ECE 376 - Homework #7

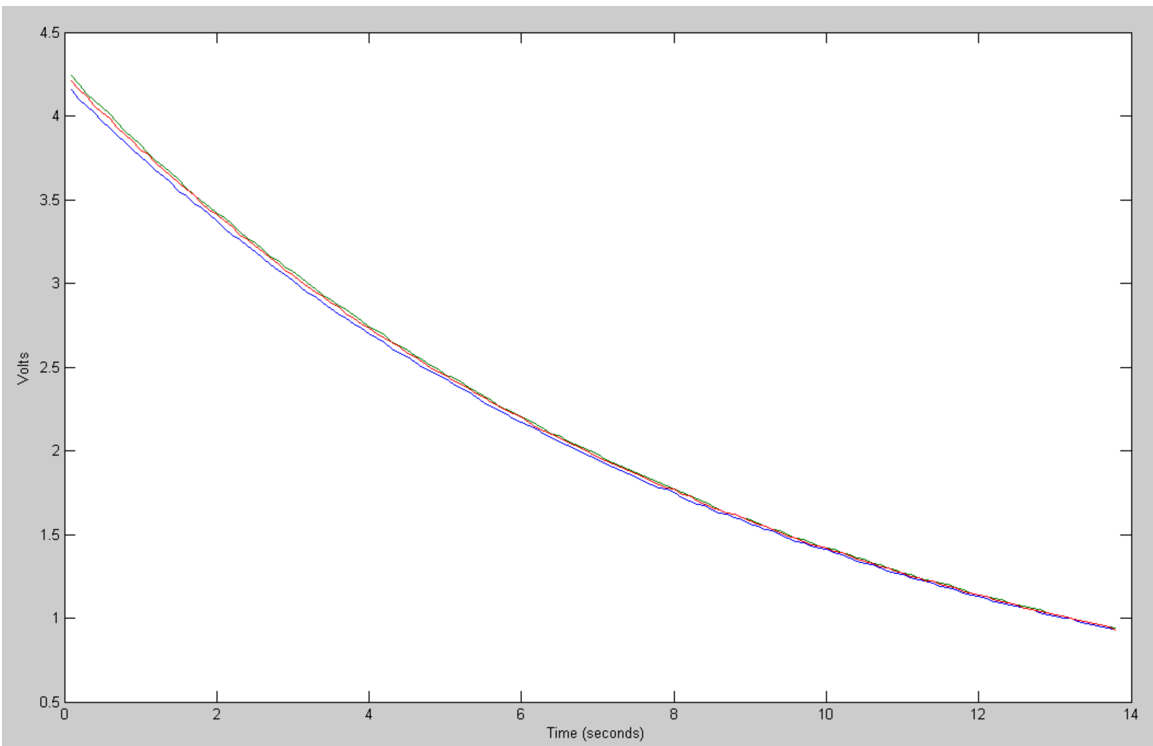
Data Collection & Student t-Test. Due Monday, March 6th
Please email to jacob.glower@yahoo.com, or submit as a hard copy, or submit on BlackBoard

Data Collection (population A)

1) Measure one of the following with at least two data sets and 20+ data points per run:

- The voltage across a capacitor as it discharges

Plot the resulting data vs. time.



C Code:

```
// Logger.C
//
// Data Logger
// This program reads the A/D on RA0
// and sends it to the serial port at 9600 baud

// Global Variables

const unsigned char MSG0[21] = "Logger.C            ";

 // Subroutine Declarations
#include <pic18.h>

// Subroutines
#include        "lcd_portd.c"


unsigned int A2D_Read(unsigned char c)
{
   unsigned int result;
   unsigned char i;
   c = c & 0x0F;
   ADCON0 = (c << 2) + 0x01;
   for (i=0; i<20; i++);
   GODONE = 1;
   while(GODONE);
   return(ADRES);
   }


// Main Routine

void main(void)
{
   int A2D;     // raw A/D readings
   int VOLT;    // Volts*100 (500 means 5.00V)

   unsigned int i, j;

   TRISA = 0;
   TRISB = 0x0F;
   TRISC = 0x0F;
   TRISD = 0;
   TRISE = 0;
   ADCON1 = 0x0F;

   LCD_Init();                  // initialize the LCD

   LCD_Move(0,0);  for (i=0; i<20; i++) LCD_Write(MSG0[i]);
   Wait_ms(500);

// Initialize the A/D port
   TRISA = 0xFF;
   TRISE = 0x0F;
   ADCON2 = 0x85;
   ADCON1 = 0x07;
   ADCON0 = 0x01;
   i = 0;

// Initialize Serial Port to 9600 baud
   TRISC = TRISC | 0xC0;
   TXIE = 0;
   RCIE = 0;
   BRGH = 0;
```

```
BRG16 = 1;
SYNC = 0;
SPBRG = 255;
TXSTA = 0x22;
RCSTA = 0x90;
A2D = 5;
while(1) {
   A2D = A2D_Read(1);
   VOLT = 0.488*A2D ;

    //  LCD_Move(0,10);  LCD_Out(VOLT, 5, 2);

   SCI_Out(VOLT, 5, 2);
   SCI_CRLF();

   Wait_ms(100);
   }
}
```

2) Determine the time constant from your data using least-squares

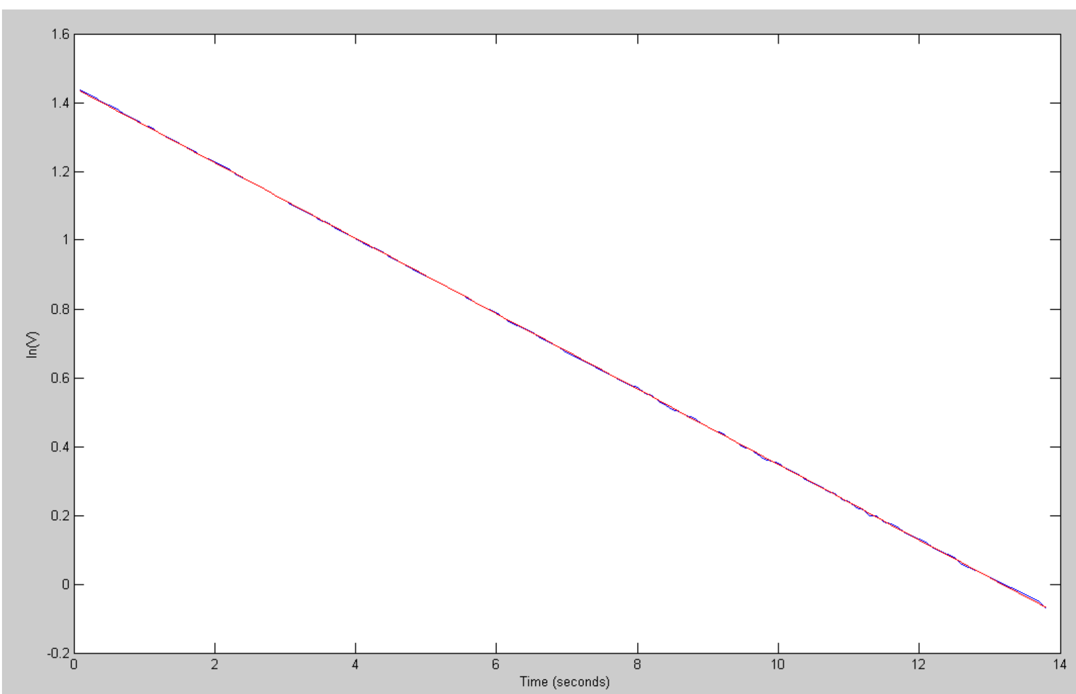
$$V = ae^{-bt} \qquad\qquad T = ae^{-bt} + T_{amb}$$

$$\ln(V) = \ln(a) - bt \qquad\qquad \ln(T - T_{amb}) = \ln(a) - bt$$

```
>> t = [1:138]' * 0.1;
>> B = [t, t.^0];
>> A = inv(B'*B)*B'*log(V1)

   -0.1093
    1.4316

>> a1 = A(1);
>> A = inv(B'*B)*B'*log(V2)

   -0.1098
    1.4500

>> a2 = A(1);
>> A = inv(B'*B)*B'*log(V3)

   -0.1097
    1.4444
```

Check: Plot the data vs. the curve fit

```
>> plot(t, log(V3), 'b', t, B*A, 'r')
>> xlabel('Time (seconds)');
>> ylabel('ln(V)')
```



Calculate C from the data

```
>> DATA = [a1,a2,a3]

   -0.1093   -0.1098   -0.1097

>> R = 1e5;
>> C = -1 ./ (R*DATA)
>> uF = C*1e6

   91.5320   91.0410   91.1859
```

3) Use a student t-test to determine the 90% confidnence interval for your time constant (b).

5% tails with 2 degrees of freedom has a t-score of 2.92.

- Go 2.92 standard deviations left and right of the mean to capture 90% of the data

```
>> x = mean(uF)

x =   91.2529

>> s = std(uF)

s =    0.2523

>> x - 2.92*s

ans =   90.5162

>> x + 2.92*s

ans =   91.9896
```

From the data, I'm 90% certain that my next reading will be in the range of

(90.5162uF, 91.9896uF)

Since I'm measuring the same capacitor, it's *true* value has a variance that drops with the sample size

```
>> s = std(uF) / sqrt(3)

s =    0.1457

>> x + 2.92*s

ans =   91.6783

>> x - 2.92*s

ans =   90.8276
```

From the data, I'm 90% certain that the measured value of the capacitor is in the range of

(90.8276uF, 91.6783uF)

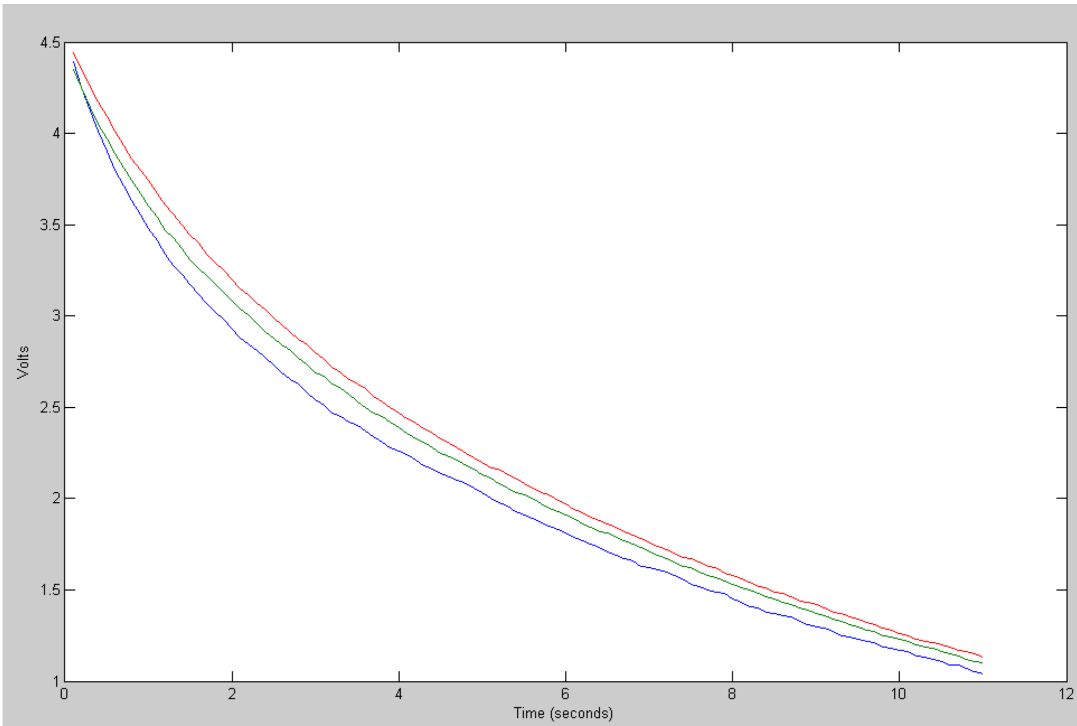
Data Collection (population B)

Change something in your experiment

- Reverse the polarity of the capacitor

4) Take a second set of data with the change.

- Plot the resulting data vs. time



5) Determine the time constant from your data using least-squares

```
>> B = [t, t.^0];
>> A = inv(B'*B)*B'*log(Y1)
>> b1 = A(1);

>> A = inv(B'*B)*B'*log(Y2)
>> b2 = A(1);

>> A = inv(B'*B)*B'*log(Y3)
>> b3 = A(1);

>> DATAb = [b1,b2,b3]

DATAb =   -0.1205   -0.1188   -0.1194

>> uFb = -1./(R*DATAb) * 1e6
```

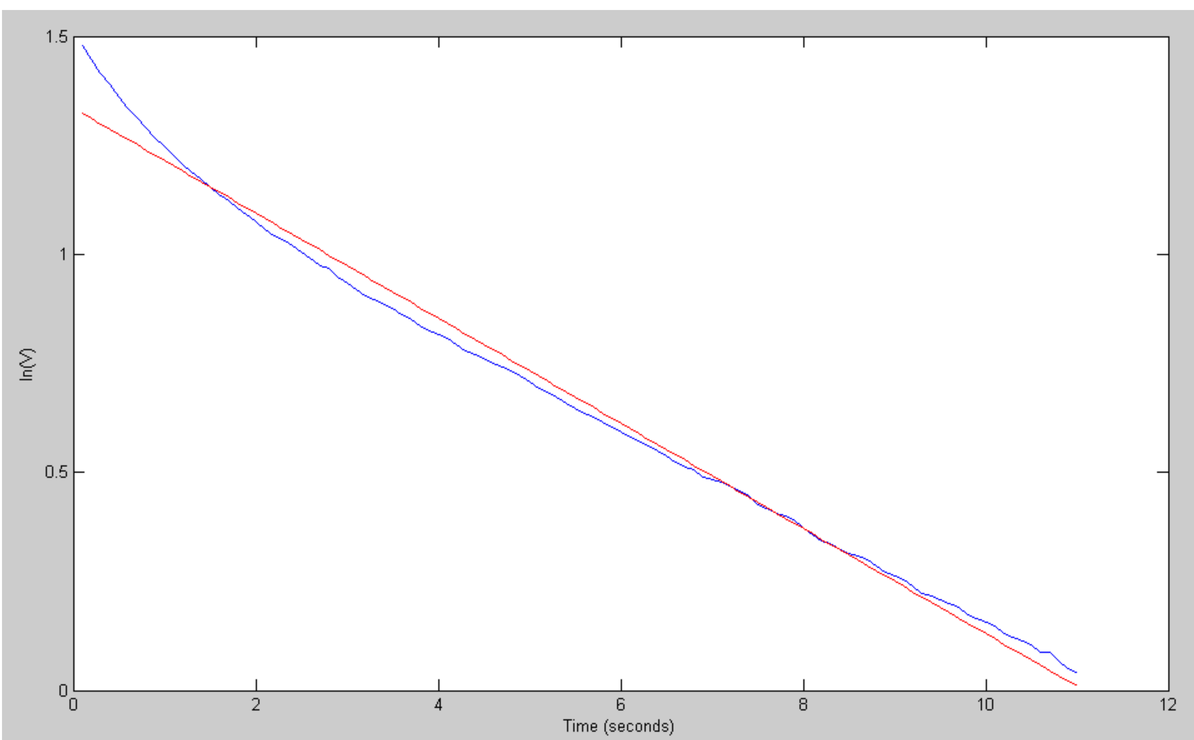
uFb =   82.9803   84.1870   83.7530

Just for fun, plot the data for the curve fit:

```
>> t = [1:110]' * 0.1;
>> plot(t,log(Y1),'b',t,B*A1,'r')
>> xlabel('Time (seconds)');
>> ylabel('ln(V)')
```

This isn't as good of a fit - which means

- The slope changes with voltage
- The capacitacce changes with voltage



6) Use a student t test to determine the 90% confidnence interval for your time constant (b).

With a sample size of three (two degrees of freedom), the t-score with 5% tails is 2.92

```
>> Xb + 2.92*Sb

ans =   85.4248

>> Xb - 2.92*Sb

ans =   81.8554
```

I'm 90% certain that the next reading with reverse polarity will be in the range of

(81.8554uF, 85,4248uF)

So, the data for the two populations are:

- A (correct polarity) and
- B (incorrect polarity)

```
>> Xb = mean(uFb)

Xb =   83.6401

>> Sb = std(uFb)

Sb =    0.6112

>> Xa = mean(uF)

Xa =   91.2529

>> Sa = std(uF)

Sa =    0.2523
```

Comparison of Means Test (A vs. B)

7) Do a comparison of means test to determine the probability that

- The next measurement from A will have a higher value than the next meaurement from B
- Population A has a higher mean than population B

Case 1: If you care about individuals (next reading of A and B)

Create a new variable, W = A - B:

```
>> Xw = Xa - Xb

Xw =    7.6128

>> Sw = sqrt(Sa^2 + Sb^2)

Sw =    0.6612

>> tw = Xw / Sw

tw =   11.5133
```

Convert this to a probability using a t-table (individual: next sample)

With 2 d.o.f, this corresponds to a tail with an area of about 0.004

I'm 99.6% certain that the next reading with correct polarity will be more than with the incorrect polarity

Student t-Table (area of tail) (http://www.sjsu.edu/faculty/gerstman/StatPrimer/t-table.pdf)										
p	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
1	1	1.38	1.96	3.08	6.31	12.71	31.82	63.66	318.31	636.62
2	0.82	1.06	1.39	1.89	2.92	4.3	6.97	9.93	22.33	31.6
3	0.77	0.98	1.25	1.64	2.35	3.18	4.54	5.84	10.22	12.92
4	0.74	0.94	1.19	1.53	2.13	2.78	3.75	4.6	7.17	8.61
5	0.73	0.92	1.16	1.48	2.02	2.57	3.37	4.03	5.89	6.87
10	0.7	0.88	1.09	1.37	1.81	2.23	2.76	3.17	4.14	4.59
15	0.69	0.87	1.07	1.34	1.75	2.13	2.6	2.95	3.73	4.07
20	0.69	0.86	1.06	1.33	1.73	2.09	2.53	2.85	3.55	3.85
60	0.68	0.848	1.05	1.3	1.67	2	2.390	2.660	3.232	3.46
infinity	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.29

Case 2: You care about the populations

```
>> Xw = Xa - Xb

Xw =    7.6128

>> Sw = sqrt( (Sa^2)/3 + (Sb^2)/3 )

Sw =    0.3818

>> tw = Xw / Sw

tw =   19.9417
```

With 2 d.o.f., this corresponds to a tail with an area of about 0.0015

I'm 99.85% certain that the correct polarity has a higher capacitance than the incorrect polarity

Student t-Table (area of tail) (http://www.sjsu.edu/faculty/gerstman/StatPrimer/t-table.pdf)										
p	0.25	0.20	0.15	0.10	0.05	0.025	0.01	0.005	0.001	0.0005
1	1	1.38	1.96	3.08	6.31	12.71	31.82	63.66	318.31	636.62
2	0.82	1.06	1.39	1.89	2.92	4.3	6.97	9.93	22.33	31.6
3	0.77	0.98	1.25	1.64	2.35	3.18	4.54	5.84	10.22	12.92
4	0.74	0.94	1.19	1.53	2.13	2.78	3.75	4.6	7.17	8.61
5	0.73	0.92	1.16	1.48	2.02	2.57	3.37	4.03	5.89	6.87
10	0.7	0.88	1.09	1.37	1.81	2.23	2.76	3.17	4.14	4.59
15	0.69	0.87	1.07	1.34	1.75	2.13	2.6	2.95	3.73	4.07
20	0.69	0.86	1.06	1.33	1.73	2.09	2.53	2.85	3.55	3.85
60	0.68	0.848	1.05	1.3	1.67	2	2.390	2.660	3.232	3.46
infinity	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.090	3.29