ECE 321 - Homework #2

Light & Temperature Sensors, Audio & Strain Sensors. Due Wednesday, April 12th
Please email to jacob.glower@ndsu.edu, or submit as a hard copy, or submit on BlackBoard

Temperature Sensors

Assume you are using a thermistor where the temperature - resistance relationship is

$$R = 1000\ \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\ \Omega$$

where T is the temperature in degrees C.

1) Design a linearizing circuit so that the resistance is approximately linear from -20C to +20C. Plot the resulting resitance vs. temperature relationship.

First write a Matlab m-file to compute how liner the resistor is:

```
function [J] = Prob1(Z);

Ra = Z(1);
Rb = Z(2);

T1 = -20;
T2 = 0;
T3 = 20;

R1 = 1000*exp(3905/(T1+273) - 3905/298);
R2 = 1000*exp(3905/(T2+273) - 3905/298);
R3 = 1000*exp(3905/(T3+273) - 3905/298);

Z1 = (Ra+R1)*(Rb) / (Ra + R1 + Rb);
Z2 = (Ra+R2)*(Rb) / (Ra + R2 + Rb);
Z3 = (Ra+R3)*(Rb) / (Ra + R3 + Rb);

E = Z1 + Z3 - 2*Z2;

J = E^2;
end
```

Optimize with fminsearch()

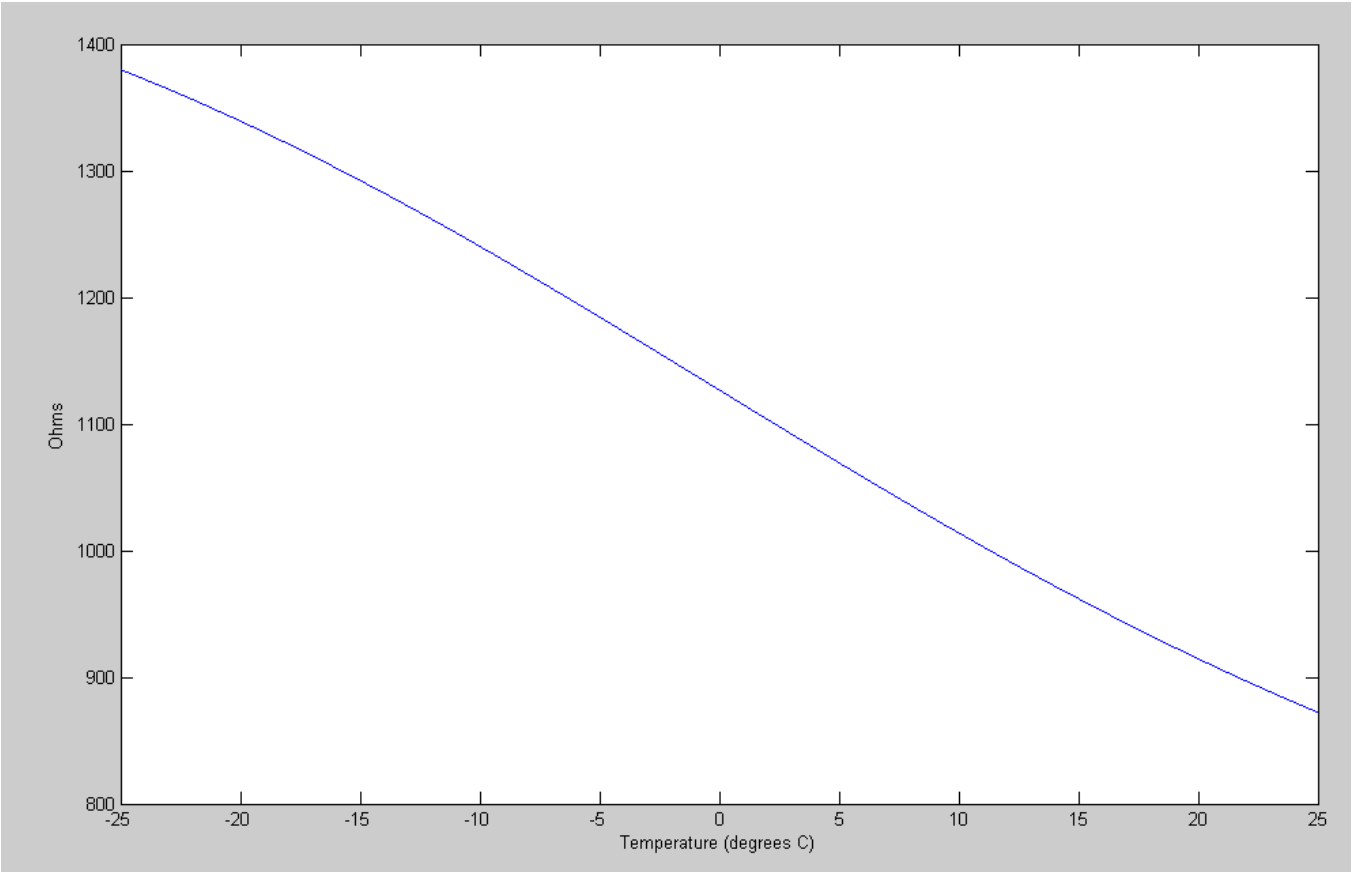
```
>> [Z,e] = fminsearch('Prob1',[1000,2000])

Z = 1049.6    1518.9

e =     0
```

Plot the resulting resistance vs. temperature:

```
>> Ra = Z(1);
>> Rb = Z(2);
>> T = [-20:0.01:20]';
>> T = [-25:0.01:25]';
>> R = 1000 * exp( 3905 ./ (T+273) - 3905/298);
>> Z = (Ra+R)*Rb ./ (Ra+R+Rb);
>> plot(T,Z)
>> xlabel('Temperature (degrees C)');
>> ylabel('Ohms');
```


1400
1300
1200
1100
1000
900
800
Ohms
-25
-20
-15
-10
-5
0
5
10
15
20
25
Temperature (degrees C)

2) Using the linearizing circuit from problem 4, design a circuit which outputs

- 0V at -20C
- +5V at +20C
- Proportional in between.

Plot the resulting output voltage vs. temperature.

```
>> % -20C
>> T = -20;
>> R = 1000 * exp( 3905 ./ (T+273) - 3905/298);
>> Z1 = (Ra+R)*Rb ./ (Ra+R+Rb);
>> V1 = Z1 / (Z1+1000)*10

V1 =    5.7254

>> % +20C
>> T = 20;
>> R = 1000 * exp( 3905 ./ (T+273) - 3905/298);
>> Z2 = (Ra+R)*Rb ./ (Ra+R+Rb);
>> V2 = Z2 / (Z2+1000)*10

V2 =    4.7776

>> gain = (5-0) / (V2-V1)

gain =   -5.2749

>> offset = (V1+V2)/2

offset =    5.2515
```