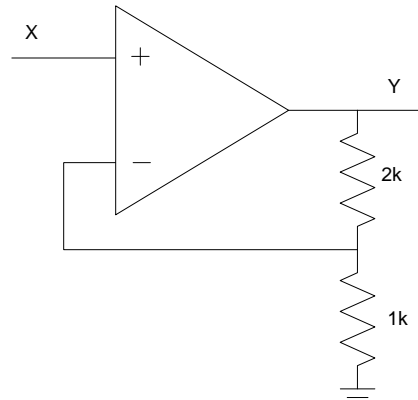# ECE 321 - Homework #1

Op-Amps, Instrumentation Amplifiers. Due Monday, October 31st
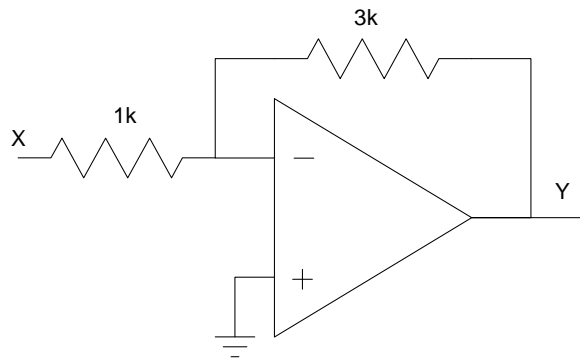
Assume ideal op-amps.

1) Design an op-amp circuit with a gain of +3.

There are many solutions. One that works is:

2) Design an op-amp circuit with a gain of -3

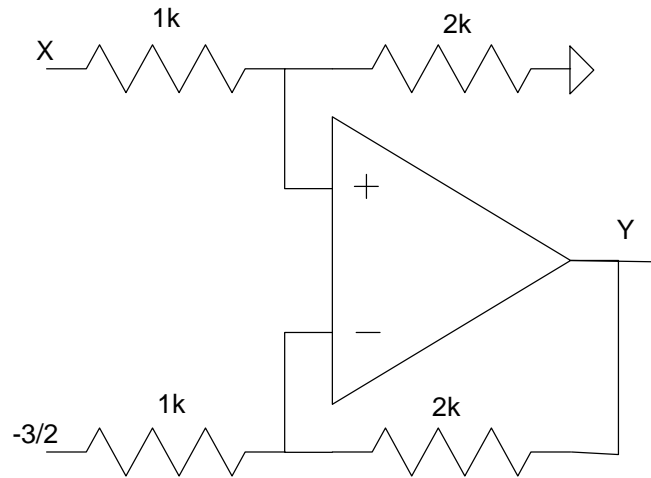There are many solutions. One that works is:

3) Design an op-amp circuit to implement the funciton

$$Y = 2X + 3$$

Rewrite as

$$Y = 2\left(X - \left(-\frac{3}{2}\right)\right)$$

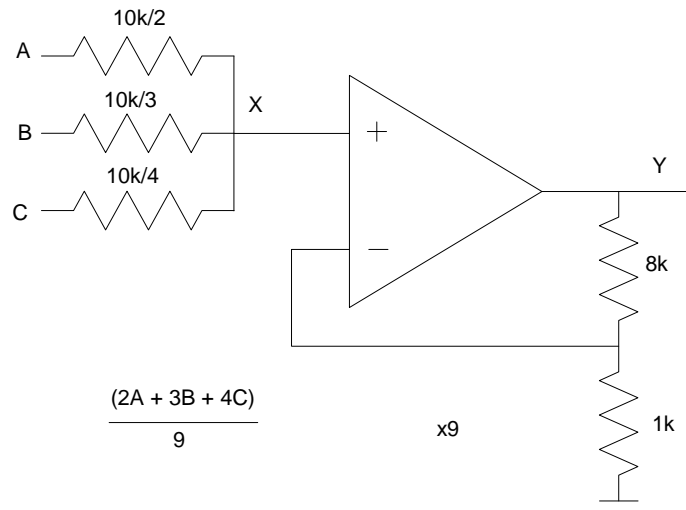4) Design a circuit which meets the following requirements

Input: 3 voltages (A, B, C), each ± 5V, 0-10kHz, capable of driving 10mA
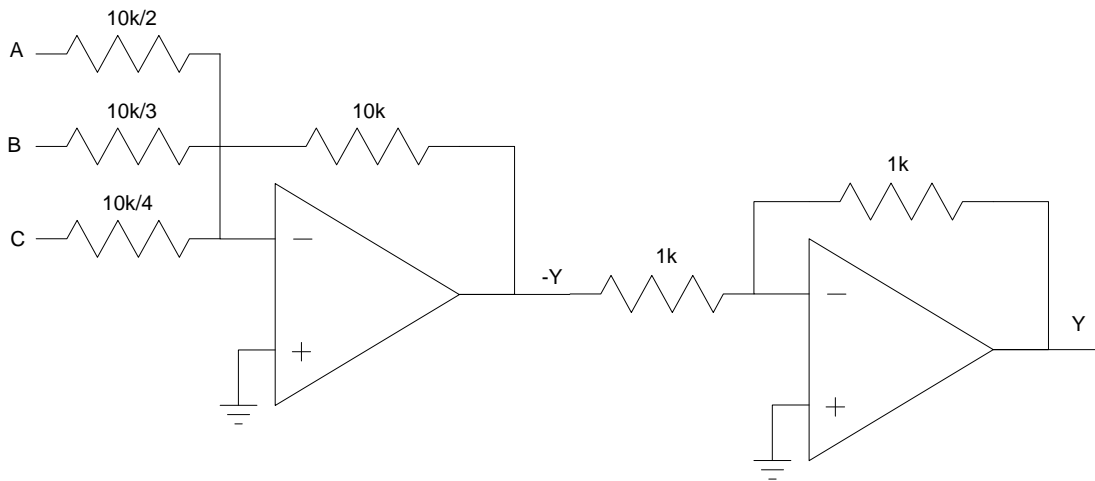
Output: Y: ± 5V, capable of driving 10mA

Relationship: Y = 2A + 3B + 4C

The input resistors need to be more than

$$R_{in} > \frac{5V}{10mA} = 500\Omega$$

Solution Based upon Non-Inverting Amplifiers:

Solution using inverting amplifiers.

5) Design a circuit which meets the following requirements:

Input: Thermistor

$$R = 1000 \cdot e^{-0.05(T-25)} \ \Omega$$

Output: Y, 0 .. 10V signal, capable of driving 10mA

Relationship:
- At 0C, Y = 0V
- At 10C, Y = 10V
- Y is proportional to temeprature for 0C < T < 10C

At 0C

R = 3490 Ohms

At 10C

R = 2117 Ohms

Use a voltage divider with Rtop = 2700 Ohms (the geometric mean of 0C and 10C).

$$R_{top} = \sqrt{3490 \cdot 2117} = 2718 \Omega$$

Then, at 0C

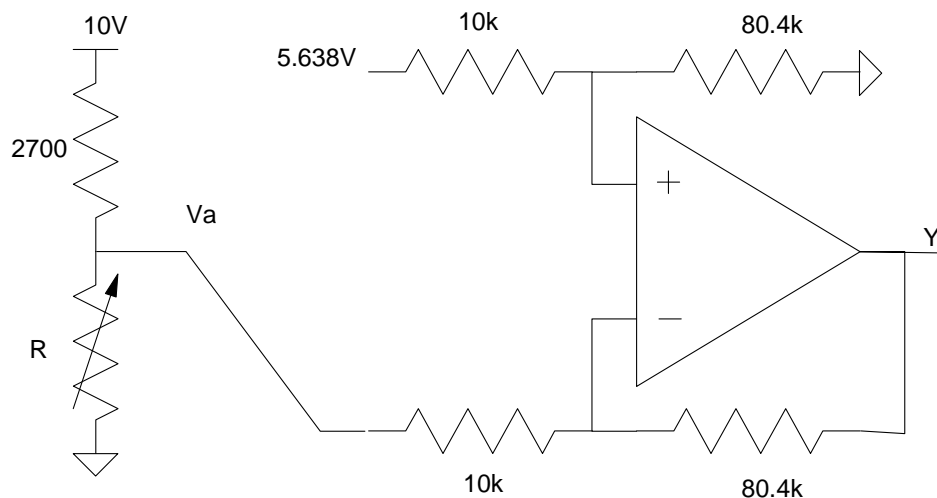$$V_a = \left(\frac{3490}{3490+2700} \right) 10V = 5.638V$$

At 10C

$$V_a = \left(\frac{2117}{2117+2700} \right) 10V = 4.3949V$$

For the output to have a spread of 10V, the gain needs to be

$$gain = \left(\frac{10V-0V}{4.3949V-5.638V} \right) = -8.04$$

The output increases when the input decreases (negative gain) so connect the divider to the - input.

The output is 0V when the input is 5.638V. Set the offset to 5.638V

In Matlab (not required)

```
-->T = [0:0.01:10]';

-->R = 1000*exp(-0.05*(T - 25));

-->Va = (R ./ (2700 + R))*10;

-->gain = 8.04;

-->Offset = 5.638;

-->Y = gain*(Offset - Va);

-->plot(T,Y)

-->xlabel('Temperature (C)');

-->ylabel('Y (Volts)');
```