# ECE 376 - Test #2: Name ____________________

### C-Programming on a PIC Processor

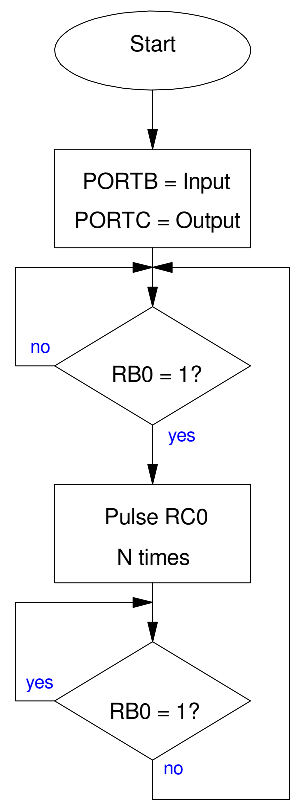
Open book, open notes. Calculators and Matlab permitted. Individual effort (help from other people or web sites where other people help you solve the problems not permitted).

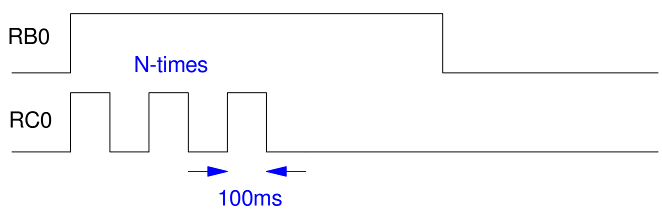
**1) C Coding & Flow Charts.** Write a C program for video game cheat:

- Each time you press RB0 (rising edge)
- N pulses are output on RC0 (fire N times)
- Each pulse is on for 100ms, off for 100ms

Let N be your birth month plus one (2..14)

**N = 6 (month + 1)**



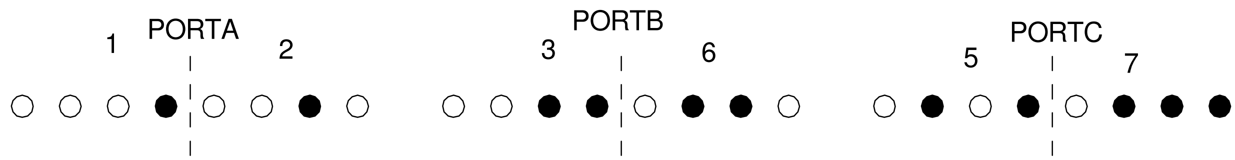




```
#include <pic18.h>

void main(void) {
   ADCON1 = 0x0F;

   TRISB = 0xFF:
   TRISC = 0;

   while(1) {

      while(RB0 == 0);

      for(i=0; i<6; i++) {

         RC0 = 1;
         Wait_ms(100);
         RC0 = 0;
         Wait_ms(100);

         }

      while(RB0 == 1);

      }
```

**2) Binary Clock!** Write a C subroutine to drive the display on a binary clock.

- Hours, Minutes, and Seconds are passed to the subroutine
- Hours are displayed on PORTA as ( tens : ones )
- Minutes are displayed on PORTB as ( tens : ones )
- Seconds are displayed on PORTC as ( tens : ones )

For example: 12:36:57 would display as

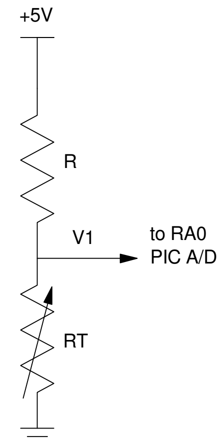



```
void Problem2(unsigned char Hr, Min, Sec);
{

   unsignded char Ten, One;

   Ten = Hr / 10;
   One = Hr % 10;
   PORTA = Ten*16 + One;

   Ten = Min / 10;
   One = Min % 10;
   PORTB = Ten << 4 + One;

   Ten = Sec / 10;
   One = Sec % 10;
   PORTC = Ten*16 + One;


   }
```

## Analog Inputs

3) Assume the A/D input to a PIC processor has the following hardware connection where $R_T$ is a 3k thermistor where T is the temperature in degrees C

$$R_T = 2000 \cdot \exp\left(\frac{4200}{T+273} - \frac{4200}{298}\right)\Omega$$




Let R be a resistor

R = 900 + 100*(your birth month) + (your birth date).

If the A/D reading is 769, determine

- The voltage at V1
- The resistance, RT,
- The temperature, T, in degrees C, and
- The smallest change in temperature you can detect

| R<br>900 + 100*mo + day | A/D Reading | V1<br>volts | $R_T$<br>Ohms | Temperature<br>degrees C | Smallest change in T you can detect |
|---|---|---|---|---|---|
| **1414** | **769** | **3.7586V** | **4280.97 Ohms** | **9.733 C** | **0.0998 C** |

$$V_1 = \left(\frac{769}{1023}\right)5V = 3.7586V$$

$$R_T = \left(\frac{3.7586V}{5V - 3.7586V}\right)1414\Omega = 4280.97\Omega$$

$$T = 9.733^0 C$$

If the A/D was 770 (the smallest chance in the A/D is one count0

$$V_1 = \left(\frac{770}{1023}\right)5V = 3.7634V$$

$$R_T = \left(\frac{3.7634V}{5V - 3.7634V}\right)1414\Omega = 4303.48\Omega$$

$$T = 9.633^0 C$$

The temperature difference is

$$dT = 0.0998^0 C$$

## chi-squared test

4) (10pt). The number of scores that fall into each region for NFL teams in 2021 (week 1-4) are:

| 0-9 | 10-19 | 20-29 | 30-39 | 40-49 |
|---|---|---|---|---|
| 11 | 33 | 48 | 30 | 6 |

Use a chi-squared test to determine the probability that points scored follows a Normal distribution with

- Mean = 23.5
- Standard Deviation = 9.66

| Points Scored | probability p<br>normal distribution | np<br>n = 128 scores | N<br># scores in this region | chi-squared score |
|---|---|---|---|---|
| 0 - 9 | 0.074 | 9.47 | 11 | **0.2472** |
| 10 - 19 | 0.3326 | 45.57 | 33 | **3.4673** |
| 20 - 29 | 0.393 | 50.30 | 48 | **0.1052** |
| 30 - 39 | 0.218 | 27.90 | 30 | **0.1581** |
| 40+ | 0.049 | 6.72 | 6 | **0.0771** |
| | | | **Total** | **4.05** |

There is a 60% chance that scores do not follow a normal distribution

Chi-Squared Table

Probability of rejecting the null hypothesis

| dof | 99% | 95% | 90% | 80% | 60% | 40% | 20% | 10% | 5% | 1% |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.64 | 3.84 | 2.71 | 1.65 | 0.71 | 0.28 | 0.06 | 0.02 | 0 | 0 |
| 2 | 9.21 | 5.99 | 4.61 | 3.22 | 1.83 | 1.02 | 0.45 | 0.21 | 0.05 | 0.01 |
| 3 | 11.35 | 7.82 | 6.25 | 4.64 | 2.95 | 1.87 | 1.01 | 0.58 | 0.22 | 0.07 |
| 4 | 13.28 | 9.49 | 7.78 | 5.99 | $\boxed{4.05}$ | 2.75 | 1.65 | 1.06 | 0.48 | 0.21 |
| 5 | 15.09 | 11.07 | 9.24 | 7.29 | 5.13 | 3.66 | 2.34 | 1.61 | 0.83 | 0.41 |

## t-Tests

5) (15pt) The current gain of four ZTX869 transistors were measured using the correct and incorrect polarity

| polarity | Current gain | mean | st dev |
|---|---|---|---|
| A: correct | { 605, 743, 564, 588} | 625.0 | 80.44 |
| B: incorrect | {507, 655. 452. 488 } | 525.5 | 89.29 |

a) What is the 90% confidence interval for the gain of a ZTX869 transistor when used with the correct polarity?

With 5% tails and 3 degrees of freedom (sample size four) the t-score is 2.35

$$625 - 2.35 \cdot 88.44 < \beta < 625 + 2.35 \cdot 80.44$$

$$417.17 < \beta < 832.83$$

b) What is the probability that the correct polarity has a higher gain than the incorrect polarity?

for any given transistor (individual)

$$W = A - B$$

$$\bar{x}_W = 625 - 525.5 = 99.5$$

$$s_W = \sqrt{s_A^2 + s_B^2} = 120.18$$

$$t = \frac{99.5}{120.18} == 0.8279$$

3 degrees of freedom: p = 0.23 (about)

**There is 23% chance that a given transistor has a higher gain when used backwards**

| Student t-Table<br>area of tail | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| dof \ p | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0 |
| 1 | 1 | 1.38 | 1.96 | 3.08 | 6.31 | 12.71 | 31.82 | 63.66 | 318.31 | 636.62 |
| 2 | 0.82 | 1.06 | 1.39 | 1.89 | 2.92 | 4.3 | 6.97 | 9.93 | 22.33 | 31.6 |
| 3 | 0.77 | 0.98 | 1.25 | 1.64 | 2.35 | 3.18 | 4.54 | 5.84 | 10.22 | 12.92 |
| 4 | 0.74 | 0.94 | 1.19 | 1.53 | 2.13 | 2.78 | 3.75 | 4.6 | 7.17 | 8.61 |
| 5 | 0.73 | 0.92 | 1.16 | 1.48 | 2.02 | 2.57 | 3.37 | 4.03 | 5.89 | 6.87 |
| infinity | 0.674 | 0.842 | 1.036 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 | 3.29 |

**(take 2)** Population:

$$W = A - B$$

$$\bar{x}_w = 625 - 525.5 = 99.5$$

$$s_w = \sqrt{\frac{s_A^2}{4} + \frac{s_B^2}{4}} = 60.09$$

$$t = \frac{99.5}{60.09} = 1.6558$$

3 degrees of freedom

Converting to a probability, p = 10%

**There is a 10% chance that, overall, ZTX869 transistors have a higher gain when used backwards**

| Student t-Table<br>area of tail | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| dof \ p | 0.25 | 0.20 | 0.15 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0.0005 |
| 1 | 1 | 1.38 | 1.96 | 3.08 | 6.31 | 12.71 | 31.82 | 63.66 | 318.31 | 636.62 |
| 2 | 0.82 | 1.06 | 1.39 | 1.89 | 2.92 | 4.3 | 6.97 | 9.93 | 22.33 | 31.6 |
| 3 | 0.77 | 0.98 | 1.25 | 1.64 | 2.35 | 3.18 | 4.54 | 5.84 | 10.22 | 12.92 |
| 4 | 0.74 | 0.94 | 1.19 | 1.53 | 2.13 | 2.78 | 3.75 | 4.6 | 7.17 | 8.61 |
| 5 | 0.73 | 0.92 | 1.16 | 1.48 | 2.02 | 2.57 | 3.37 | 4.03 | 5.89 | 6.87 |
| infinity | 0.674 | 0.842 | 1.036 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 | 3.090 | 3.29 |

**(take 3):** Another way to analyze the data: Take the ratio of the gains (only works if you have access to each transistor's gain each way)

A/B = {1.1933, 1.1344, 1.2478, 1.2049}

mean = 1.1951

st dev = 0.0468

t-score

$$t = \left( \frac{1.1951 - 1.0000}{0.0468} \right) = 4.1688$$

This corresponds to a tail of 1.26% (or 98.74% chance).

**There is nearly a 98.74% chance that the gain of given ZTX869 transistor is higher when used with the correct polarity than with the incorrect polarity.**