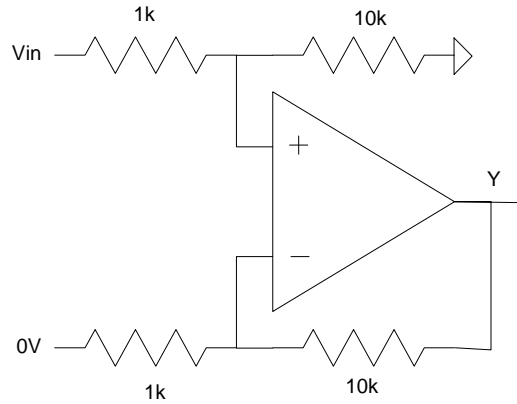# ECE 321 - Homework #1

Op-Amp Amplifiers. Due Monday, November 9th

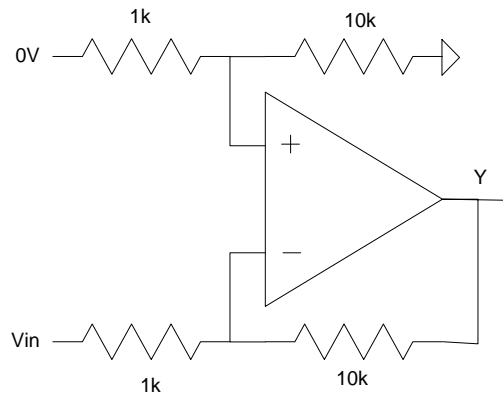1) Design an op-amp circuit to implement

$$Y = 10X$$

Multiple solutions. One that works uses an instrumentation amplifier

2) Design an op-amp circuit to implement

$$Y = -10X$$

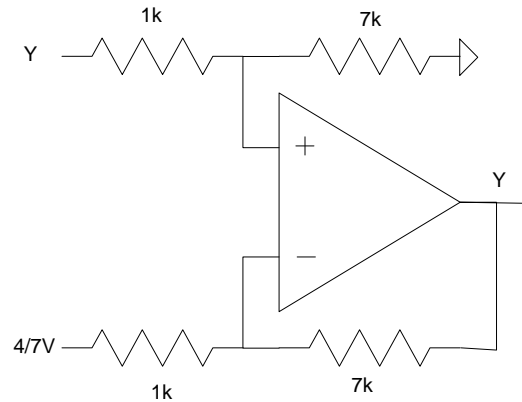Multiple solutions. One that works uses an instrumentation amplifier

3) Design an op-amp circuit to implement

       Y = 7X - 4

Rewrite as

       Y = 7 (X - 4/7)

4) A thermistor has the temperature-voltage relationship of

$$R = 1000 \cdot e^{-0.0515(T-25)}\,\Omega$$

Design an op-amp circuit which output
- 0V at 0C,
- 10V at +40C,
- Proportional (0..10V) for temperatures between 0C and +40C

Assume a 1k resistor for a voltage divider

At 0C

       R = 3623 Ohms

       Va = 7.8372V

At +40C

       R = 462 Ohms
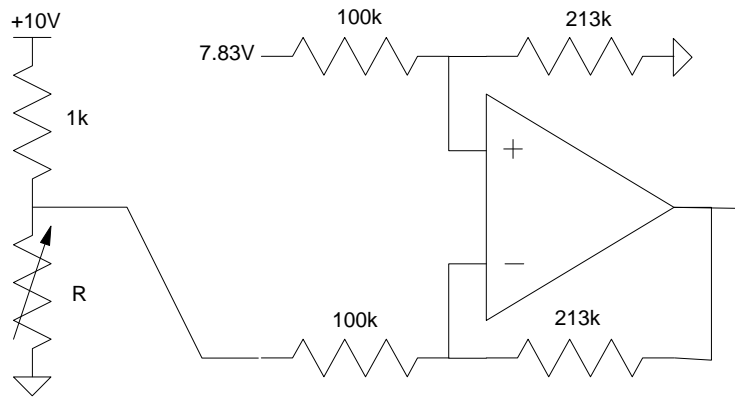
       Va = 3.1594V

The gain you need is

$$gain = \left(\frac{10V-0V}{7.8372V-3.1594V} \right) = 2.1377$$
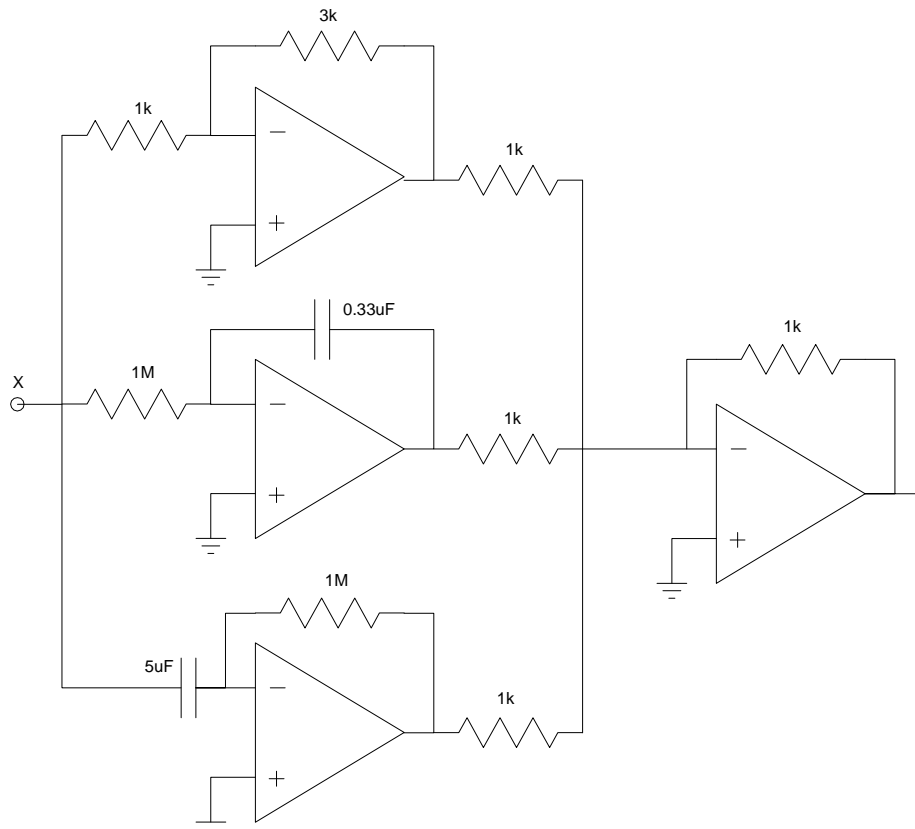
The output increases as Va decreases, so connect Va to the - input

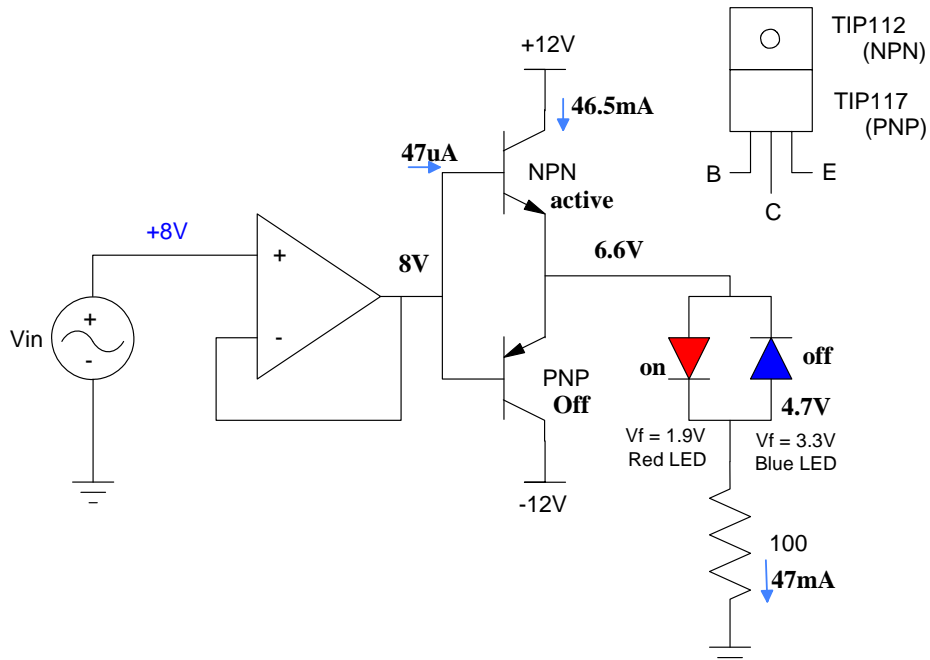The output should be 0V when Va = 7,83V (0C), so make the offset 7.83V

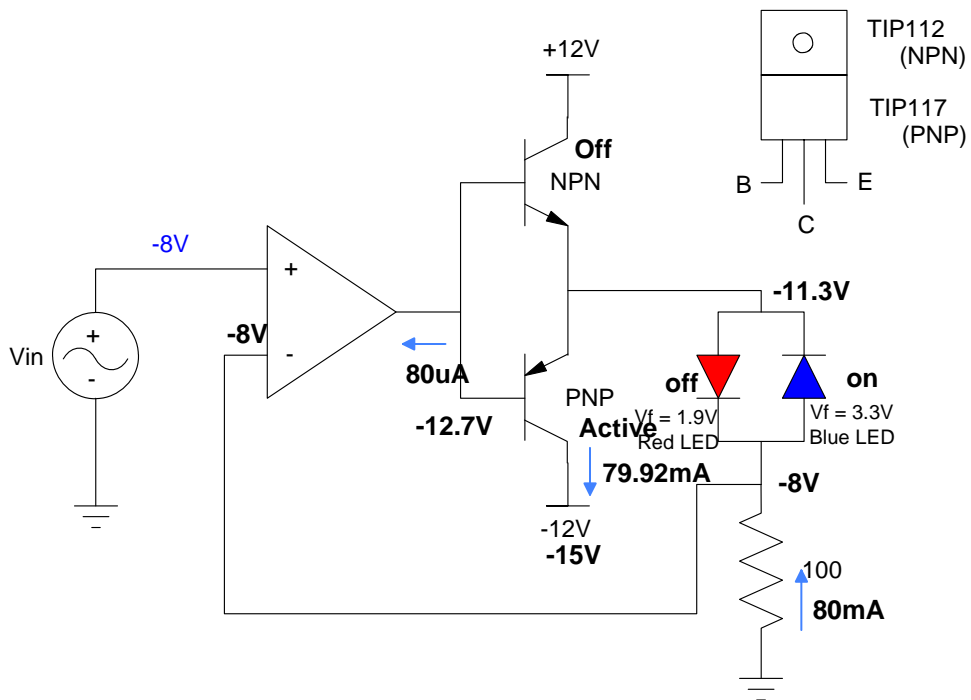5) Design an op-amp circuit to implement the following differential equation

$$Y = \left(3 + \frac{4}{s} + 5s\right)X$$

6) Determine the node voltages for the following circuit when the input is +8VDC. Assume a TIP112 and TIP117 transistors. ($\beta = 1000$, $V_{be} = 1.4V$, $V_{ce:sat} = 0.9V$

+12V

46.5mA

47uA

NPN
active

TIP112
(NPN)

TIP117
(PNP)

B   E

C

+8V

+

8V

6.6V

Vin

+
-

-

on   off

PNP
Off

4.7V

Vf = 1.9V
Red LED

Vf = 3.3V
Blue LED

-12V

100

47mA

7) Determine the node voltages for the following circuit when the input is -8VDC. Assume a TIP112 and TIP117 transistors.

+12V

Off

NPN

TIP112
(NPN)

TIP117
(PNP)

B   E

C

-8V

+

-11.3V

-8V

-

Vin

+
-

80uA

off   on

PNP
Active

Vf = 1.9V
Red LED

Vf = 3.3V
Blue LED

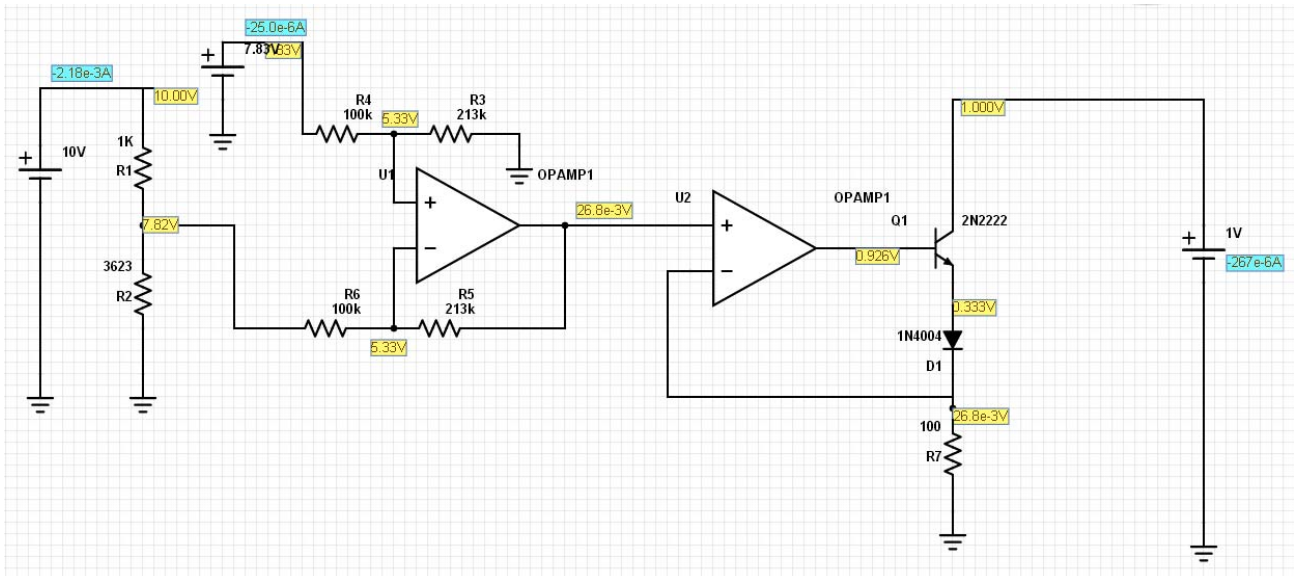-12.7V

79.92mA

-8V

-12V
-15V

100

80mA

8) Design an op-amp circuit with a push-pull amplifier to drive a 100mA light
   - 0mA at 0C
   - 100mA at 40C
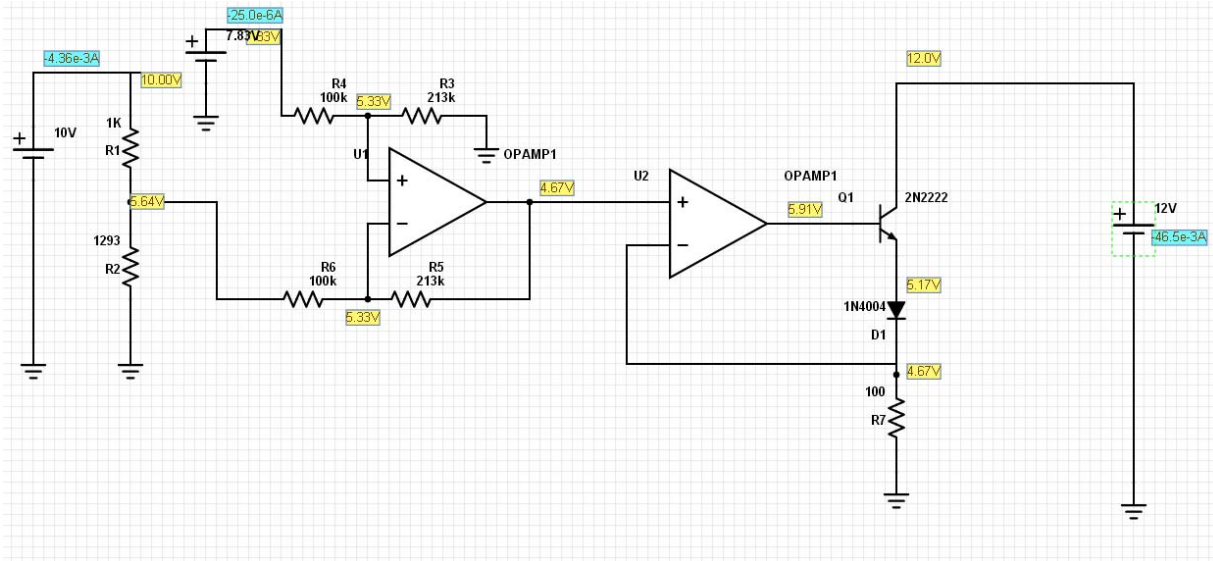   - Proportioanal (0..100mA) for temperatures between 0C and +40C.
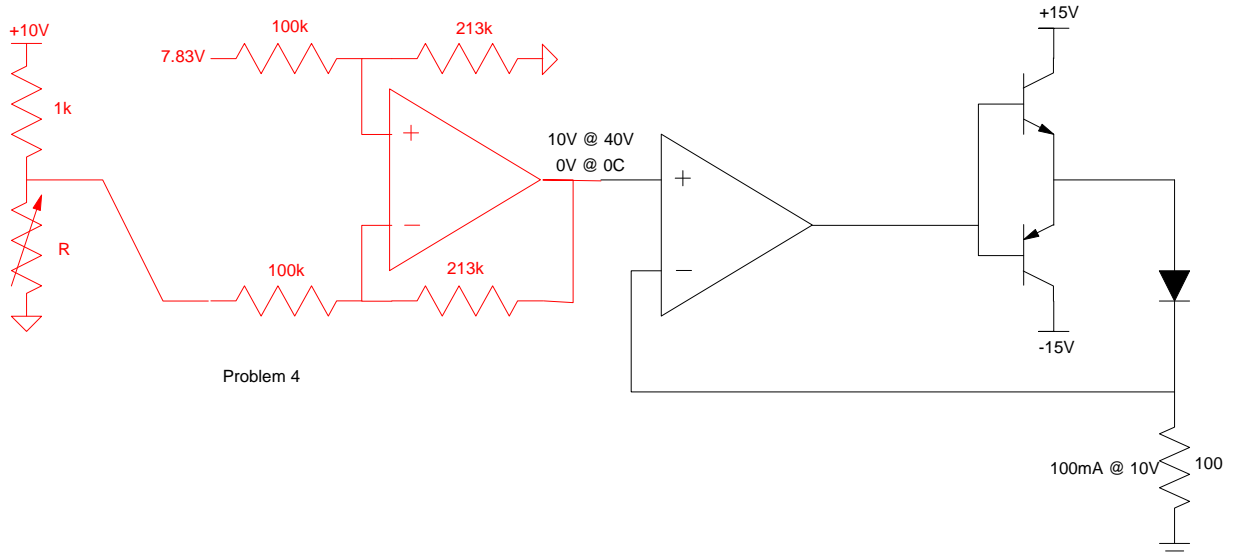
Problem 4

(the PNP transistor in the push-pull amplifier can be deleted - current (and voltage) never goes negative)
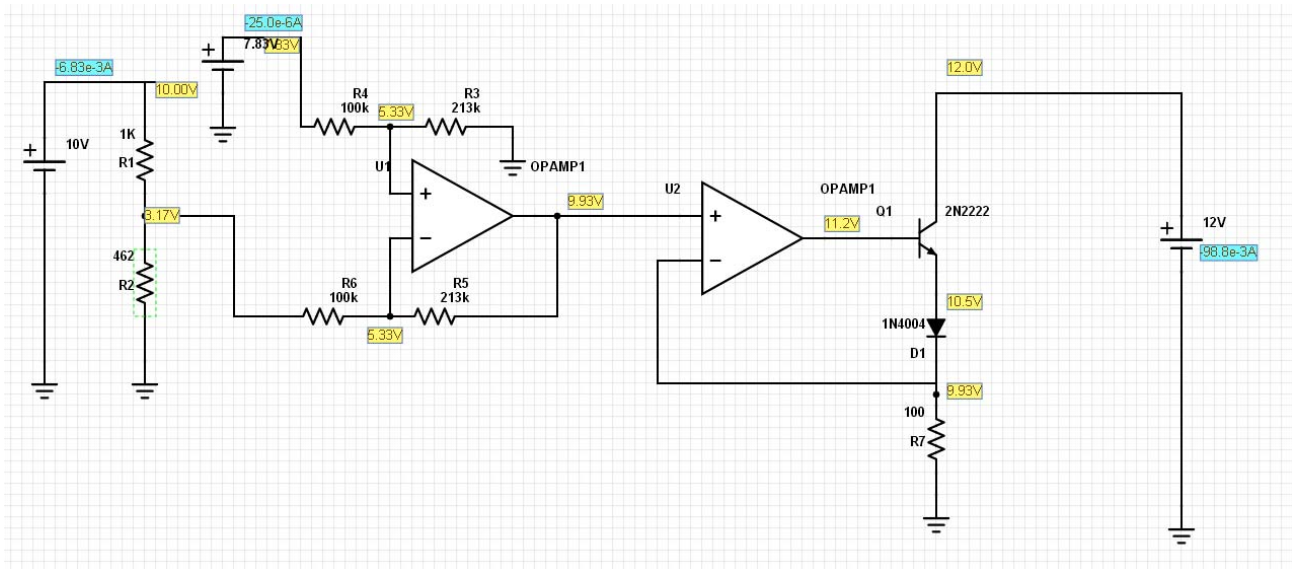
9) Simulate your circuit in problem 8 in PartSim (or similar software)

0C: Current to LED = 0mA

+20C: Current to LED = 46.5mA (approx half way to 100mA)

+40C: Current to LED = 100mA

10) Lab: Build the circuit you designed in problem #8 in lab and verify its operation.