ECE 376 - Homework #8

Timer 2 Interrupts.

Measuring Time to 0.1ms with Timer2 Interrupts

One way to measure capacitance is to measure the RC time constant.

- Charge up a capacitor to +5V (make RA1 output, set RA1 to 5V, wait 1 second)
- Change RA1 to be an analog input
- Measure the time when the voltage drops to 800 A/D reading
- Measure the time when the voltage drops below 400 A/D reading

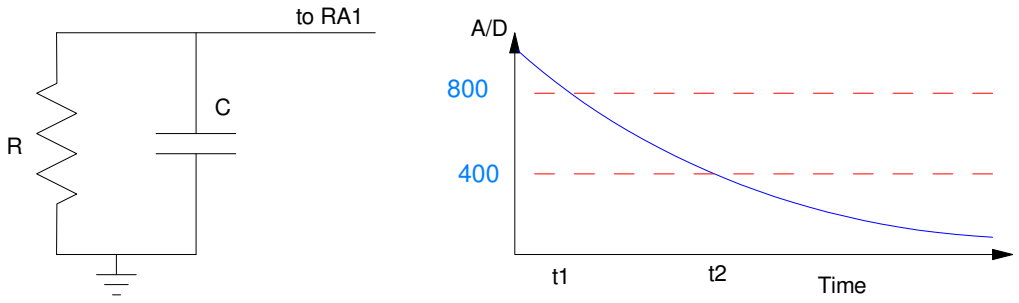
C is then

$$500 = 1000 \cdot \exp\left(\frac{-t}{RC}\right)$$

$$(t_2 - t_1) = RC \cdot \ln(2)$$

$$C = \left(\frac{N}{10{,}000}\right)\left(\frac{1}{R \cdot \ln(2)}\right) = 1.44 \cdot 10^{-9} N \quad \text{Farads}$$

$$C = 1.4427N \quad \text{nF}$$



1) Write a C program which

- Measures time to 0.1ms using Timer2 interrupts
- Measures a capacititor connected between RA1 and ground (R = 100k), and
- Displays the value of C.

Interrupt Service Routine:

```
void interrupt IntServe(void)
{
   if (TMR2IF) {
      TIME += 1;
      TMR2IF = 0;
      }
   }
```

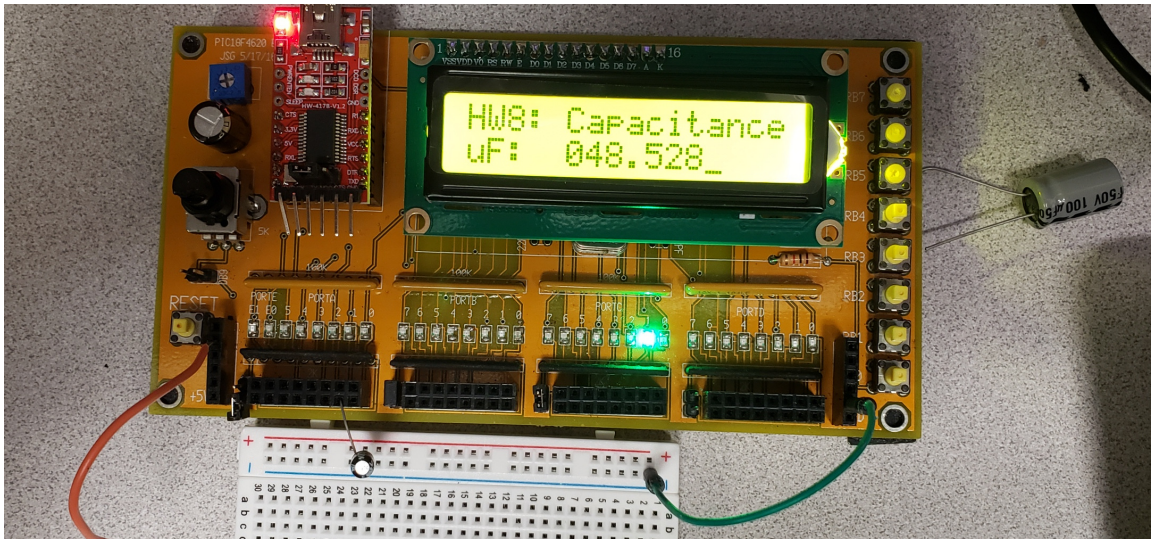
Main Routine:

```
      while(1) {

// Switch RA1 to output and charge to 4.4V+ (A/D > 900)
      PORTC = 4;
      while(A2D_Read(1) < 900) {
          TRISA1 = 0;
          RA1 = 1;
          Wait_ms(100);
          TRISA1 = 1;
          }

// Switch RA1 to input and read the votlage with the A/D
      PORTC = 8;
      A0 = A2D_Read(1);
      while(A2D_Read(1) > 800);
      TIME = 0;
      while(A2D_Read(1) > 400);
      N = TIME;
      nF = 1.4427*N;

      LCD_Move(1,  4);  LCD_Out(nF, 6, 3);
                                          }
```



2) Measure the value of two (or more) 10.0uF capaitors using the correct polarity (different values are OK). From this data, determine the 90% confidence interval for a given 47uF capacitor

47uF: Correct polarity (same capacitor measured 4 times):

- 48.528uF (a)
- 48.588uF (a)
- 48.663uF (a)
- 48.767uF (a)

This tells you the experimental error

- mean = 48.636uF
- st dev = 0.103uF
- t-score for 5% tails (3dof): 2.35336
- 90% confidence interval: (48.394uF, 48.879uF)

The experimental error is +/- 0.245uF

47uF: Correct Polarity (four different capacitors)

- 48.787uF (a)
- 48.007uF (b)
- 58.689uF (c)
- 55.399uF (d)

This is a combination of the experimental error and the population's variation

- mean = 52.5705uF
- st dev = 4.9529uF

The 90% confidence interval is

- (40.91uF, 64.22uF)

A 47uF capacitor with correct polarity will read in the range of (40.91uF, 64.22uF) with a probability of 0.9

3) Measure the value of two (or more) 47.0uF capaitors using incorrect polarity. From this data, determine the 90% confidence interval for a given 10uF capacitor when used with the incorrect polarity.

47uF (incorrect polarity)

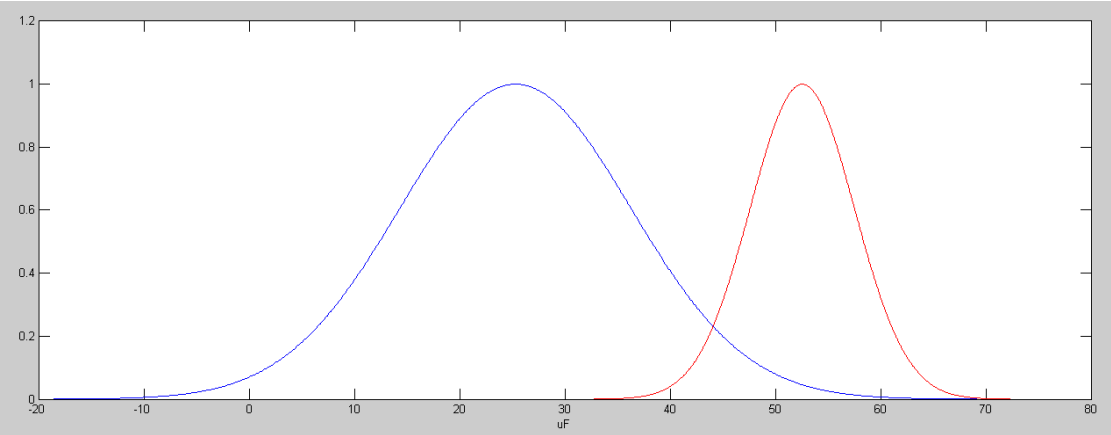
- 38.061uF (a)
- 20.919uF (b)
- 12.643uF (c)
- 29.644uF (d)

The statistics for incorrect polarity (population B) is

- mean = 25.3167uF
- st dev = 10.9713uF

The 90% confidence interval for a 47uF capacitor used backwards is

- (-0.612uF - 51.2458uF)



pdf for a 47uF capacitor with correct polarity (red) and incorrect polarity (blue)

Generating Frequencies with Timer2

4 Write a program which outputs the music note D#3 (155.56 Hz) using Timer2 interrupts

- Verify the frequency of the square wave you generate
- (Pano Tuner app on you cell phone works well for this)

$$N = \left(\frac{10{,}000{,}000}{2 \cdot Hz}\right) = 32,141.19$$

Come up with A*B*C = N subject to

- A = [1..16]
- B = [1..256]
- C = {1, 4, 16}

Try

- C= 16
- A = 10
- B = 201
- N = A*B*C = 32,160 (off by +0.056%)

T2CON = 0x4F							
7	6	5	4	3	2	1	0
0	1	0	0	1	1	1	1
	A = 10					C = 16	

```
// set up Timer2 123.47Hz
   T2CON = 0x4F;
   PR2 = 201;
   TMR2ON = 1;
   TMR2IE = 1;
   TMR2IP = 1;
   PEIE = 1;
```

Timer2 Roulette Wheel

4) Requirements:

Inputs:

- RB0: Spin the roulette wheel

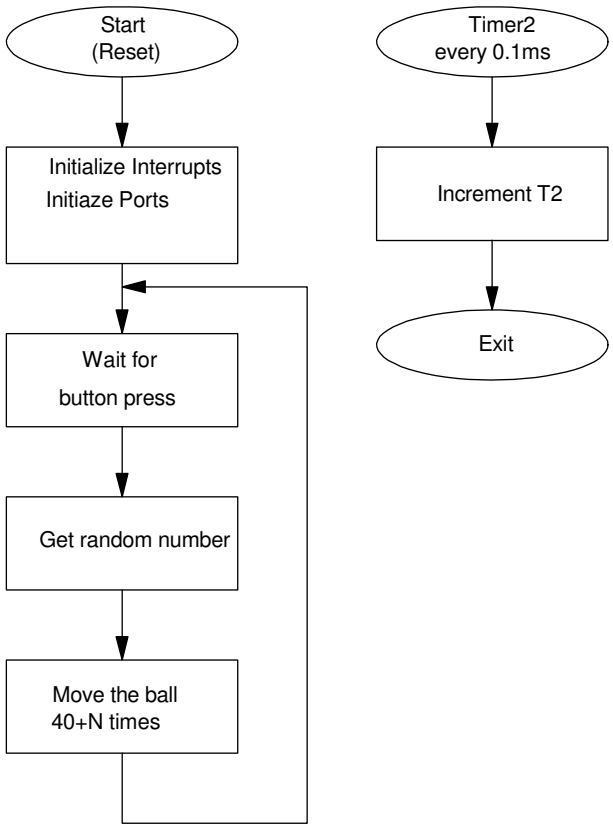
Outputs:

- LCD Display: Display the current ball position (0..7)
- PORTC: Display the current ball position (0..7)
- Speaker: Beep each time the ball moves one spot

Relationship:

- Timer2 counts in the background, one count every 0.1ms
- When you press RB0, a random number, N, is determined by taking the current time mod 8
- The routlette ball then moves 40 + N spaces
- Each movement beeps and waits 10..1000ms (starting at 10ms/step, ending at 1000ms/step)

5) C-Code and flow chart.



6) Data. Your raw data (at least two data points)

Wining numbers are:

- 5, 1, 5, 4, 4, 2, 2, 6, 0, 0, 4, 5, 4, 4, 6, 1, 5, 2, 7, 3

7) Statistical Analysis: Analyze your data to determine

Do a chi-squared test. There isn't enough date for 8 bins (20 data points), so group the data into two bins: even & odd numbers

Bin	p	np	N	chi-squared
0,2,4,6	0.5	10	11	0.1
1,3,5,7	0.5	10	9	0.1
			Total	0.2

From StatTrek, a chi-squared critical value of 0.2 corresponds to a probability of 0.35

There is a 35% chance that the die is loaded (no conclusion)

8) Demo (in person during Zoom office hours or in a video)