ECE 321 - Homework #1

Push-Pull Amplifiers, Instrumentation Amplifiers, Temperature Sensors. Due Wednesday, Novembber 13th

ECE 321 Project:

0) Pick a project for ECE 321 (see page 2 for suggestions)

- Give the name of the people in your group
- Specify the requirements for the overall project

For the following sections, assume TIP112 (NPN) and TIP117 (PNP) transistors:

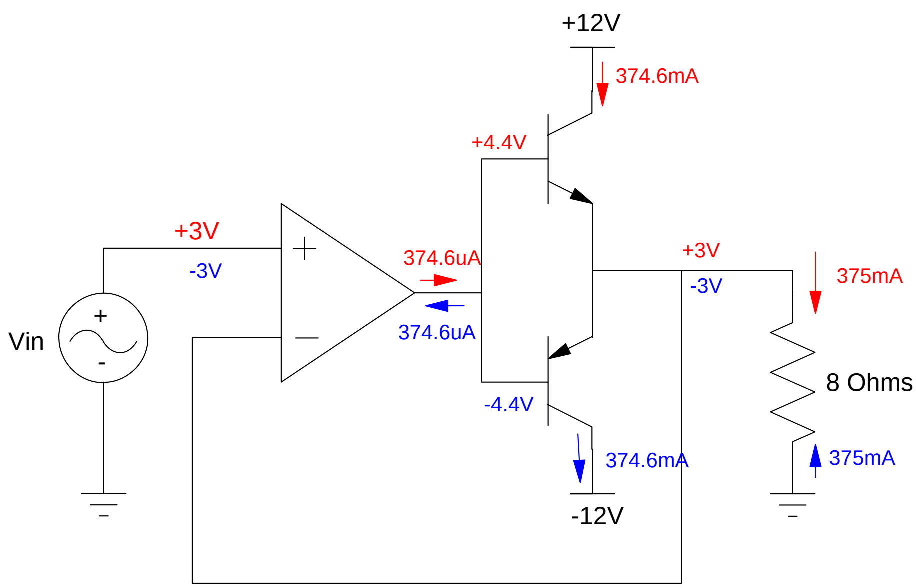
- ß = 1000
- Vbe = 1.4V
- min (Vce) = 0.9V
- max (Ic) = 3A

Push-Pull Amplifiers

1) Determine the voltages and currents for a the push-pull amplifier with a voltage outout for

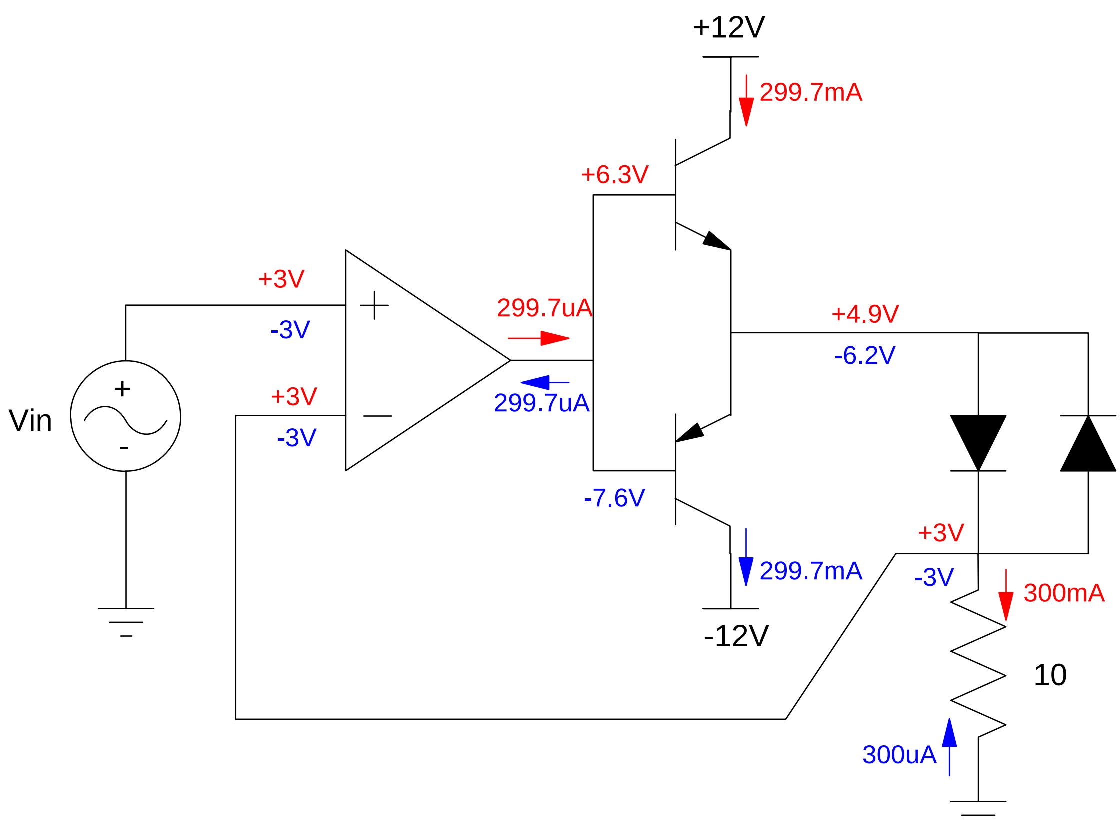
- X = -3V
- X = +3V
- X = 0V

At 0V, everything is zero



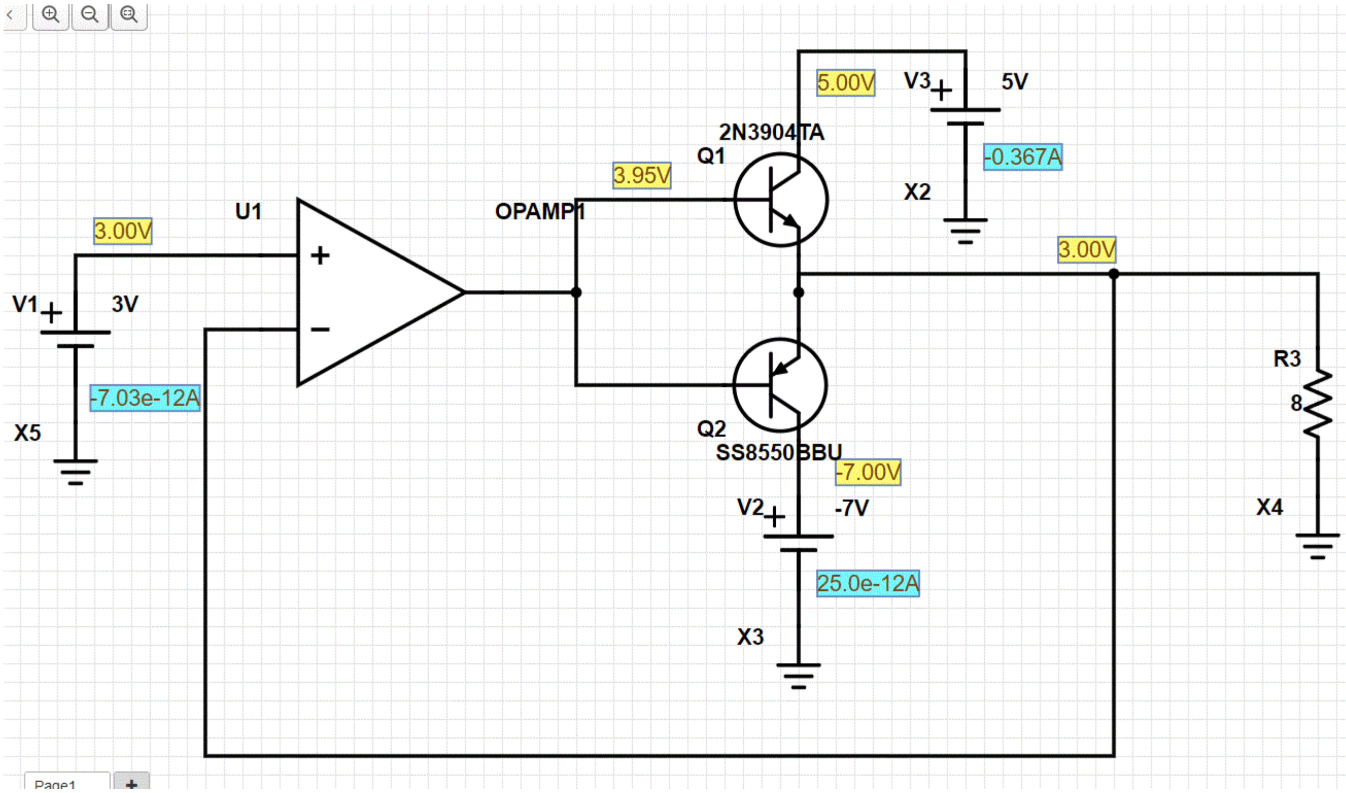
2) Determine the voltages and currents for a the push-pull amplifier with a current outout for

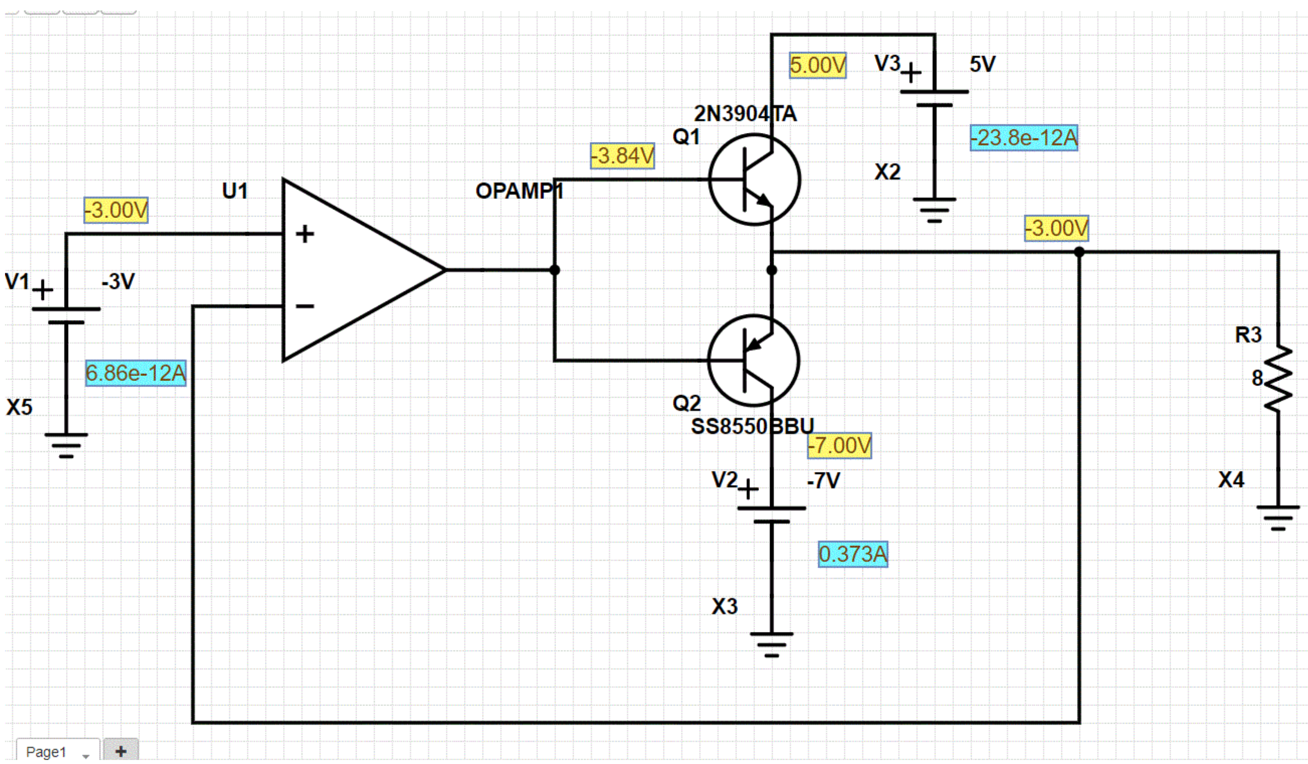
- X = -3V
- X = +3V
- X = 0V



Pick one of these two push-pull amplifiers (your choice) for your term project.

3) Check your comutations using PartSim for the amplfier you picked (votlage or current output)

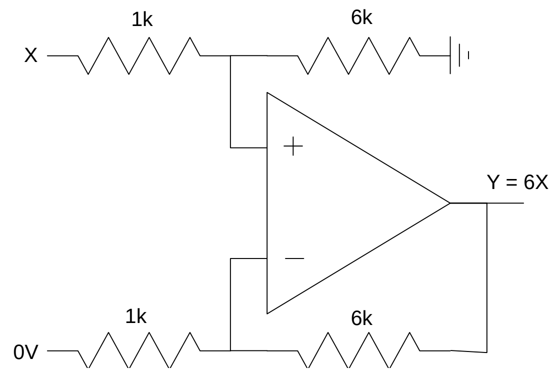




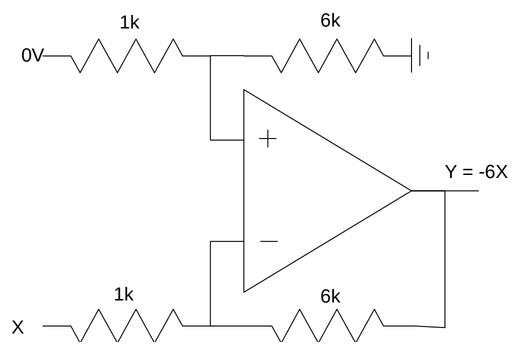
4) Build this amplifier in lab. Verify that is is operating correctly at -3V, 0V, and +3V.

Instrumentation Amplfiers

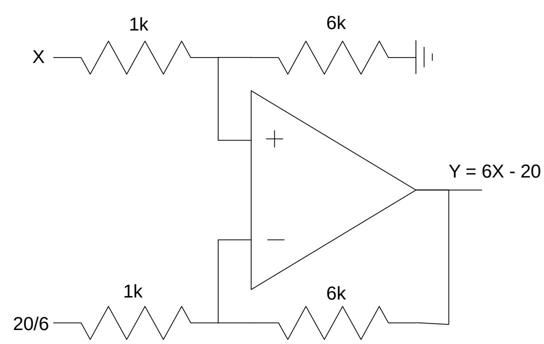
5) Design an op-amp circuit to implement the following functions



$$Y = 6X$$



$$Y = -6X$$



$$Y = 6X - 20$$

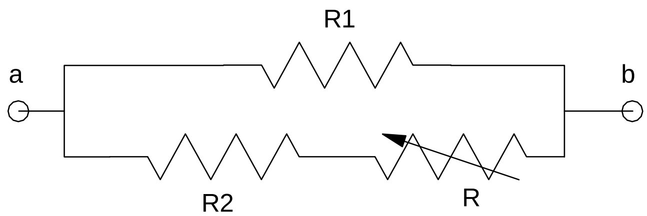
Temperature Sensors

Assume a thermistor has a temperature - resistance relationship of

$$R = 1000 \cdot \exp\left(\frac{3905}{T} - \frac{3905}{298}\right)\ \Omega$$

6) Design a circuit so that the resistance is linear between 0C and +20C

Assume the following circuit



0C:

R = 3320.12 Ohms

20C:

R = 1250.59 Ohms

The total resistance is

$$R_{ab} = \left(\frac{R_1(R_2+R)}{R_1+R_2+R}\right)$$

Find R1 and R2 so that the resistance at 10C is the midpoint between 0C and 20C

$$R_{ab}(10C) = \left(\frac{R_{ab}(20C)+R_{ab}(0C)}{2}\right)$$

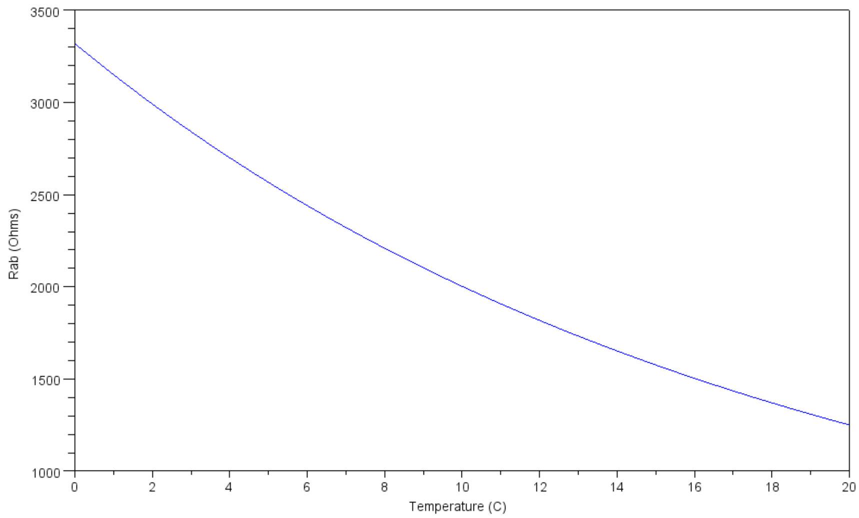
After some trial and error, a cost function that works is

```
function J = costR(Z)
// linearizing resistance

R1 = Z(1);
R2 = Z(2);

R0 = 3320.12;
R10 = 2002.83;
R20 = 1250.59;

Rab0 = (R1*(R2+R0)) / (R1 + R2 + R0);
Rab10 = (R1*(R2+R10)) / (R1 + R2 + R10);
Rab20 = (R1*(R2+R20)) / (R1 + R2 + R20);

E1 = 2*Rab10 - Rab0 - Rab20;
E2 = (R1 - 1000)/1000;

J = E1^2 + E2^2;

end
```

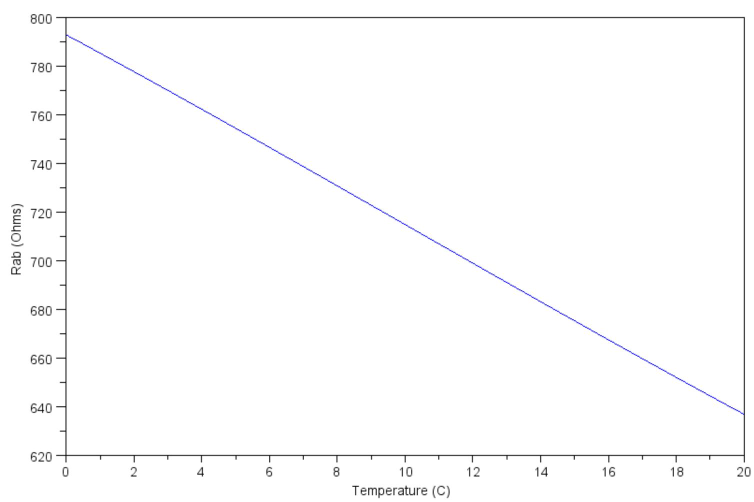
```
[E, Z] = leastsq(costR, [1000,2000])
          R1              R2
 Z  =    1000.0003    504.52357
 E  =    2.991D-16
```

Plotting Rab from 0C to 20C

```
-->T = [0:0.01:20]';
-->K = T + 273;
-->R = 1000*exp( 3905 ./ K - 3905/298 )
-->plot(T,R)
```



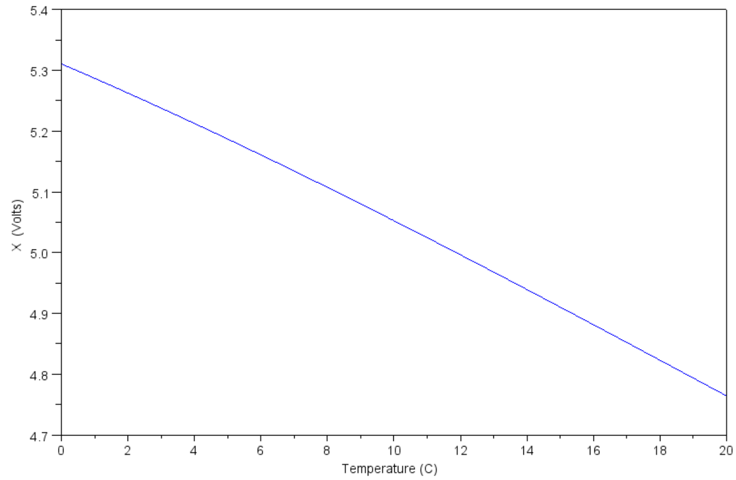

```
-->Rab = R1*(R2+R) ./ (R1 + R2 + R);
-->plot(T,Rab)
```



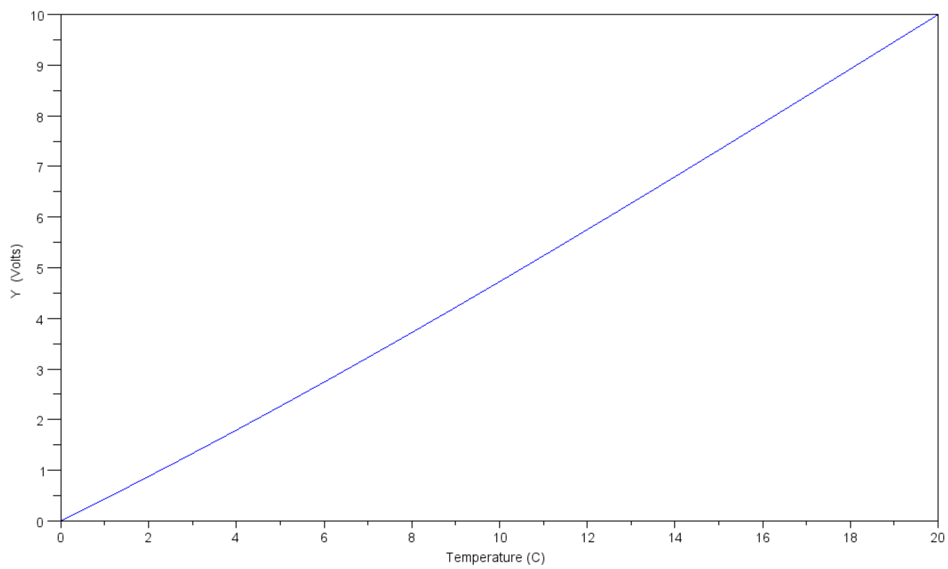
7) Design a circuit which outputs

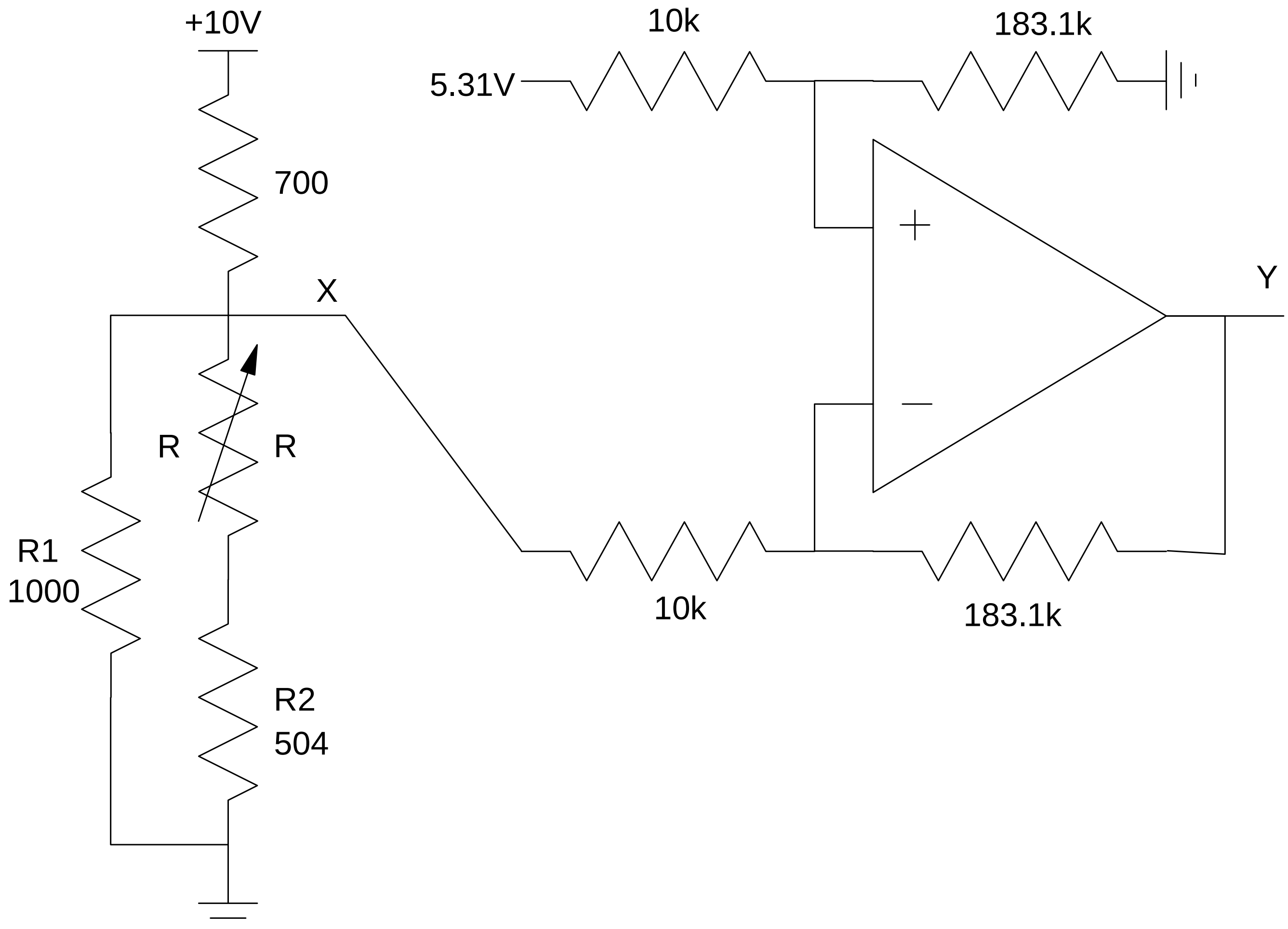
- 0V at 0C,
- 10V at 20C, and
- Proportional inbtween 0C and 20C

```
-->X = Rab ./ (700 + Rab) * 10;
-->plot(T,X)
-->xlabel('Temperature (C)');
-->ylabel('X  (Volts)')
```




```
gain = (10 - 0) / (max(V1) - min(V1))
    gain  =    18.31307

offset = V1(1)
    offset  =  5.3106093

Y = gain*(offset - X);
plot(T,Y)
xlabel('Temperature (C)');
ylabel('Y  (Volts)')
```





There are other solutions...