DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
FACULTY OF ENGINEERING
WESTERN UNIVERSITY, CANADA
ECE3375b-Microprocessors and Microcomputers
(Sections 1 and 2)
Midterm Exam, Winter 2019
Monday March 11, 2019
Time: 3:30 pm – 5:00 pm

Student Name: ______________________ (Answers are printed here in Red Color)

Student Number: ________________________ **Section Number:** _____________________

Instructions:

- † University policy states that cheating, including plagiarism, on an examination is a scholastic offense. The commission of a scholastic offense is attended by academic penalties which might include expulsion from the program. If you are caught cheating, there will be no second warning.
- † This examination is **closed book**, with no aids permitted (i.e. NO books, notes, or any information processing devices). Calculators are not permitted. All sheets (including rough work) must be handed in; no part of the examination may be taken from the room.
- † Answer **ALL PARTS** of **ALL QUESTIONS**. Clearly state any assumptions you make when answering these questions.
- † **This exam book is 10 pages long. The student is responsible for ensuring that no pages are missing from this document.**

Please do not write in this table.

Q#	Mark	Weight
Q1		**/5**
Q2		**/3**
Q3		**/6**
Q4		**/8**
Q5		**/10**
Q6		**/6**
Q7		**/12**
Total		**/50**

Q1. (**05 points**) Circle the correct answer

1. How many bits does a ***WORD*** have?

   A. 4 B. 8 C. 16 [✓ D. 32] E. 64
2. How many bits does a ***register*** have in the ARM processor?

   A. 4 B. 8 C. 16 [✓ D. 32] E. 64
3. Memory address is always in terms of ***bytes***.

   [✓ A. TRUE] B. FALSE
4. What is the result of **y** in binary? **y = 0x11<<2**

   A. 0b1100 [✓ B. 0b1000100] C. 0b0011 D. 0b0000 E. 0b0101
5. If the physical memory address has 32 bits, the maximum amount of memory it can access is

   [✓ A. 4GB] B. 4MB C. 1GB D. 2GB E. 2MB
6. In a C program, what does the following code do? **x &= ~(1<<k);**

   [✓ A. Clear a bit] B. Set a bit C. Toggle a bit D. Check a bit
7. In a C program, what does the following code do? **x |= 1<<k;**

   A. Clear a bit [✓ B. Set a bit] C. Toggle a bit D. Check a bit
8. In a C program, what does the following code do? **x ^= 1<<k;**

   A. Clear a bit B. Set a bit [✓ C. Toggle a bit] D. Check a bit
9. In a C program, a ***pointer*** is actually a memory address.

   [✓ A. TRUE] B. FALSE
10. If you do not follow the protocol, your program might still run correctly. But your assembly program cannot be called by a standard C procedure or by another assembly program written by a different programmer.

    [✓ a. TRUE] b. FALSE

Q2. **(03 points)** For the 4-bit binary representations in the table below, show the equivalent decimal values when the data is interpreted as unsigned binary or signed binary.

Binary representation	Signed Decimal Value	Unsigned Decimal Value
0000	0	0
0111	7	7
1111	-1	15

Q3. **(06 points)** Assume an array of 30 integers (each integer is a word). A compiler associates variables x and y with registers r0 and r1, respectively. Assume that the base address for the array is located in register r2. Translate this C statement into ARM assembly language.

```
x = array[7] + y;
```

LDR r0, [r2, #28]

ADD r0, r0, r1

Note: Other answers are also considered and receive full mark if they are correct.

Q4. **(08 points)** Suppose we have a hypothetical processor, of which each register has only five bits. The contents of registers r0 and r1 are initialized as follows

- r0 = **0b11101**
- r1 = **0b10110.**

What are the N, Z, C, and V flags of the following instructions? Assume initially N = 0, Z = 0, C = 1, V = 0, and these instructions are executed independently and separately after the above initializations (*i.e.*, they are NOT part of a program).

(1) ADDS r3, r0, r1

N	Z	C	V
1	0	1	0

r3=0b10011

(2) SUBS r3, r0, r1

N	Z	C	V
0	0	1	0

r3=0b00111

(3) EOR r3, r0, r1

N	Z	C	V
0	0	1	0

r3=0b01011

(4) ANDS r3, r1, r1, LSL #3

N	Z	C	V
1	0	1	0

r3=0b10000

Q5. **(10 points)** ARM Data Addressing. Suppose r0 = 0x00008000, and the memory layout is presented in this table.

Address	Data
0x00008000	0x1A
0x00008001	0x2C
0x00008002	0xEB
0x00008003	0x0D
0x00008004	0xFD
0x00008005	0xA3
0x00008006	0xCD
0x00008007	0x79

i. (04 points) ARM processors can be configured as big-endianness or little-endianness. What is the value of r1 after running

LDR r1, [r0]?

a. If little-endianness is used:

r1 = ________0x0DEB2C1A________________________

b. If big-endianness is used:

r1 = ________0x1A2CEB0D____________________________

ii. (06 points) Suppose the system is based on little-endianness. What are the values of r1 and r0 if the following instructions are executed separately and independently after initialization of r0 = 0x00008000?

LDR r1,[r0,#4]

r0 **=** _____0x00008000____

r1= _____0x79CDA3FD____

LDR r1,[r0,#4]!

r0 = ___0x00008004____

r1 = ___0x79CDA3FD____

Q6. **(06 points)** Suppose r0 = 0x2000,0000 and r1 = 0x1234,5678. All bytes in memory are initialized to 0x00.

```
STR r1, [r0], #4
STR r1, [r0, #8]!
STR r1, [r0]
```

Assume the computer uses Little Endian to store data. Show the memory content when the above program completes successfully.

Memory Address	Memory Content
0x2000,0013	
0x2000,0012	
0x2000,0011	
0x2000,0010	
0x2000,000F	12
0x2000,000E	34
0x2000,000D	56
0x2000,000C	78
0x2000,000B	
0x2000,000A	
0x2000,0009	
0x2000,0008	
0x2000,0007	
0x2000,0006	
0x2000,0005	
0x2000,0004	
0x2000,0003	12
0x2000,0002	34
0x2000,0001	56
0x2000,0000	78

Q7. **(12 points)** What do the following assembly programs calculate?

Program 1:

```
f       MOV r2, #1
        MOV r1, #1
loop    CMP r1, r0
        BGT done
        MUL r2, r1, r2
        ADD r1, r1, #1
        B   loop
done    MOV r0, r2
```

It calculates $n!$ of value n in register r0

Program 2:

```
      AREA my code, CODE
      EXPORT __main
      ALIGN
      ENTRY
__main PROC

      MOVS   r0,#0
      MOVS   r1,#15
      MOVS   r2,#0

loop
      CMP    r2,r1
      BGT    stop
      MLA    r0,r2,r2,r0
      ADDS   r2,r2,#1
      B      loop

        % The final result is saved in register r0

stop
      B     stop
      ENDP
       END
```

It calculates $\sum_{i=0}^{15} i^2$ or $\sum_{i=1}^{15} i^2$. Both answers are correct.

Questions have been marked according to the following assignment

Question #	Marked by:
1	Sam Aleyadeh
2	Sam Aleyadeh
3	Alexis Pascual
4	Long Pham
5	Tianqi Yu
6	Ruitao Chen
7	Scott Aker

-EOF-