

# ECE 376 - Homework #6

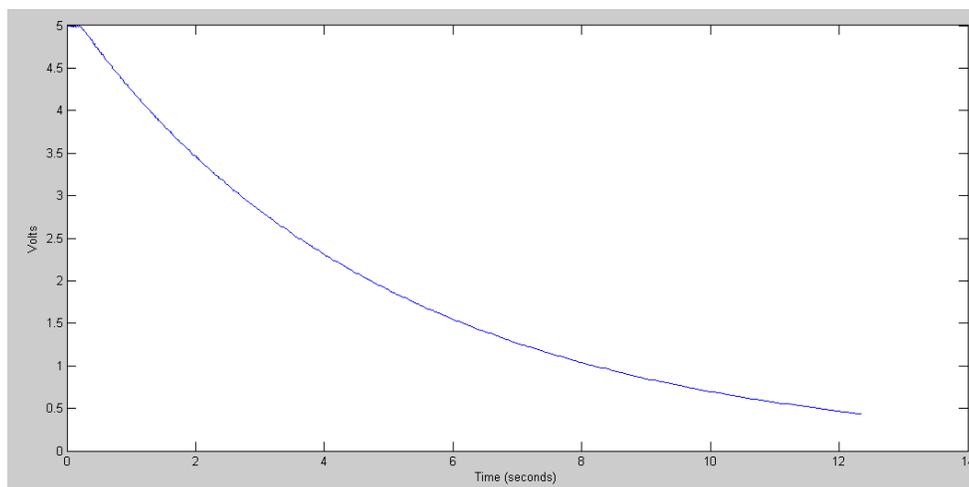
Data Collection & Chi-squared Test. Due Monday, February 27th  
Please email to [jacob.glower@ndsu.edu](mailto:jacob.glower@ndsu.edu), or submit as a hard copy, or submit on BlackBoard

## 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 =

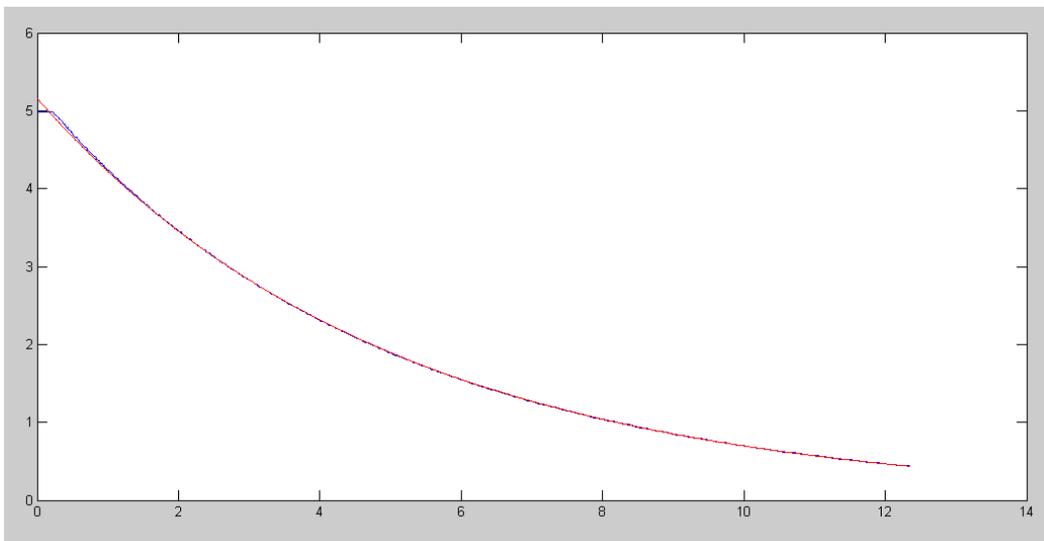
    -0.2001
     1.6404

>> 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 by the total time (8.0427 seconds) gives the probability 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 experimentally 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**

- Enter value for degrees of freedom.
- Enter a value for one, and only one, of the other textboxes.
- Click **Calculate** to compute a value for the remaining textbox.

Degrees of freedom

Chi-square value (x)

Probability:  $P(X^2 \leq 9.3247)$

Probability:  $P(X^2 \geq 9.3247)$

**Calculate**

5) Determine experimentally 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 convert the chi-squared score (19.844) to a probability using StatTrek

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

- Enter value for degrees of freedom.
- Enter a value for one, and only one, of the other textboxes.
- Click **Calculate** to compute a value for the remaining textbox.

Degrees of freedom

Chi-square value (x)

Probability:  $P(X^2 \leq 19.844)$

Probability:  $P(X^2 \geq 19.844)$



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	1/3	15	14	0.0667
incorrect	2/3	30	31	0.0333
			Total:	0.1000

From StatTrek, a chi-squared score of 0.1 corresponds to a probability of 0.248

**There is a 24.8% chance that I'm not just guessing (no conclusion)**

- Enter value for degrees of freedom.
- Enter a value for one, and only one, of the other textboxes.
- Click **Calculate** to compute a value for the remaining textbox.

Degrees of freedom

Chi-square value (x)

Probability:  $P(X^2 \leq 0.1)$

Probability:  $P(X^2 \geq 0.1)$

**Calculate**