ECE 376 - Homework #6

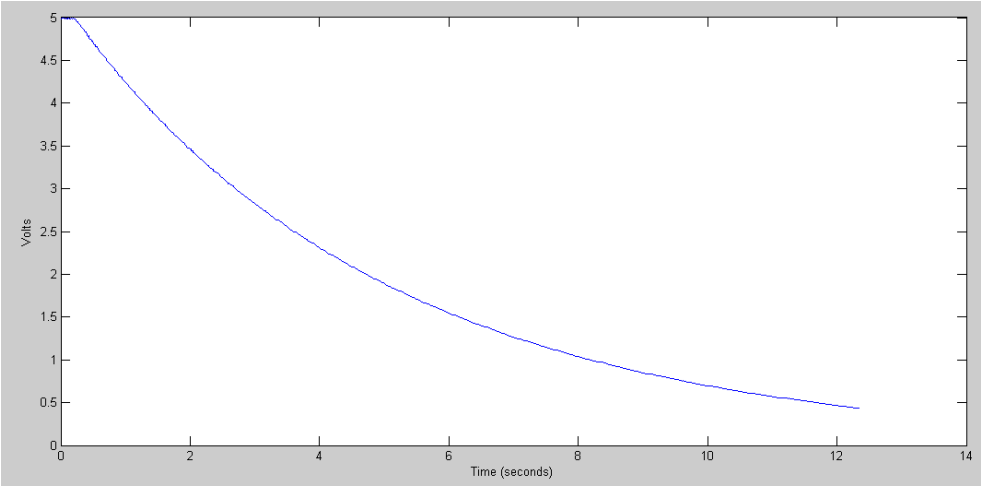
Data Collection & Chi-squared Test.

Data Collection

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.



2) Come up with an exponential curve fit for your data in the form of

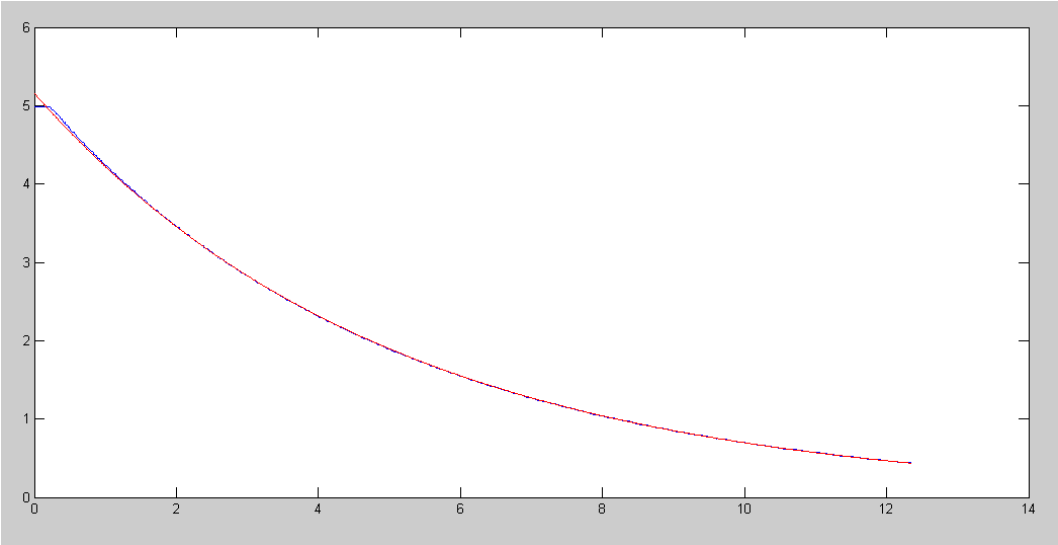
$$V = a \cdot \exp(bt)$$

or

$$\ln(V) = bt + \ln(a)$$

in Matlab

```
>> t = [1:length(V)]' * 0.01;
>> plot(t,V)
>> xlabel('Time (seconds)');
>> ylabel('Volts');
>> B = [t, t.^0];
>> Y = log(V);
>> A = inv(B'*B)*B'*Y

A =

   -0.2001
    1.6404

>> b = A(1);
>> a = exp(A(2))

a =

    5.1573

>> plot(t,V,'b',t,a*exp(b*t),'r')
>>
```



3) Use a chi-squared test to determine if your data has an exponential distribution

- Split the data into N bins (N different times)
- Count the number of data points in each bin
- Compare to the expected frequency using a chi-squared test)

In Matlab

```
>> sum( (V>4) )
ans =   105

>> sum( (V>3).*(V<4) )
ans =   140

>> sum( (V>2).*(V<3) )
ans =   200

>> sum( (V>1).*(V<2) )
ans =   343
```

The voltage should decay as

$$V = 5 \cdot \exp(-0.2001t)$$

The time it takes to decay to

- 4V: 1.115 seconds
- 3V: 2.554 seconds
- 2V: 4.5815 seconds
- 1V: 8.0427 seconds

The time spent in each region divided buy the total time (8.0427 seconds) gives the probablility that a given data point is in that region

Voltages	Time in Region	p	np	N	chi-squared
4V - 5V	1.115 sec	0.1386	109.2168	105	0.1628
3V - 4V	1.439 sec	0.1789	140.9732	140	0.0067
2V - 3V	2.027 sec	0.2520	198.5760	200	0.0102
1V - 2V	3.461 sec	0.4303	339.0764	343	0.0454
				Total:	0.2251

From StatTrek, a chi-squared score of 0.2251 with 3 degrees of freedom corresponds to a probability of 0.027

There is a 2.7% chance that this is not an exponential distribution

Fair & Loaded Dice

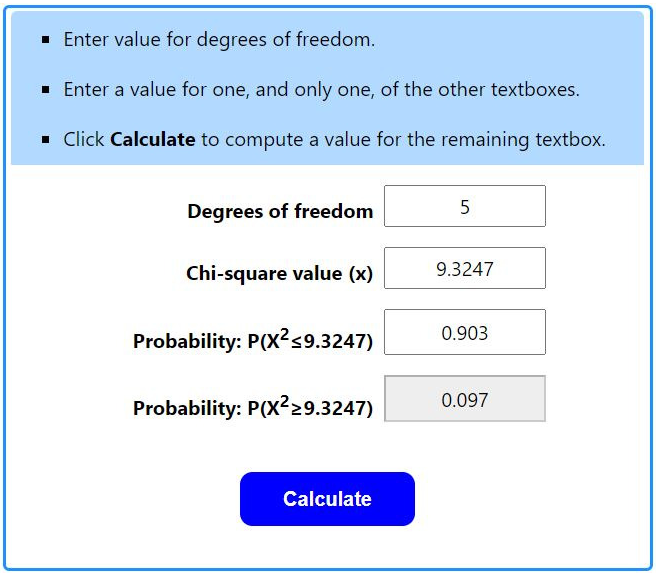
4) Determine experimentaly using a chi-squared test whether or not the following C code produces a fair 6-sided die:

```
while(1) {
   while(!RB0);
   while(RB0) DIE = (DIE + 1) % 6;
   DIE += 1;
   LCD_Move(1,0);  LCD_Out(DIE, 1, 0);
   SCI_Out(DIE, 1, 0);
   SCI_CRLF();
   }
```

bin	p	np	N	chi-squared
1	1/6	25.67	17	2.9264
2	1/6	25.67	33	2.0952
3	1/6	25.67	34	2.7056
4	1/6	25.67	27	0.0693
5	1/6	25.67	23	0.2771
6	1/6	25.67	20	1.2511
			Total:	9.3247

From StatTrek, with 5 degrees of freedom, this corresponds to a probability of 0.903

There is a 90.3% chance that this is not a fair die



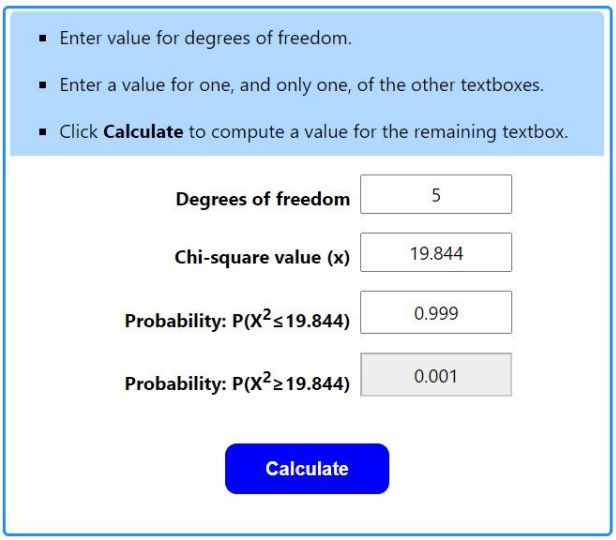
5) Determine experimentaly using a chi-squared test whether or not the following C code produces a fair 6-sided die:

```
while(1) {
   while(!RB0);
   while(RB0) {
      DIE = (DIE + 1) % 6;
      X = (X + 1) % 11;
      }
   DIE = DIE + 1;
   if(X == 0) DIE = 6;

   LCD_Move(1,0);  LCD_Out(DIE, 1, 0);
   SCI_Out(DIE, 1, 0);
   SCI_CRLF();
   }
```

bin	p	np	N	chi-squared
1	1/6	25.6667	19	1.7316
2	1/6	25.6667	25	0.0173
3	1/6	25.6667	19	1.7316
4	1/6	25.6667	15	4.4329
5	1/6	25.6667	37	5.0043
6	1/6	25.6667	39	6.9264
			Total:	19.8442

Now covnvert the chi-squared score (19.844) to a probability using StatTrek

There is a 99.9% chance that this is not a fair die



Am I Psychic?

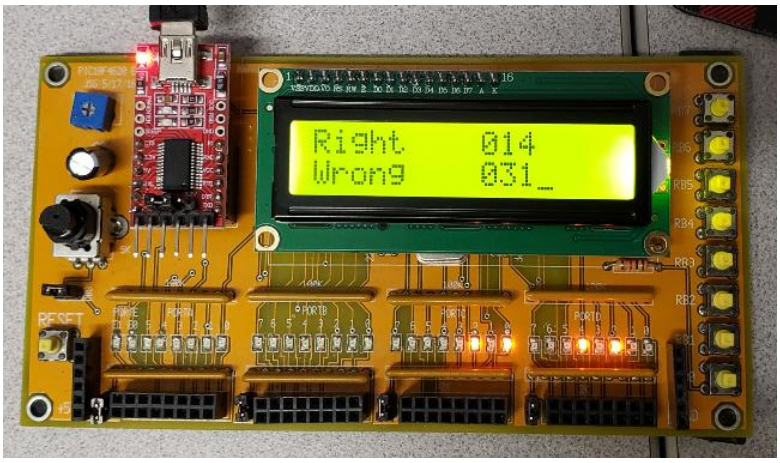
6) Write a C program which tests if you're psychic with a 4-sided die:

- Each round, predict which number is going to come up (0..3)
- Press the corresponding button RB0..RB3.
- When you release the button, a random number in the range of 0..3 is generated
- If you were right, the PIC records that. Likewise if you were wrong.
- The LCD display displays how many times you were right and wrong.

```
// Global Variables

const unsigned char MSG0[21] = "Right                ";
const unsigned char MSG1[21] = "Wrong                ";

// Subroutine Declarations
#include <pic18.h>

// Subroutines
#include        "lcd_portd.c"

// Main Routine

void main(void)
{

:
:

   }
}
```

7) Collect data with your program.

Correct	Incorrect
14	31



8) Determine the chance that you were not just guessing using a chi-squared test

- Null hypothesis: you are just guessing (correct 33% of the time).

bin	p	np	N	chi-squared
correct	1/4	11.25	14	0.6722
incorrect	3/4	33.75	31	0.2241
			Total:	0.8963

From StatTrek, a chi-squared score of 0.1 corresponds to a probability of 0.65622

There is a 65.6% chance that I'm not just guessing (no conclusion)