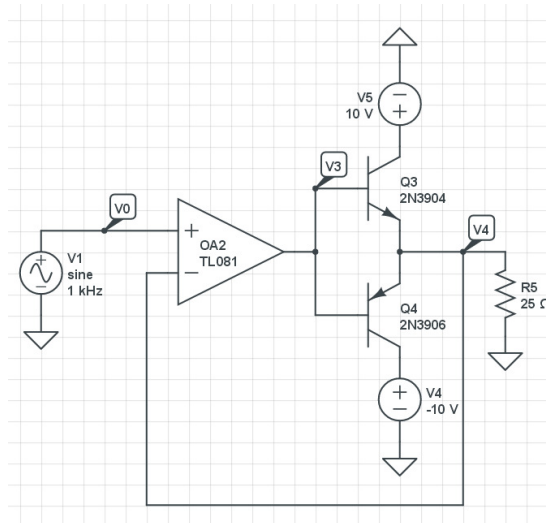
$$Y = 13X$$



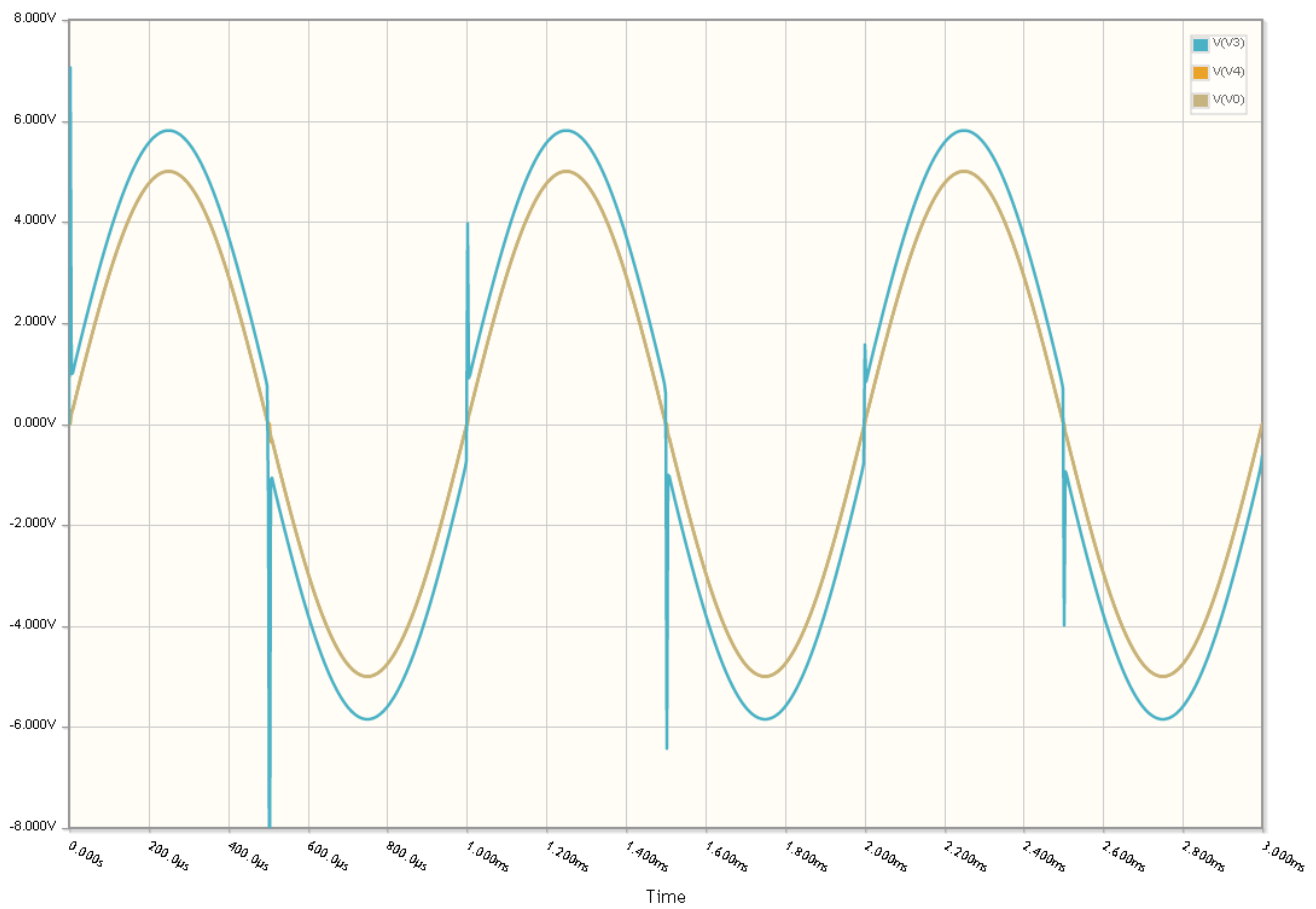
## Push-Pull Amplifier

3) Design a circuit so that  $Y = X$

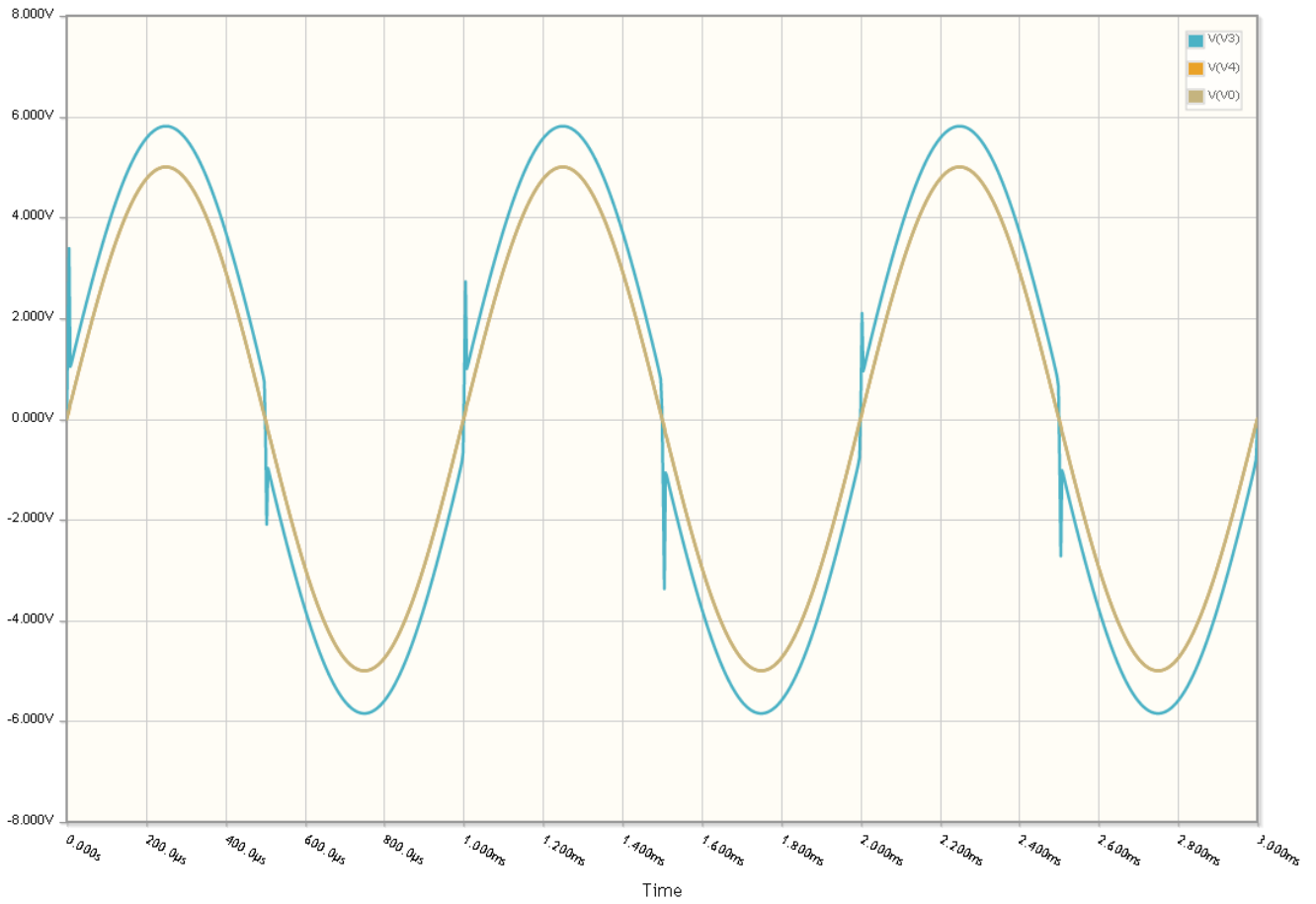
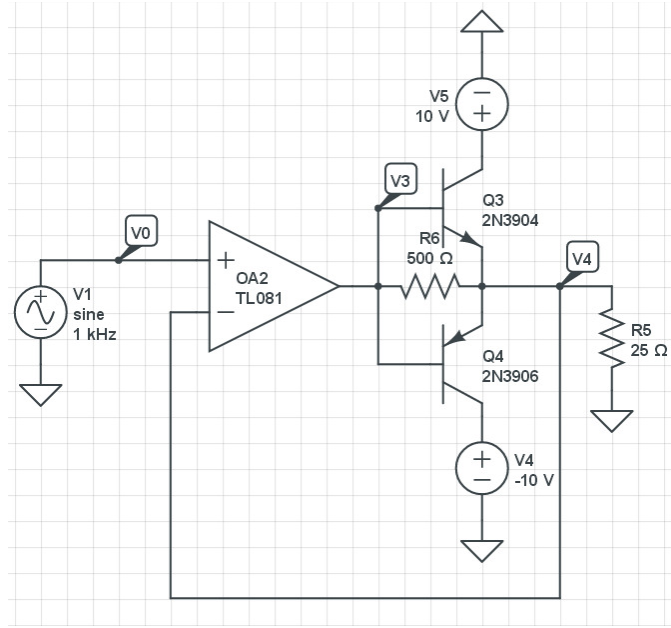
- $X = -5V$  to  $+5V$ ,  $10mA$  max
- $Y = -5V$  to  $+5V$ ,  $200mA$  ( $25\ \Omega$  speaker (net))



4) Simulate in CircuitLab

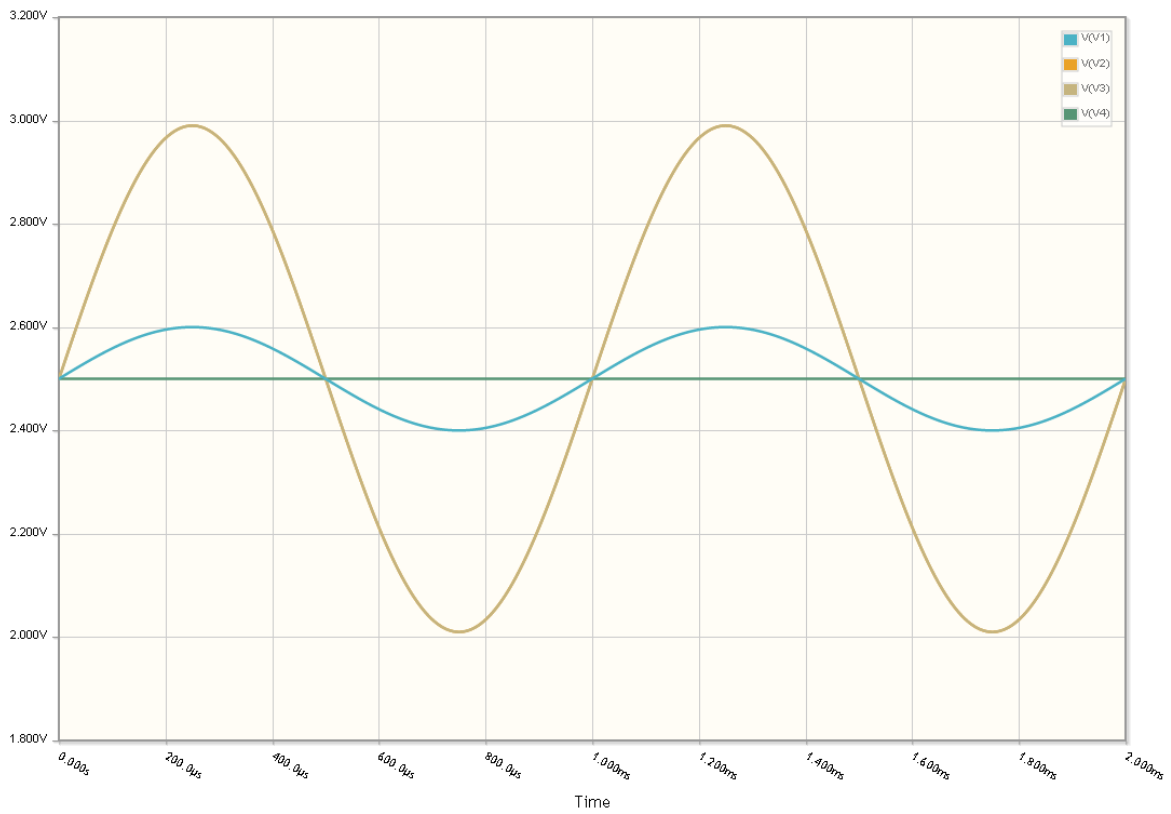
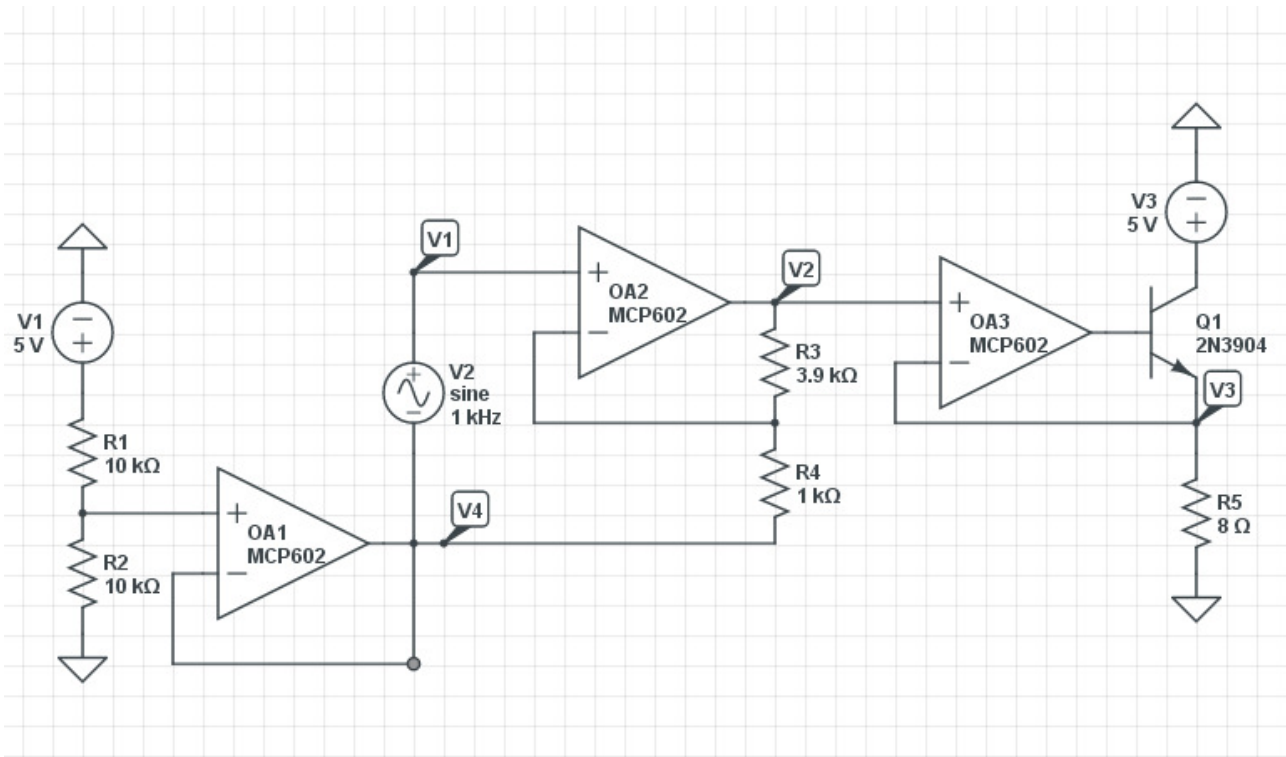


# Variation on Problem #3 and #4



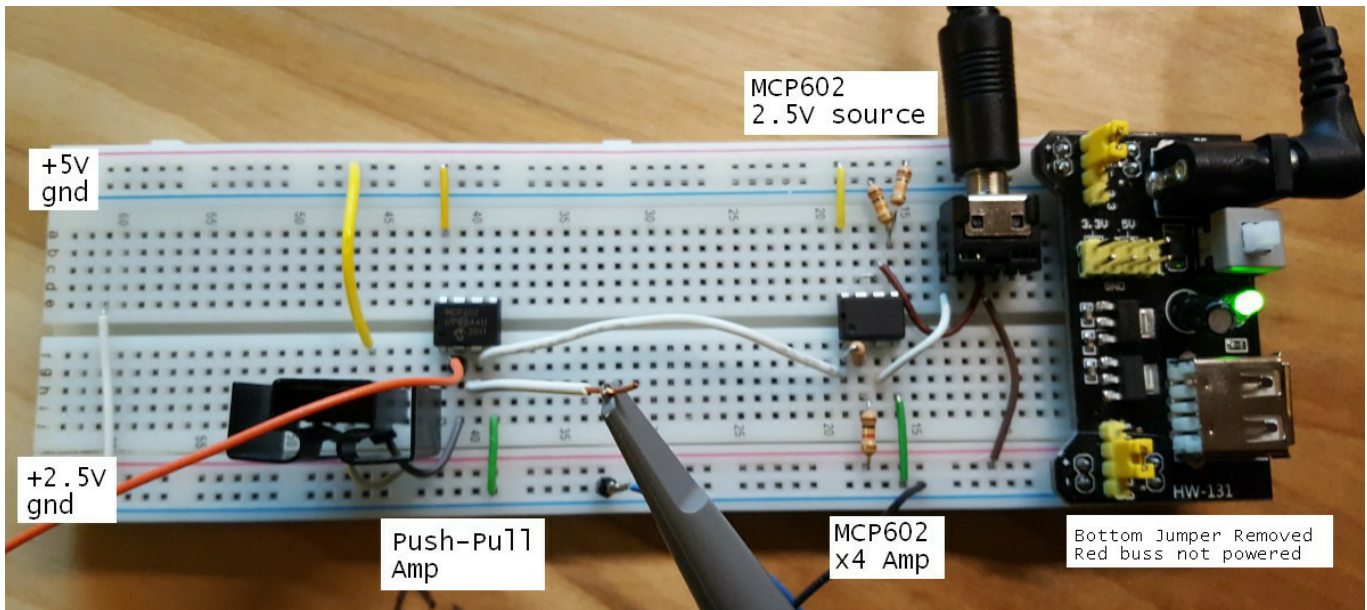
# Lab (Hardware)

5) Simulate this circuit in CircuitLab with X being a 1Vpp 1kHz sine wave



6) Build this circuit in hardware

- Verify that  $Y = 4X$  (use a volt meter with an AC measurement for X and V1)
- Verify that you can hear the voltage at V1 if you connect a speaker to V1 through a 100 Ohm resistor ( $2V @ 100 \text{ Ohms} = 20\text{mA}$ , meaning you don't over-load the op-amp)



DC Voltage = 2.248v (should be 2.500V)

AC voltage from the cell phone is 0.097Vrms

AC voltage at the output of the amplifier = 1.227Vrms

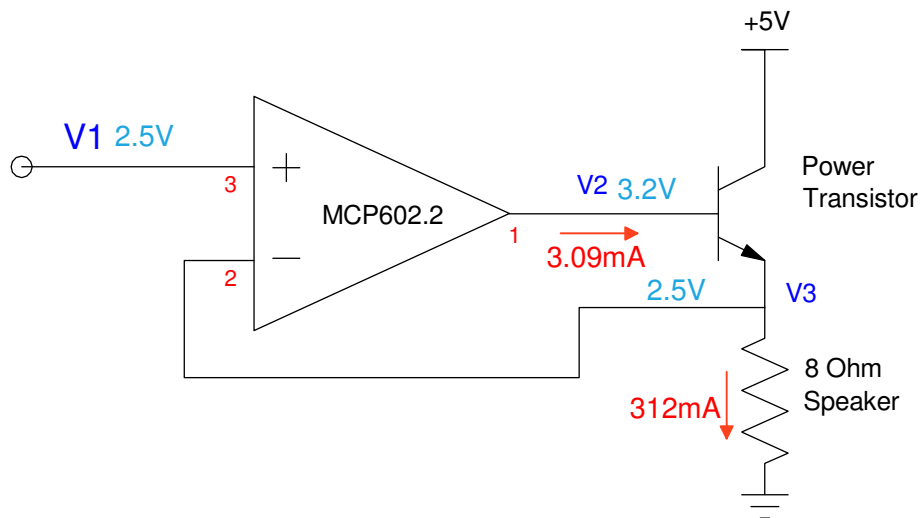
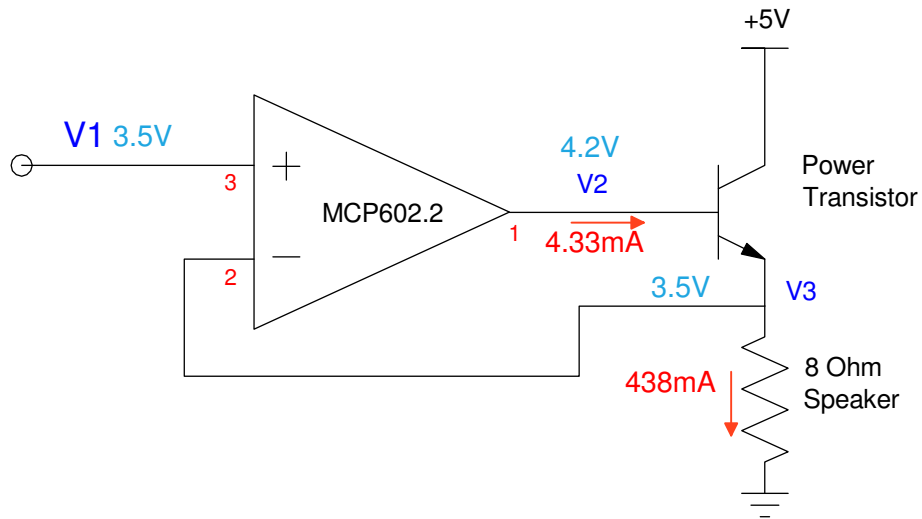
Gain = 12.649 (should be 11.00 for the circuit built: 1k and 10k resistors)

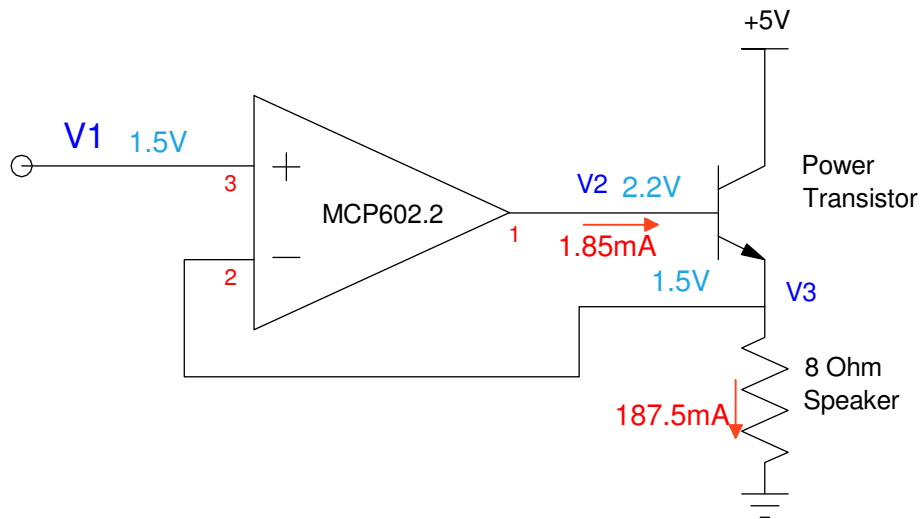
A class-A amplifier (push-only) is shown below.

- The 2.5V source from problem #4 is only capable of sourcing & sinking 25mA, meaning we can't use it as the speaker ground. The speaker requires too much current.
- If instead we use the power supply ground (shown below), we are always driving the speaker (current is always positive).
- This results in a push-only type amplifier (the PNP (pull) transistor will never turn on, so it's eliminated)

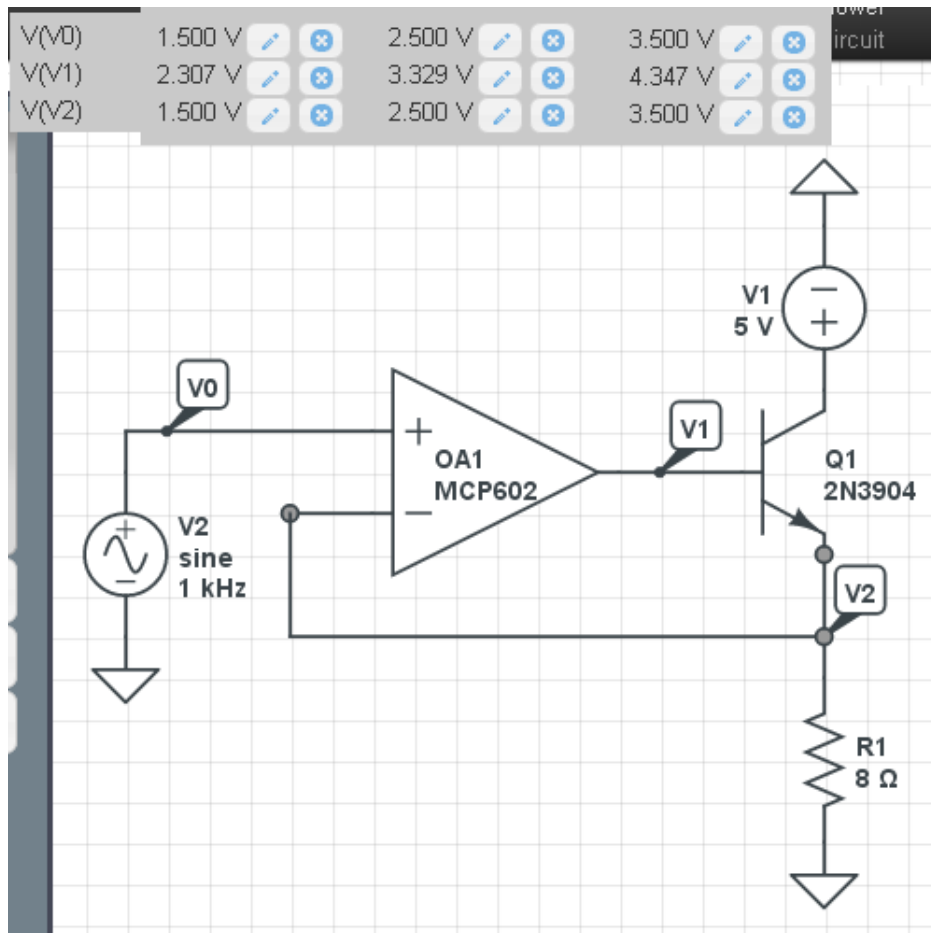
7) Compute the voltage and currents when

- $V_1 = +3.5V$  (+1V relative to 2.5V circuit ground)
- $V_1 = +2.5V$  (+0V relative to 2.5V circuit ground)
- $V_1 = +1.5V$  (-1V relative to 2.5V circuit ground);

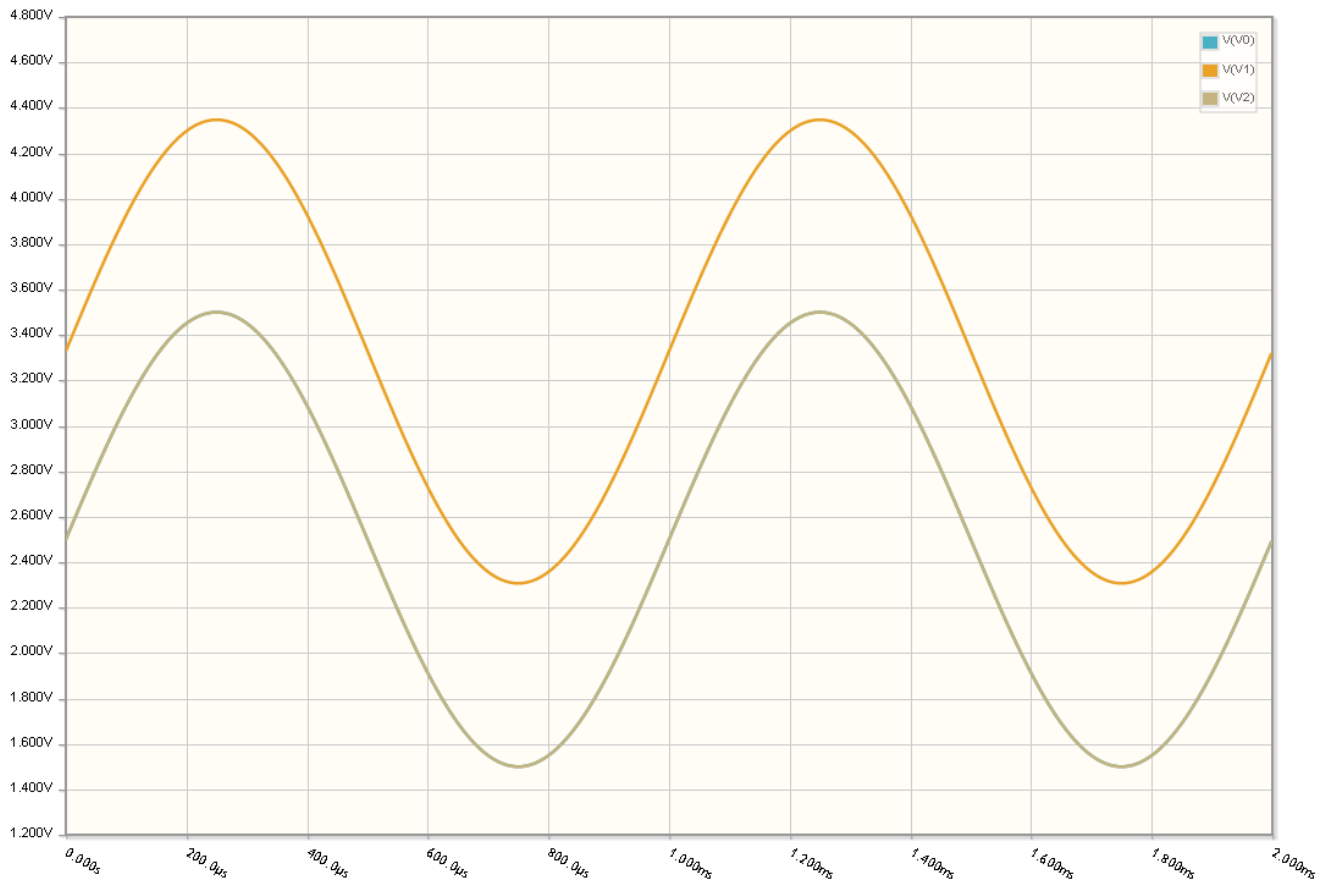




- 8) Simulate this circuit in CircuitLab with
- V1 being a DC signal {3.5V, 2.5V, 1.5V}
  - V1 being a 1kHz 1Vpp sine wave centered at 2.5V







9) Build this circuit in hardware and verify it does work correctly

- $V_3 = V_1$  when  $V_1$  is a DC signal {3.5V, 2.5V, 1.5V}
- The tune from your cell phone plays on the speaker without distortion (more or less)

10) Demo. Demonstrate your cell phone amplifier really works.