


# ECE 111 - Solution #14

## Calibration

1) Find a temperature sensor from [www.Digikey.com](http://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		Price Break	Unit Price	Extended Price
	Digi-Key Part Number	445-174901-1-ND	1	0.10000	\$0.10
	Quantity Available	22,165 Can ship immediately	5	0.09800	\$0.49
	Manufacturer	<a href="#">TDK Corporation</a>	10	0.08800	\$0.88
	Manufacturer Part Number	NTCG104BH102HT1	25	0.08080	\$2.02
	Description	THERMISTOR NTC 1KOH	50	0.06460	\$3.23
	Manufacturer Standard Lead Time	12 Weeks	100	0.05540	\$5.54
Detailed Description		NTC Thermistor 1k 0402 (	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.

$R = 1000 \text{ Ohms at } 25\text{C}$

$B_{25/85} = 4100\text{K}$

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

This is used in various devices...

## Overview of the NTCG series

### APPLICATIONS

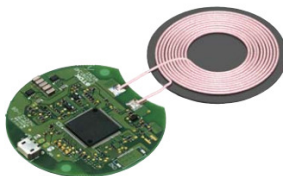
◆ Smart phones



◆ Battery



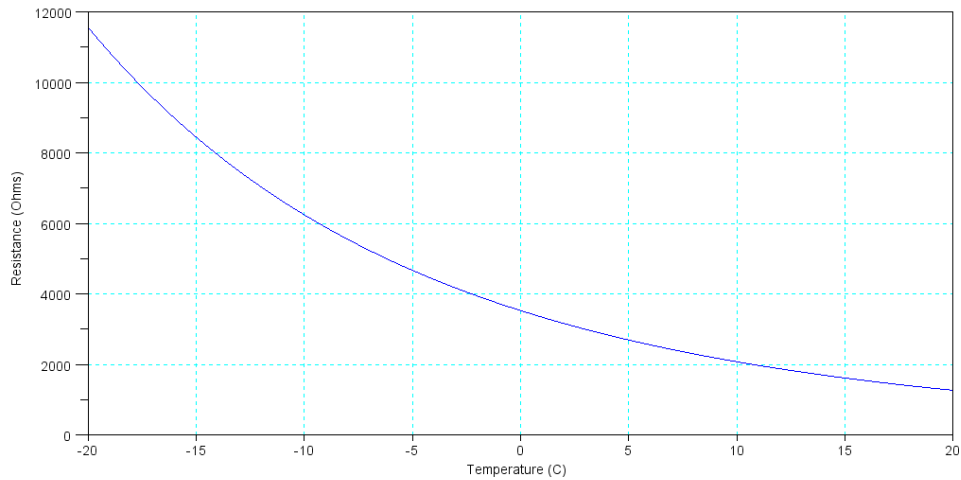
◆ Wireless charger



◆ LED



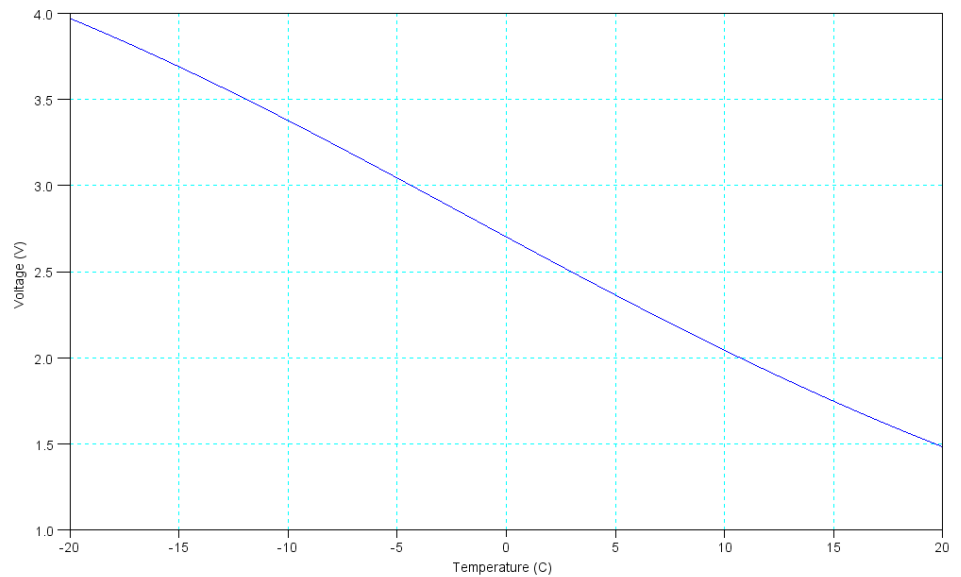
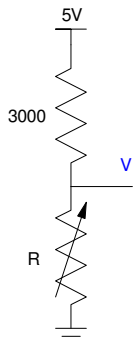
```
T = [-20:0.1:20]';
K = T + 273;
R = 1000 * exp( 4100 ./ K - 4100/298 );
plot(T,R)
xlabel('Temperature (C)');
ylabel('Resistance (Ohms)');
```



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 voltage 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

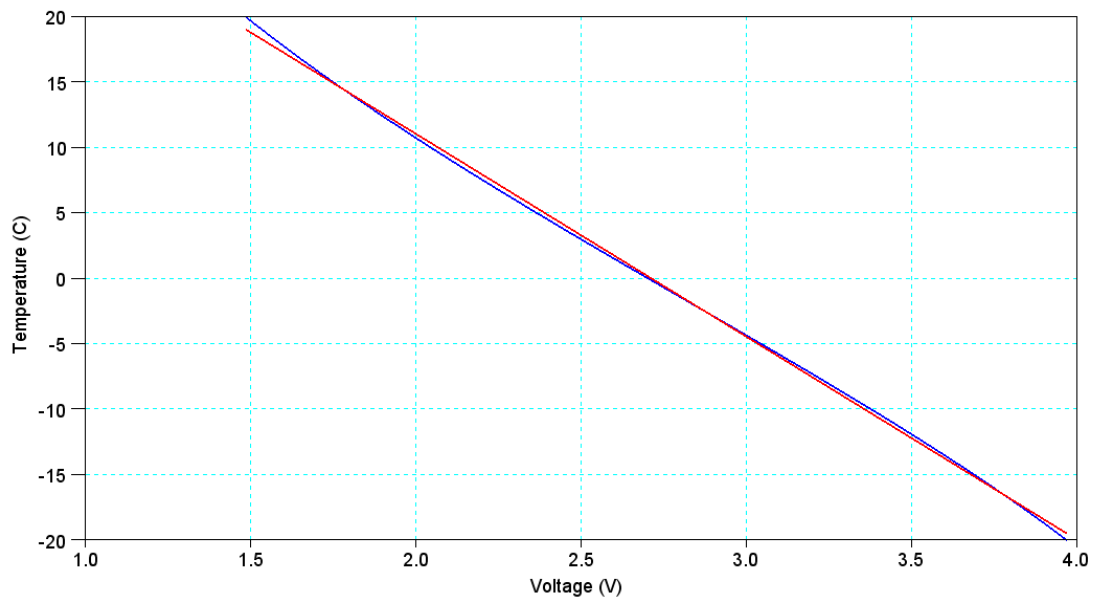
$$B = \begin{bmatrix} V & 1 \end{bmatrix}$$

```
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

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

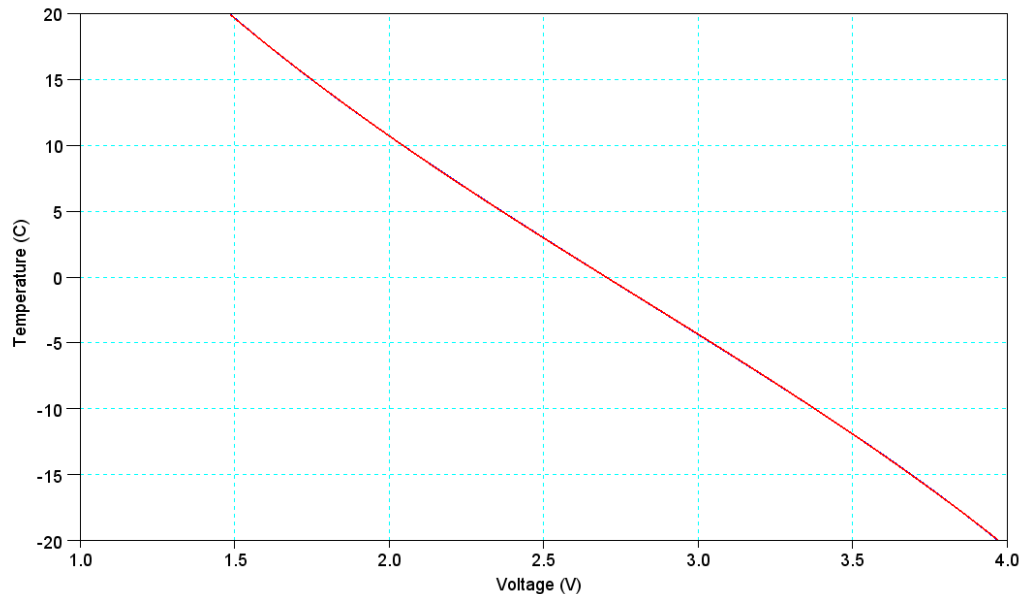
Choose a new basis

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

```
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. Temperaturer: 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
```