**ECE 245: Microcontroller Applications with IoT – Fall 2022: Final Exam**

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**Note – Cheating and Plagiarism**: Cheating and plagiarism are not permitted in any form and cause certain penalties. The instructor reserves the right to fail culprits.

**Deliverable**: All your responses to the assignment questions should be included in a single compressed file to be uploaded in the Gannon University (GU) – Blackboard Learn environment.

**Question 1.** Draw and explain a pull-up and a pull-down circuit using CMOS transistor technology. Mention how they are used for microcontrollers and LEDs.

**Question 2.** Explain the differences between a buffer cell and an inverter cell in digital design.

**Question 3.** Fixed point format, rather than floating point, is often used in low-end microprocessors to handle fractional numbers. In this question, consider a machine where integers are 16 bits and their long versions are 32 bits. Also, the signed integers are used to hold fixed-point values where the binary point is located right after the most-significant digit. Specify the exact range of representation for this fixed-point value.

**Question 4.** Explain the relationships between four components of latches, flip-flops, registers, and counters if they exist. Show their circuits based on possible relationships.

**Question 5.** Draw and explain State Diagram, Data Flow Graph, and Call Flow Graph for the Product Life Cycle of an embedded system and its running application.

**Question 6.** The following function in C language is used to multiply two 16-bit fixed-point numbers in a microcontroller application. Explain the purpose of the addition of "**0x4000**" number and why this number is used.

```
Int16 multiply(Int16 a, Int16 b)
{
      Int32 temp = a*b;
      return((Int16) (temp+0x4000)>>15);
}
```

**Question 7.** Mention applications of ADC and DAC in embedded systems.

**Question 8.** Explain the various memory addressing modes for microcontrollers.

**Question 9.** Explain different types of Structured Programming with provision of their figures.

**Question 10.** Explain advantages and disadvantages of ARM, Thumb, and Thumb-2 instructions, considering their possible exceptional cases.

**Question 11.** Draw and explain Memory Map and Layout of Registers for a microcontroller and how they are used in computations.

**Question 12.** In this question, you are asked to help a teacher to complete the following program for a microcontroller to: (a) calculate each student's grade as 'P' or 'F' depending on whether the score is higher than or equal to 75; and (b) return the average class score.

```
#define SIZE 64
struct Student {
 unsigned long id;
 unsigned long score;
 unsigned char grade; // Possible contents for it are 'P' and 'F'.
};
typedef struct Student STyp;

unsigned long Grades(STyp class[SIZE]){
     // Body of Grades() Function to Complete.
}
```

**Question 13.** Discuss the interactions between Processor, Internal Peripherals, Instructions Flash ROM, Data RAM, Input Ports, Output Ports, Instruction-Code Bus, Private Peripheral Bus, Data-Code Bus, System Bus, and Advanced High-Performance Bus in a microcontroller.

**Question 14.** Provide written explanations, formulas, and graphical representations (i.e., interactions between memory, processor, etc.) for the following assembly instructions:

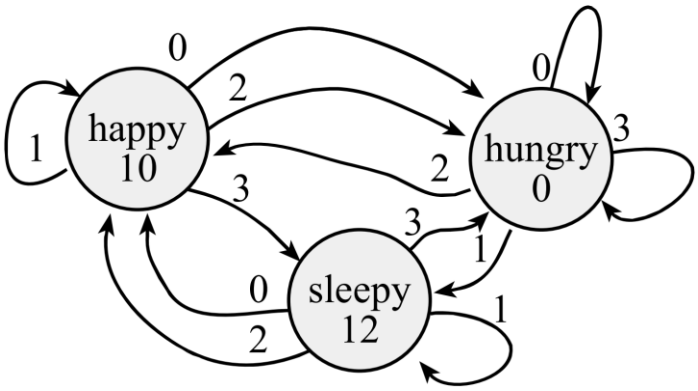
- `LDI R1, Label`
- `STR R1, R0, k`
- `ADD R1, R2, #3`
- `BRz Target`
- `BL Sub`
- `TRAP x09`

**Question 15.** Show and explain how an application for a microcontroller is tested and debugged before it is used fully in practice.

**Question 16.** Compare Microprocessors and Microcontrollers on the basis of: Instruction Set, Applications, Memory Organization, and I/O compatibility.

**Question 17.** Write a simple program in C/C++ program for a microcontroller to sense and acquire room temperature. Draw and explain the flowchart of your program.

**Question 18.** In the state machine shown below, a microcontroller program starts in the "**happy**" state. The input signal starts and remains with the value of three. Specify the sequence of outputs.




**Question 19.** Translate the following C-language code for a microcontroller using its Assembly RISC instructions. The part A and B of this question are in the same flow.

**Q19 – Part A.**

```
int a = 1;
int b = 3;
for (int i = 0; i <= 2; i++) {
      a = a + b;
}
```

**Q19 – Part B.**

```
int x = 10;
int y;
if (x > a)
  y = x;
else
  y = a;
```