ECE 376 - Homework #7

Student t-Test, D/A Converters.   Due Monday, October 17th

t-Test & Reflex Times

1) Write a rogram to measure your reflex times

- The game starts by pressing RB0
- Once pressed, the PIC will wait between 3.00 and 7.00 seconds (random)
- It then turns on the lights on PORTA
- It then waits for you to press RB0 again

Your reflex time is the time delay between the lights on PORTA turning on and your pressing RB0.

Measure this time to 1ms.

Code (next page)

Compilation Result:

```
Memory Summary:
    Program space        used   C40h (  3136) of 10000h bytes   (  4.8%)
    Data space           used    29h (    41) of   F80h bytes   (  1.0%)
    EEPROM space         used     0h (     0) of   400h bytes   (  0.0%)
    ID Location space    used     0h (     0) of     8h nibbles (  0.0%)
    Configuration bits   used     0h (     0) of     7h words   (  0.0%
```

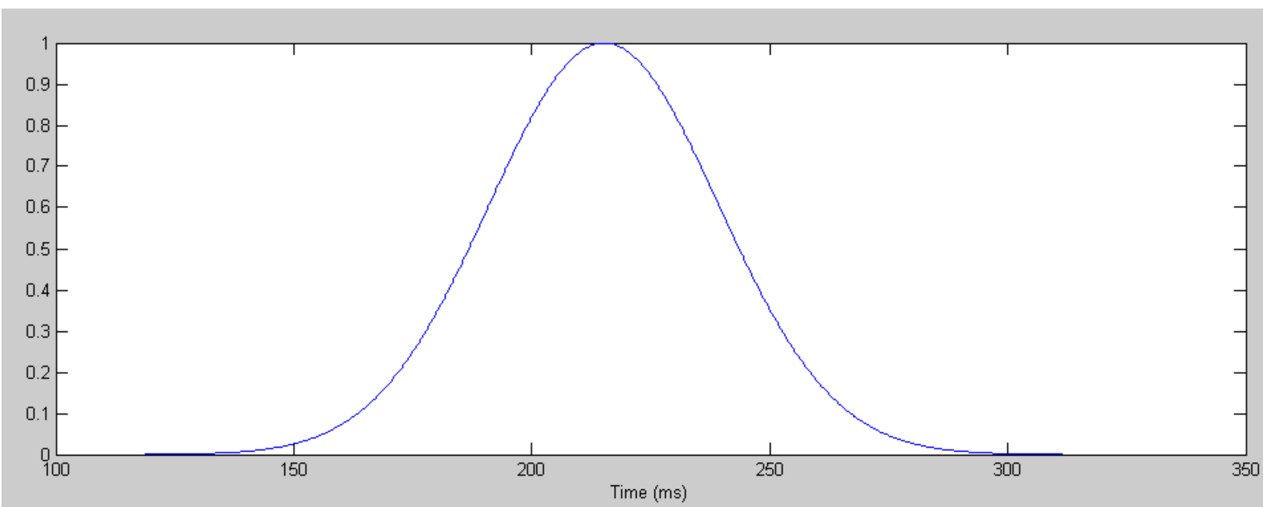
Code:

```
// Global Variables
const unsigned char MSG0[21] = "Reflex.C            ";

 // Subroutine Declarations
#include <pic18.h>

// Subroutines
#include        "lcd_portd.c"

// Main Routine

void main(void)
{
   unsigned int DELAY;
   unsigned int TIME;
   unsigned int i, j;

   TRISA = 0;
   TRISB = 0xFF;
   TRISC = 0;
   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]);

// 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;

   while(1) {
         :
         :
         C Code
         :
         :
      }
   }
```

2) Collect some data using your program to record your reflex times.

Reflex Times

```
 00.241
 00.230
 00.199
 00.182
 00.224

 DATA = [ 00.241
 00.230
 00.199
 00.182
 00.224];

>> x = mean(DATA)

x =    0.2152

>> s = std(DATA)

s =    0.0241

>> s1 = [-4:0.01:4]';
>> p = exp(-s1.^2 / 2);
>> plot((s1*s+x)*1000, p)
>> xlabel('Time (ms)')

>> xlabel('Time (ms)')
>> plot((s1*s+x)*1000, p, 163.8*[1,1],[0,0.5],'r--',266.6*[1,1],[0,0.5],'r--')
```



Normalized pdf for my reaction time

3) Use a t-test, determine

The 90% confidence interval for your reflex time

With 5 data points (4 degrees of freedom), the t-score for 5% tails is 2.13281

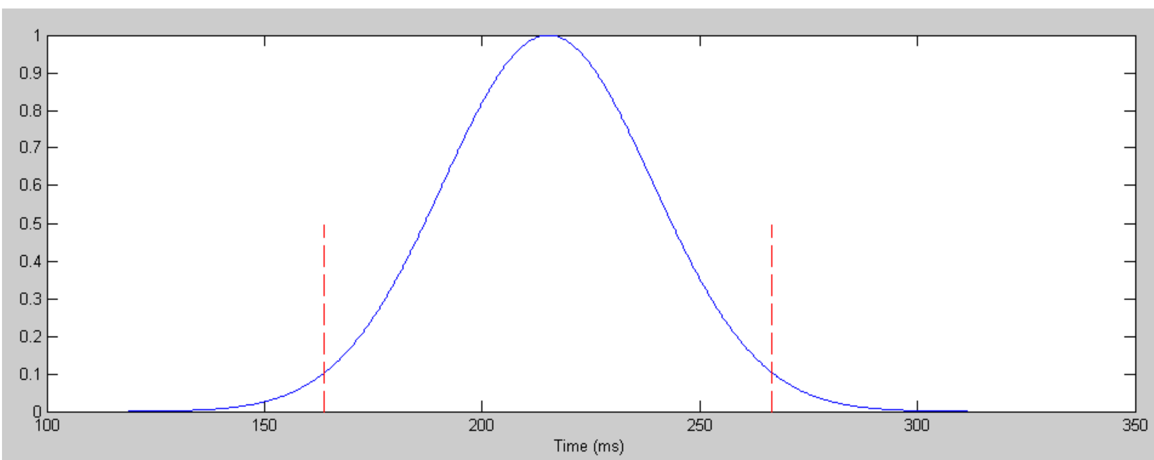
The 90% conficende interval is then

$$\bar{x} - 2.13281s < time < \bar{x} + 2.13281s$$

```
>> x - 2.13281*s

ans =     0.1638

>> x + 2.13281*s

ans =     0.2666
```

My 90% confidence interval is thus

$$\boxed{0.1638 < time < 0.2666} \quad \text{seconds}$$



90% confidence interval for my reaction time

The probability that you will resond in less than 200ms in your next trial

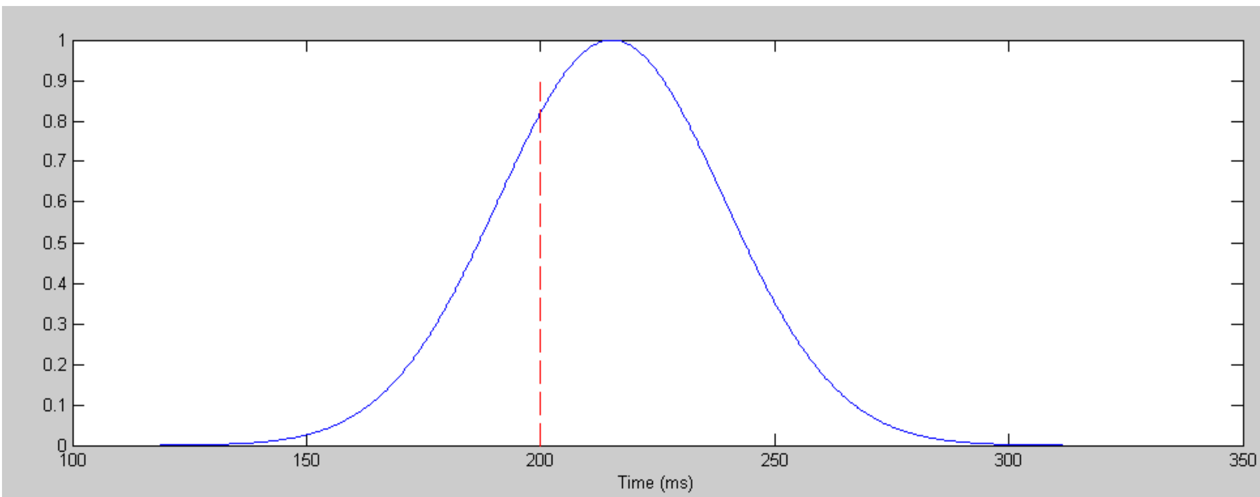
The t-score for 200ms is

$$t = \left(\frac{200ms - \bar{x}}{s} \right) = -0.6302$$

From StatTrek, this corresponds to a probability of 0.28139

There is a 28.139% chance that my next trial will have a reflex time less than 200ms

```
>> plot((s1*s+x)*1000, p, 200*[1,1],[0,0.9],'r--')
>> xlabel('Time (ms)')
```



28% chance of scoring less than 200ms

The probability that your average reflex time is less than 200ms

This is a population question, meaning you

divide the variance by the sample size, or

divide the standard deviation by the square root of the sample size

$$\bar{x} \to \bar{x} = 0.2512$$

$$s \to \frac{s}{\sqrt{n}}$$

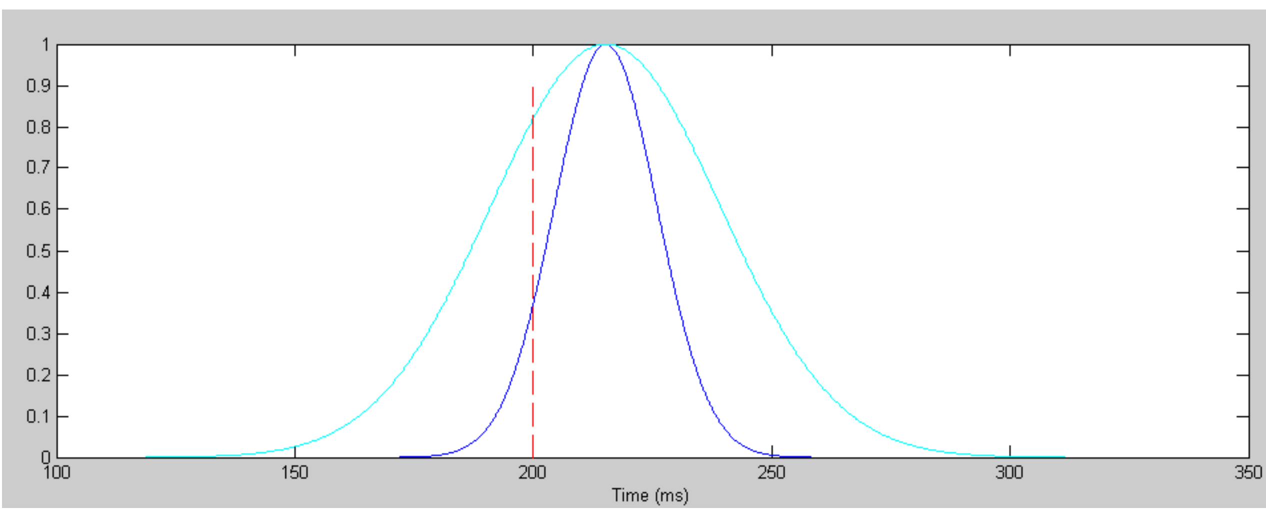
$$t = \left(\frac{200ms - \bar{x}}{s/\sqrt{5}}\right) = \left(\frac{200ms - \bar{x}}{s}\right) \cdot \sqrt{5} = -1.4092$$

From StatTrek

p = 0.11578

There is an 11.578% chance that my average reaction time is less than 200ms

```
>> plot((s1*(s/sqrt(5))+x)*1000, p, 200*[1,1],[0,0.9],'r--')
>> xlabel('Time (ms)')
>> xlim([100,350])
```



normalized pdf for my reflex time (cyan)
and average reflex time (dark blue)

4) Measure the reflex time of someone else. Using a t-test, determine

- The probability that your reflex time will be less than the other person's time the next time you run this experiment
- The probability that your average reflex time is less than the other person's average reflex time.

Experiment: Are my reflex times to sound less than my reflex times to sight?

- Tie a speaker to RA1
- Press RB0 when I head the speaker pop (light turns on)

Data:

```
00.175
00.177
00.141
00.136
00.166
00.136
```

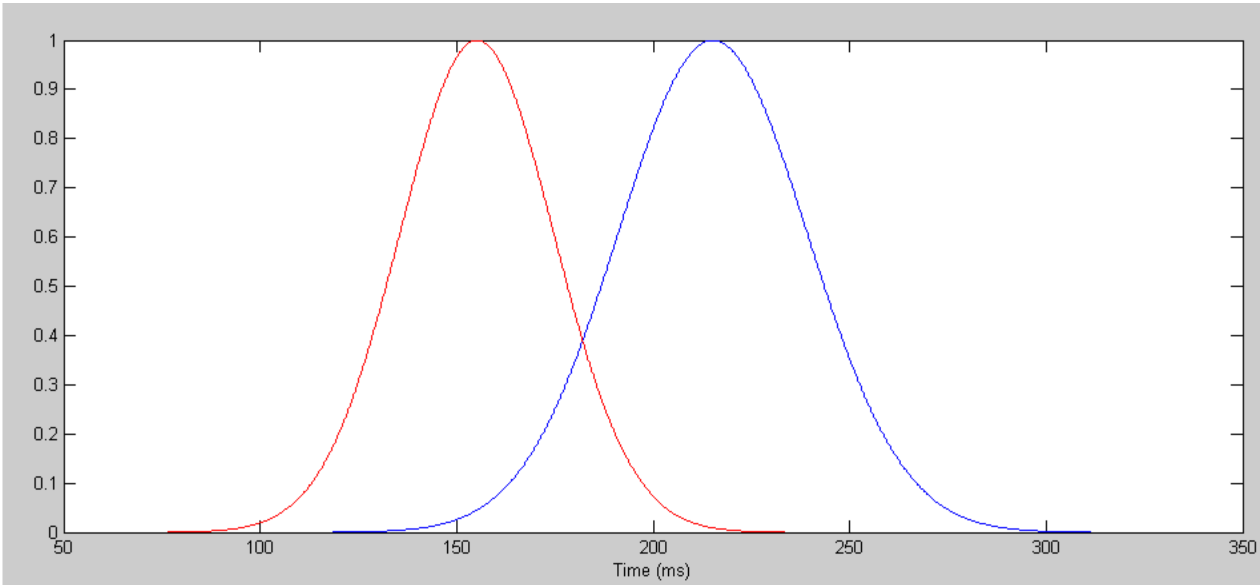
a) The probability that your reflex time will be less than the other person's time the next time you run this experiment

```
>> A = [ 0.241, 0.230, 0.199, 0.182, 0.224];
>> B = [ 0.175, 0.177, 0.141, 0.136, 0.166, 0.136];

>> Xw = mean(A) - mean(B)

Xw =    0.0600

>> Sw = sqrt(std(A)^2 + std(B)^2)

Sw =    0.0311

>> Sw = sqrt(var(A) + var(B))

Sw =    0.0311

>> t = Xw / Sw

t =    1.9313
```

From StatTrek, a t-score with 4 degrees of freedom (smaller of A and B) gives a probability of 0.06281

In my next experiment, sight has a 6.28% chance of beating sound

```
>> plot(s1*std(A)+mean(A),p,'b',s1*std(B)+mean(B),p,'r');
>> xlabel('Time (ms)')
```



Normalized pdf's for my reflex time to sound (red) and light (blue)

b) The probability that your average reflex time is less than the other person's average reflex time.

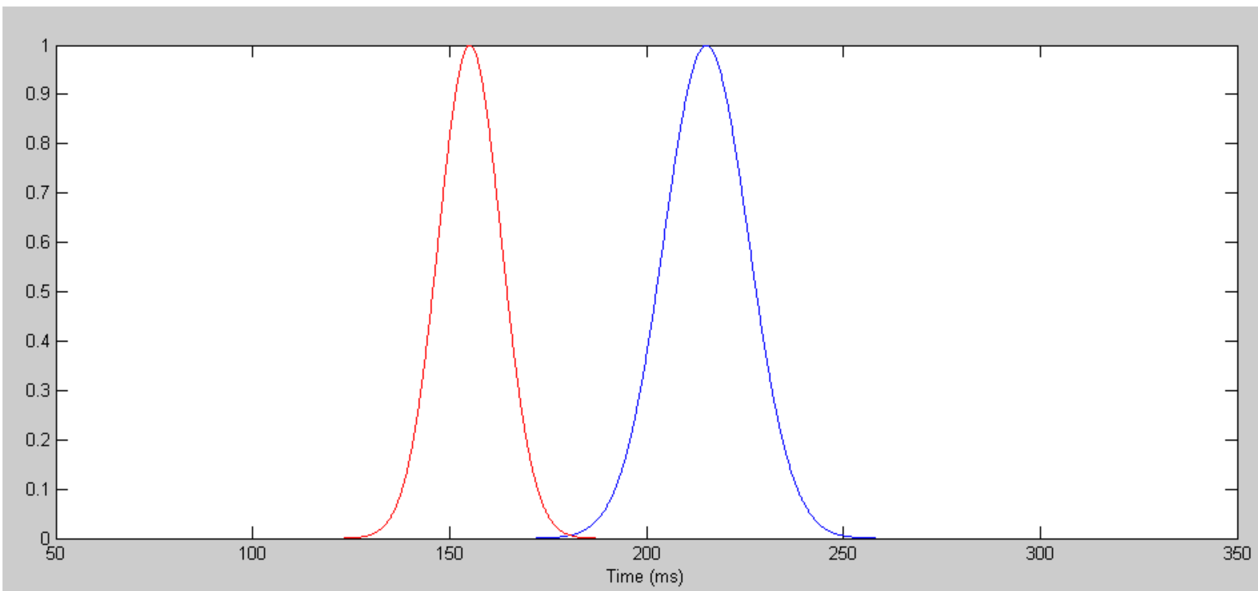
This is a population question (population mean), so the variance decreases with the sample size

```
>> Sw = sqrt(var(A)/length(A) + var(B)/length(B))

Sw =    0.0134

>> t = Xw / Sw

t =    4.4692
```

From StatTrek, a t-score of 4.4692 with 4 degrees of freedom corresponds to a probability of 0.00554

There is a 0.554% chance that my reflex time to sight is better than my reflex time to sound

```
>> plot(s1*(std(A)/sqrt(Na))+mean(A),p,'b',s1*(std(B)/sqrt(Nb))+mean(B),p,'r');
>> xlim([50,350])
>> xlabel('Time (ms)')
```



Normalized pdf for my average reaction time to sound (red) and light (blue)

D/A Converters

Turn your PIC into a device which

- Takes an input voltage (X = 0..5V), and
- Outputs the square root of the voltage (Y = X) on the D/A converter

5) Give your C code and flow chart

```
Memory Summary:
    Program space        used  19EAh (  6634) of 10000h bytes   ( 10.1%)
    Data space           used    42h (    66) of   F80h bytes   (  1.7%)
    EEPROM space         used     0h (     0) of   400h bytes   (  0.0%)
    ID Location space    used     0h (     0) of     8h nibbles (  0.0%)
    Configuration bits   used     0h (     0) of     7h words   (  0.0%)

void main(void)
{
   unsigned int i, j;
   unsigned int A2D, D2A;
   float X, Y;

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

// Turn on the LCD
   LCD_Init();                  // initialize the LCD

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

   LCD_Move(0,0);  for (i=0; i<20; i++) LCD_Write(MSG0[i]);
   LCD_Move(1,0);  for (i=0; i<20; i++) LCD_Write(MSG1[i]);

// Square Root

   while(1) {
         :
         :
         C Code
         :
         :


      }
   }
```

6) Collect data for X and Y

X	Y	Y (theory)	Error
0.333	0.566	0.577	0.011
0.777	0.868	0.882	0.013
1.193	1.079	1.092	0.013
1.674	1.282	1.294	0.012
2.18	1.451	1.477	0.025
3.67	1.899	1.916	0.017
4.76	2.16	2.182	0.022

7) From your data, compute the 90% confidence interval for the error in the output voltage (Y)

```
>> Error = [0.011, 0.013, 0.013, 0.012, 0.025, 0.017, 0.022];
>> x = mean(Error)
x =    0.0161

>> s = std(Error)
s =    0.0054
```

From StatTrek, 5% tails with 6 degrees of freedom corresponds to a t-score 1.94336

```
>> x - 1.94336*s
ans =    0.0056

>> x + 1.94336*s
ans =    0.0267
```

The 90% confidnce interval for the output voltage is

(+5.6mV, +26.7mV)

(it consistently reads high by 5.6mV to 26mV 90% of the time)