ECE 111 - Solution #14

Calibration

1) Find a temperature sensor from www.Digikey.com other than the one covered in class. From the data sheets, determine the resistance vs. temperature relationship.

Digikey sells over 7000 NTC thermistors. Picking a 1k thermistor at random

Product Overview	
Digi-Key Part Number	445-174901-1-ND
Quantity Available	**22,165** Can ship immediately
Manufacturer	TDK Corporation
Manufacturer Part Number	NTCG104BH102HT1
Description	THERMISTOR NTC 1KOH
Manufacturer Standard Lead Time	12 Weeks
Detailed Description	NTC Thermistor 1k 0402 (1

NTCG104BH102HT1 TDK Corporation \| 445-174901-1-ND DigiKey Electronics

Price Break	Unit Price	Extended Price
1	0.10000	$0.10
5	0.09800	$0.49
10	0.08800	$0.88
25	0.08080	$2.02
50	0.06460	$3.23
100	0.05540	$5.54
500	0.04852	$24.26
1,000	0.04158	$41.58
5,000	0.03696	$184.80

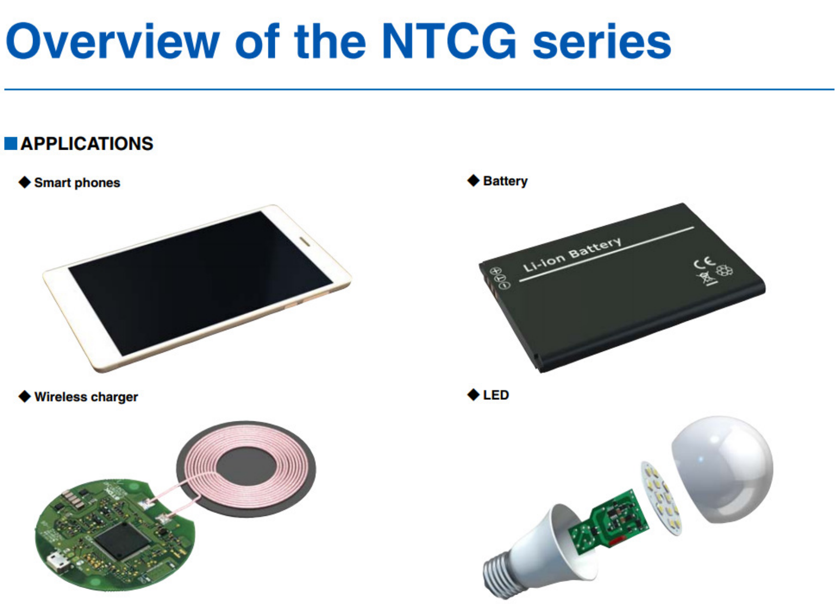
Submit a request for quotation on quantities greater than those displayed.

R = 1000 Ohms at 25C

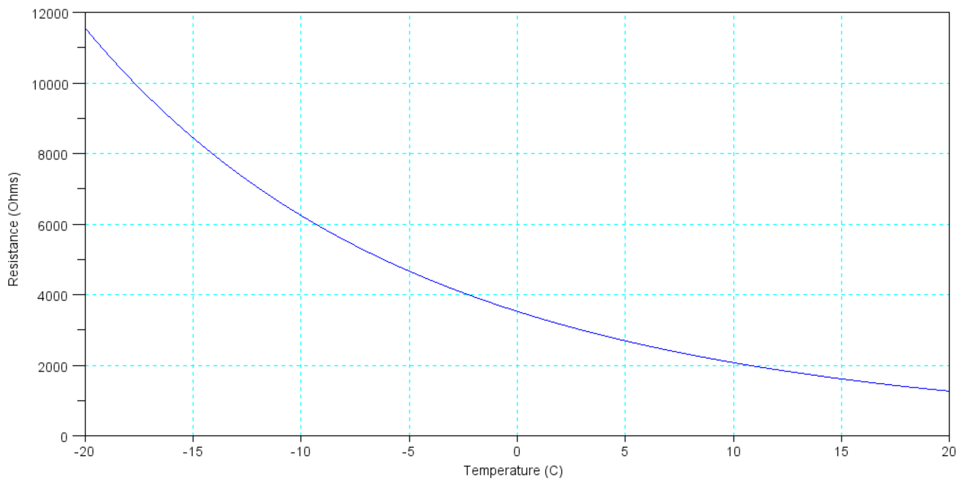
B25/85 = 4100K

$$R \approx 1000 \cdot \exp\left(\frac{4100}{K} - \frac{4100}{298}\right)$$

This is used in various devices...



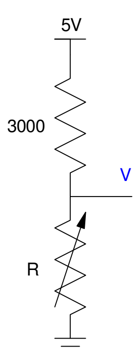
```
T = [-20:0.1:20]';
K = T + 273;
R = 1000 * exp( 4100 ./ K   -  4100/298 );
plot(T,R)
xlabel('Temperature (C)');
ylabel('Resistance (Ohms)');
```

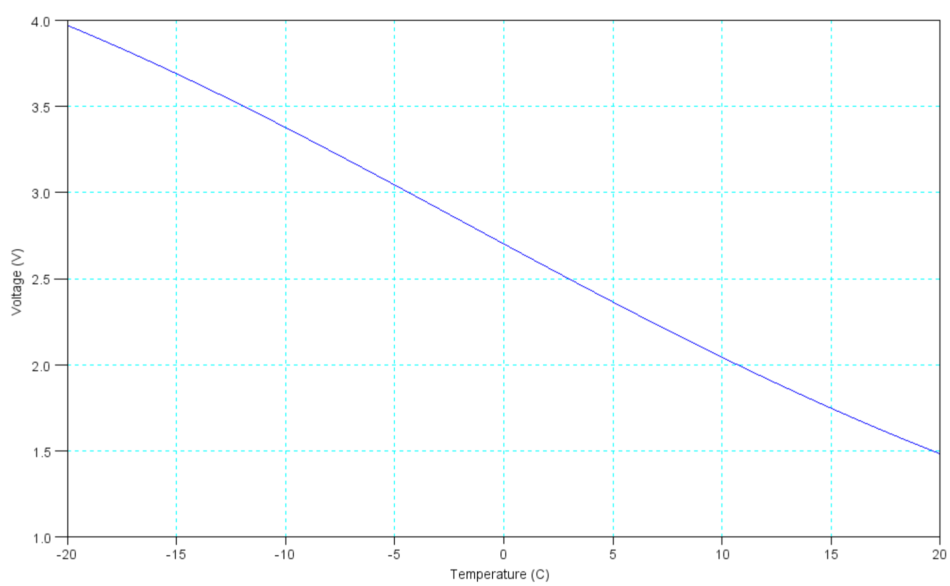


2) Convert this resistance to a voltage using a voltage divider and a +5V source. Plot the voltage vs temperature relationship. Assume a 3k resistor with a votlage divider. This results in

$$V = \left(\frac{R}{R+3000}\right) \cdot 5V$$

```
V = R ./ (3000 + R) * 5;
plot(T,V);
xlabel('Temperature (C)');
ylabel('Voltage (V)');
```





3) Over the range of -20C to +20C, determine a linear calibration curve fit as

$$T \approx aV + b$$

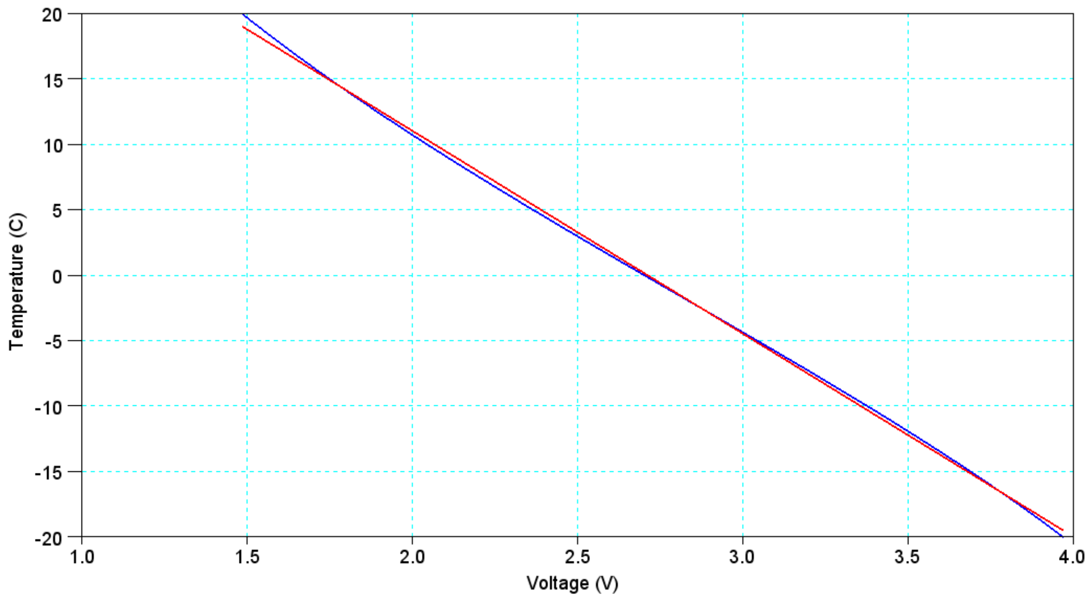
Select the basis to be

$$B = \begin{bmatrix} V & 1 \end{bmatrix}$$

```
B = [V, V.^0];
A = inv(B'*B)*B'*T
```

```
a  -15.492482
b   42.005136
```

```
plot(V,T,'b',V,B*A,'r');
xgrid(4)
ylabel('Temperature (C)');
xlabel('Voltage (V)');
```



Voltage vs. Temperatuer: Actual (blue) and Linear Curve Fit (red)

$$T \approx -15.492V + 42.005$$

4) Over the range of -20C to +20C, determine a cubic calibration curve fit as

$$T \approx aV^3 + bV^2 + cV + d$$

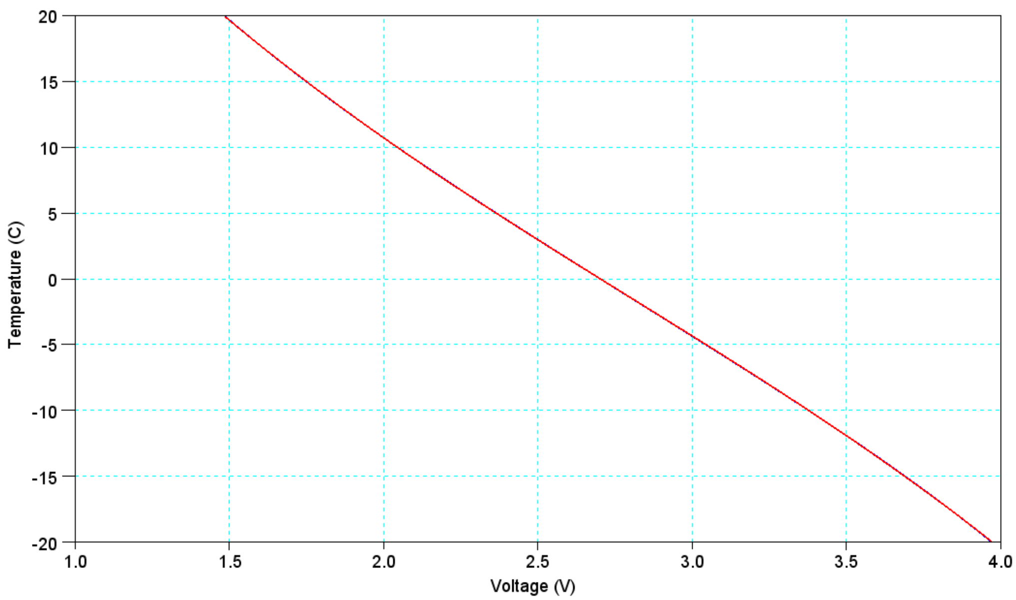
Choose a new basis

$$B = \begin{bmatrix} V^3 & V^2 & V & 1 \end{bmatrix}$$

```
B = [V.^3, V.^2, V, V.^0];
A = inv(B'*B)*B'*T
```

```
a  -0.9641867
b   8.1248794
c  -37.364148
d   60.649464
```

```
plot(V,T,'b',V,B*A,'r');
xlabel('Voltage (V)');
ylabel('Temperature (C)');
```



Voltage vs. Temperatuer: Actual (blue) and Linear Curve Fit (red)

$$T \approx -0.9642V^3 + 8.1249V^2 - 37.364V + 60.649$$

5) If the voltage across your voltage divider is 2.50V, what is the temperature?

Plug V into the above equation

```
V = 2.5;
T = [V^3, V^2, V, 1 ] *A
```

```
T =  2.9541749
```