ECE 376 - Homework #7

Data Collection & Student t-Test.   Due Monday, October 16th
Please email to jacob.glower@ndsu.edu, or submit as a hard copy, or submit on BlackBoard

Data Collection (population A)

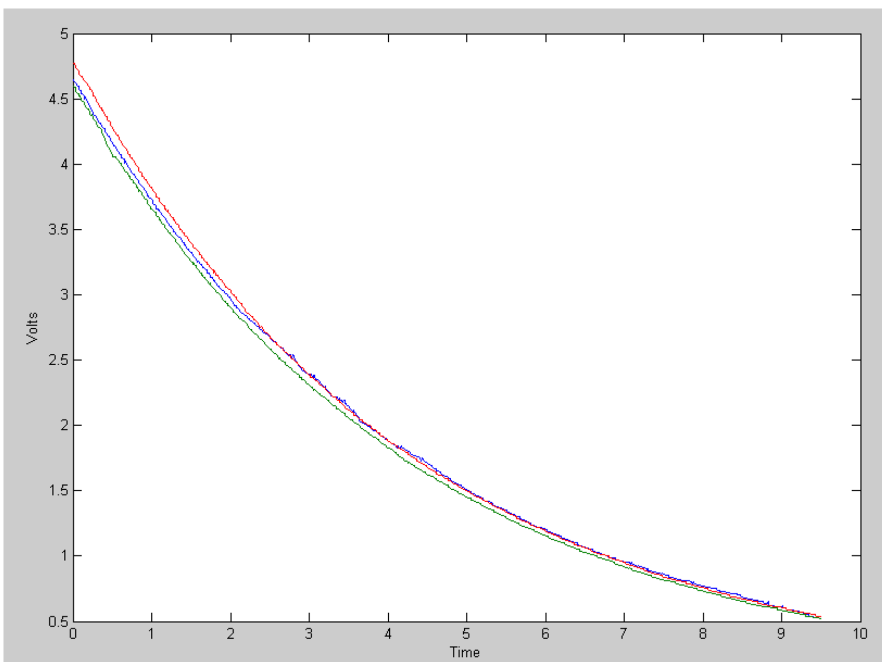
1) Measure one of the following with at least two data sets and 20+ data points per run:

- The voltage across a capacitor as it discharges
- The temperature of a cup (or can) of hot water as it cools off
- The temperature of a can of cold water as it warms up
- Other

Plot the resulting data vs. time.

The voltage of a 100uF capacitor discharging across a 100k resistor:

```
>> V1 = V1(50:1000);
>> V2 = V2(50:1000);
>> V3 = V3(50:1000);
>> t = [1:length(V1)]' * 0.01;
>> plot(t,V1,t,V2,t,V3)
>> xlabel('Time')
>> ylabel('Volts');
```



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

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

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

```
>> B = [t, t.^0];
>> A1 = inv(B'*B)*B'*log(V1)

   -0.2267
    1.5447

>> A2 = inv(B'*B)*B'*log(V2)

   -0.2297
    1.5253

>> A3 = inv(B'*B)*B'*log(V3)

   -0.2310
    1.5652

>> Data = [A1(1),A2(1),A3(1)]

Data =   -0.2267   -0.2297   -0.2310

>> uFa = -[10/A1(1), 10/A2(1), 10/A3(1)]

uFa =   44.1198   43.5405   43.2923
```

uF is the corresponding value of C assuming

- R = 100k
- t = 10ms sampling rate

note: Probably t is wrong, which is why my 100uF capacitor is measuring at 43uF

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

```
>> Xa = mean(uFa)

Xa =   43.6509

>> Sa = std(uFa)

Sa =    0.4246
```

From a t-Table with 2 degrees of freedom, 5% tails corresponds to a t-score of 2.92

The 90% confidence interval is thus

$$\bar{x} - 2.92s < b < \bar{x} + 2.92s$$

```
>> Xa + 2.92*Sa

ans =   44.8908

>> Xa - 2.92*Sa

ans =   42.4110
```

I'm 90% certain that C is in the range of (42.4110uF ... 44.8908uF)

Data Collection (population B)

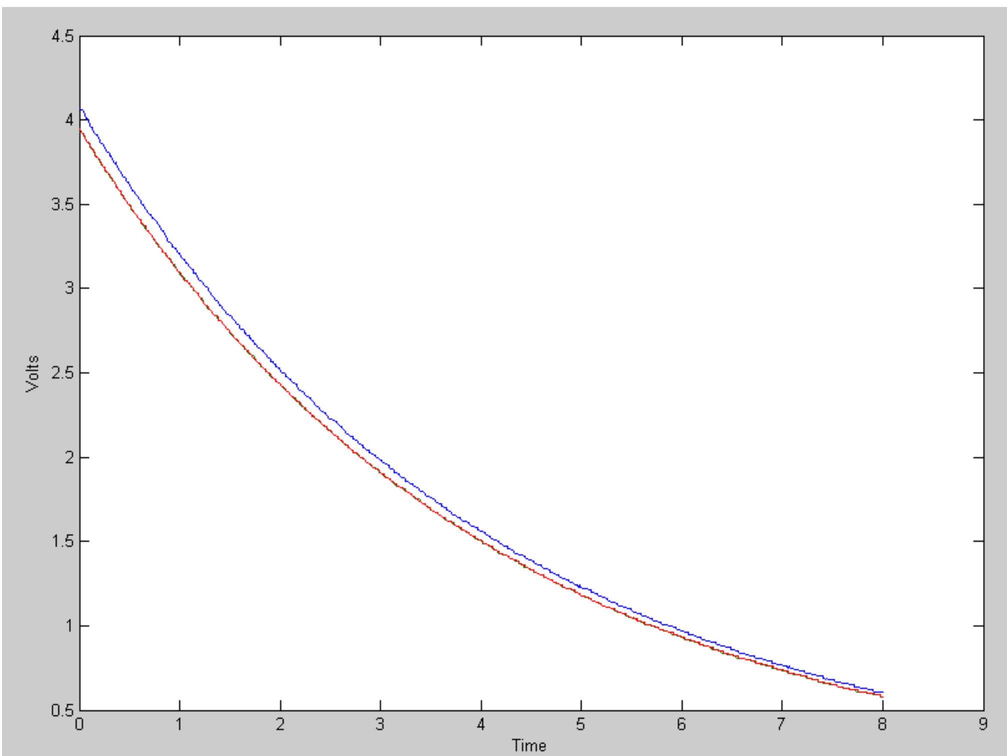
Change something in your experiment

- **Use a different 100uF capacitor**

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

Plot the resulting data vs. time

```
>> V1 = Data1(100:900);
>> V2 = Data2(100:900);
>> V3 = Data3(100:900);
>> t = [1:length(V1)]' * 0.01;
>> plot(t,V1,t,V2,t,V3)
>> xlabel('Time')
>> ylabel('Volts');
```



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

```
>> B = [t, t.^0];
>> A1 = inv(B'*B)*B'*log(V1)

   -0.2388
    1.4019

>> A2 = inv(B'*B)*B'*log(V2)

   -0.2398
    1.3679

>> A3 = inv(B'*B)*B'*log(V3)

   -0.2394
    1.3678

>> Data2 = [C1(1), C2(1), C3(1)]
```

Data2 =   -0.2388   -0.2398   -0.2394

```
>> uF2 = -[10/C1(1), 10/C2(1), 10/C3(1)]
```

uF2 =   41.8749   41.7049   41.7789

This is the measured capacitange of the second 100uF capacitor

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

Again, with a sample size of three (meaning two degrees of freedom), 5% tails corresponds to a t-score of 2.92

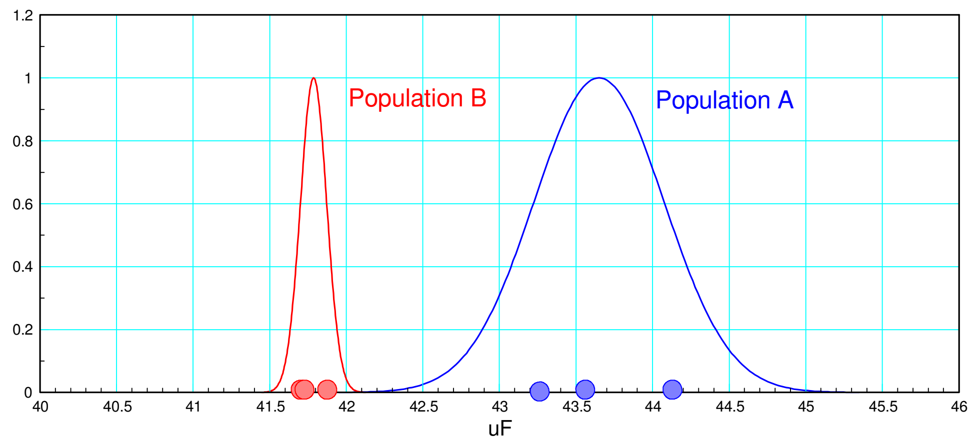
```
>> Xb = mean(uF2)

Xb =   41.7862

>> Sb = std(uF2)

Sb =    0.0852

>> Xb + 2.92*Sb

ans =   42.0351

>> Xb - 2.92*Sb

ans =  41.5374
```

I'm 90% certain that the second 100uF capacitor is the range of (41.5374uF ... 42.0531uF)

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



Individual: Create a new variable W = A - B

```
>> Xw = Xa - Xb
Xw =    1.8646

>> Sw = sqrt(Sa^2 + Sb^2)
Sw =    0.4331

>> t = Xw / Sw
t =    4.3055
```

From StatTrek, a t-score of 4.3055 with 2 dof corresponds to a probability of 0.975

I'm 97.5% certain the the next reading of capacitor A will be higher than the next reading of capacitor B

Population: (take sample size in to account): Create a new variable, W = A - B

```
>> Xw = Xa - Xb
Xw =    1.8646

>> Sw = sqrt(Sa^2 /3 + Sb^2 /3)
Sw =    0.2500

>> t = Xw / Sw
t =    7.4574
```

From StatTrekm this corresponds to a probability of 0.991

I'm 99.1% certain that capacitor A is larger than capacitor B