## ECE 376 - Test \#2: Name

## C-Programming on a PIC Processor

## 1) C Coding \& Flow Charts ( 25 points)

Write the corresponding C code for the flow chart shown to play a limited version of Black Jack

- Start with zero points
- Draw a card (aces are always 11 points)
- Compute your score
- Keep playing until you have 16 or more points
- If you go over 21 points, you lose
assume a subroutine exists that returns a number $1 . .13$ when called (different problem on this test)

```
void main(void) {
    ADCON1 = 0x0F;
    TRISB = 0xFF;
    TRISC = 0;
    Score = 0;
    while(Score < 16) {
        Value = Draw_Card(13);
        if(Card == 1) Points = 11;
        elseif(Card > 10) Points = 10;
        else Points = Card;
        Score += Points;
        if(Score < 16) RCO = !RC0;
        }
    if(Score > 21) RC1 = 1;
    else RC2 = 1;
// Stop
    while(1);
    }
```


## 2) Subroutines: (25 points)

Write a subroutine

- Which is passed an integer, N
- The subroutine waits until you press and release button RB0
- When released, a random number (X) is returned in the range of 1 .. $N$

```
unsigned int Draw_Card(unsigned int N)
{
    unsigned int X;
    while(!RB0);
    while(RB0) {
        X = (X + 1) % N;
        }
    X = X + 1;
    return(X);
    }
```


## 3) Analog Inputs (25 points)

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

$$
R=2200 \cdot \exp \left(\frac{3800}{T+273}-\frac{3800}{298}\right) \Omega
$$

Let the R1 be your birthday

$$
\begin{aligned}
& \mathrm{R} 1=900+100 * \text { month }+ \text { day } \\
& \text { May } 15 \text { th would give } \mathrm{R} 1=1415 \text { Ohms }
\end{aligned}
$$

If the $\mathrm{A} / \mathrm{D}$ reads 872 , determine

- The temperature in degrees C ,
- The resistance, R,

- The voltage, V1, and
- The smallest change in termperature you can detect

| R1 <br> $900+100^{*}$ mo + day | T (degees C) | R <br> Thermistor - Ohms | V1 <br> Volts | A/D Reading |
| :---: | :---: | :---: | :---: | :---: |
| $\mathbf{1 4 1 5}$ | $\mathbf{- 2 . 8 0 3 9} \mathbf{C}$ | $\mathbf{8 1 8 1 . 3 9}$ Ohms | $\mathbf{4 . 2 6 2 0} \mathbf{V}$ | $\mathbf{8 7 2}$ |
|  |  |  |  |  |

$$
\begin{aligned}
& V_{1}=\left(\frac{872}{1023}\right) 5 V=4.2620 V \\
& V_{1}=\left(\frac{R}{R+1415}\right) 5 V=4.2620 V \\
& R=\left(\frac{V_{1}}{5 V-V_{1}}\right) 1415 \Omega \\
& R=8171.39 \Omega \\
& R=8181.39 \Omega=2200 \cdot \exp \left(\frac{3800}{T+273}-\frac{3800}{298}\right) \Omega
\end{aligned}
$$

$$
T=-2.8039^{\circ} \mathrm{C}
$$

## 4) chi-squared test (10 points)

The high and low temperature in Fargo has been recorded each day since 1900 (124 years). So far this year, Fargo has hit a record high nine times in the past 71 days.

Use a chi-squared test to determine the probability that 2024 is no different than any other year (the probability of any given day being a record high is $1 / 124$ ).
note: $\mathrm{n}=71$ (first 71 days of 2024

| Case | p <br> binomial distribution | np <br> expected results | N <br> actual results | Chi-Squared |
| :---: | :---: | :---: | :---: | :---: |
| Record High | $1 / 124$ | $\mathbf{0 . 5 7 2 6}$ | 9 | $\mathbf{1 2 4 . 0 3 7 4}$ |
| Normal Year | $123 / 124$ | $\mathbf{7 0 . 4 2 7 4}$ | 62 | 1.0084 |

$n p=71 \cdot p$
$\chi^{2}=\left(\frac{(N-n p)^{2}}{n p}\right)$

Degrees of Freedom $=1.000$
two bins

From the chi-squared table, the probability is more than $99 \%$
It is more than $99 \%$ likely that 2024 does not follow the behaviour of the past 124 years
From StatTrek, a probability of 0.99999 corresponds to a chi-squared value of 24.00 . This is way beyond that.

| Chi-Squared Table <br> 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 | 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 |
| 6 | 16.81 | 12.59 | 10.64 | 8.55 | 6.21 | 4.57 | 3.07 | 2.20 | 1.63 | 0.87 |
| 7 | 18.47 | 14.06 | 12.02 | 9.80 | 7.28 | 5.49 | 3.82 | 2.83 | 2.17 | 1.24 |

## 5) t-Tests (15 points)

Hector Airport has been recording temperatures in Fargo since 1942 (82 years of data). The statistics for the high temepature for the month of February are:

- mean $=42.9183 \mathrm{~F}$
- st dev $=7.0888 \mathrm{~F}$
- $\mathrm{n}=82$ (numer of data points)

In 2024, the high for February was 61.0 F
Use a student t -test to determine the probability of being warmer than 61.0 F in the month of February

Determine the t-score

$$
t=\left(\frac{61.0 F-42.9183 F}{7.0888 F}\right)=2.5507
$$

There are 81 degrees of freedom (sample size $=82$ )
This $t$-score corresponds to a probability of 0.006
There is a $\mathbf{0 . 6 \%}$ chance of any given February having a high of 61.0F or more

## 167:1 odds against

Student t-Table (area of tail)

| $\mathbf{d f} \backslash \mathbf{p}$ | $\mathbf{0 . 0 0 1}$ | $\mathbf{0 . 0 0 2 5}$ | $\mathbf{0 . 0 0 5}$ | $\mathbf{0 . 0 1}$ | $\mathbf{0 . 0 2 5}$ | $\mathbf{0 . 0 5}$ | $\mathbf{0 . 1}$ | $\mathbf{0 . 1 5}$ | $\mathbf{0 . 2}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathbf{1}$ | -636.619 | -318.309 | -63.6567 | -31.8205 | -12.7062 | -6.3138 | -3.0777 | -1.9626 | -1.3764 |
| $\mathbf{2}$ | -31.5991 | -22.3271 | -9.9248 | -6.9646 | -4.3027 | -2.92 | -1.8856 | -1.3862 | -1.0607 |
| $\mathbf{1 0}$ | -4.5869 | -4.1437 | -3.1693 | -2.7638 | -2.2281 | -1.8125 | -1.3722 | -1.0931 | -0.8791 |
| $\mathbf{2 0}$ | -3.8495 | -3.5518 | -2.8453 | -2.528 | -2.086 | -1.7247 | -1.3253 | -1.064 | -0.86 |
| $\mathbf{3 0}$ | -3.646 | -3.3852 | -2.75 | -2.4573 | -2.0423 | -1.6973 | -1.3104 | -1.0547 | -0.8538 |
| $\mathbf{4 0}$ | -3.551 | -3.3069 | -2.7045 | -2.4233 | -2.0211 | -1.6839 | -1.3031 | -1.05 | -0.8507 |
| $\mathbf{5 0}$ | -3.496 | -3.2614 | -2.6778 | -2.4033 | -2.0086 | -1.6759 | -1.2987 | -1.0473 | -0.8489 |
| $\mathbf{6 0}$ | -3.4602 | -3.2317 | -2.6603 | -2.3901 | -2.0003 | -1.6706 | -1.2958 | -1.0455 | -0.8477 |
| $\mathbf{7 0}$ | -3.435 | -3.2108 | -2.6479 | -2.3808 | -1.9944 | -1.6669 | -1.2938 | -1.0442 | -0.8468 |
| $\mathbf{8 0}$ | -3.4163 | -3.1953 | $-\mathbf{2 . 6 3 8 7}$ | $\mathbf{- 2 . 3 7 3 9}$ | -1.9901 | -1.6641 | -1.2922 | -1.0432 | -0.8461 |
| $\mathbf{9 0}$ | -3.4019 | -3.1833 | -2.6316 | -2.3685 | -1.9867 | -1.662 | -1.291 | -1.0424 | -0.8456 |
| $\mathbf{1 0 0}$ | -3.3905 | -3.1737 | -2.6259 | -2.3642 | -1.984 | -1.6602 | -1.2901 | -1.0418 | -0.8452 |

