CMPE 364 (Makeup)
Midterm Exam 1
Spring 2017
April 2nd, 2017

Instructions: Read carefully through the entire exam first, and plan your time accordingly. Note the relative weights of each segment. Make sure that you have all pages of the exam. If you are missing any pages, inform the instructor immediately.

During this exam you may use the book *Introduction to Microprocessor Based Systems Using the Arm Processor* by Kris Schindler as well as any notes handwritten by you. The use of any other reference material will result in the confiscation of your exam and you receiving a score of 0. No electronic devices are allowed.

Write your answers on this exam. **Do not write on the back of any pages.** If you need additional space, use the extra pages at the end of the exam. Anything written on the backside of a page will not be graded.

When answering questions that require calculations, be sure to show your work. Answers without appropriate work will not receive credit. When answering questions that request an explanation, keep your explanation short and correct. Explanations containing incorrect or irrelevant information will be marked wrong, even if correct information is also included.

When you are done, present your completed exam to the instructor at the head table. If leaving before the exam period is concluded, please leave as quietly as possible as a courtesy to your neighbors.

TL;DR:

- **You can use the book and handwritten notes, but nothing else.**
- **Don't write on the back of any pages, use the extra pages at the end.**
- **Show your work or you won't get points.**
- **Keep justifications concise and correct.**

Name:

Student ID Number:

Signature:

1. Short answer

   Answer the follow short questions. For answers requiring an explanation, use 1-2 sentences. For answers requiring calculations, show your work.

   (a) (5 points) What is the value of register r3 after the following instruction has executed? Assume that r1 and r2 contain `0x9596a442` and `0xa59c6d64` respectively.

   ```
   ADD r3, r2, r1
   ```

   Solution:
   0x3B3311A6

   (b) Determine the value of the CPSR after the following instruction executes. Assume the CPSR, register r1, and register r4 initially contain 0xA0000010, `0x00000008`, and `0x0x0000004B` respectively.

   ```
   CMP r1, r4
   ```

   Solution:
   CPSR = `0xA0000010`

2. Memory

(a) (5 points) Consider the following map of memory. What are the contents of registers r2 and r4 after the execution of the following instruction? Assume that r2 and r4 initially contain `0x01596273` and `0x80084020` respectively. Also assume that processor is configured in little-endian mode.

```
LDR r2, [r4], #4
```

Address	Contents
0x80084024	0xa1
0x80084023	0xc1
0x80084022	0x7d
0x80084021	0x55
0x80084020	0x62
0x8008401F	0xac
0x8008401E	0xfb
0x8008401D	0x07

Solution:

r4 = 0x80084024
r2 = 0xc17d5562

(b) (5 points) Consider the following map of memory. Determine the contents of registers r4, r2, r5, and `sp` after the execution of the following instruction, given an initial value of `0x80084018` for `sp`.

```
LDMED sp!, {r4,r2,r5}
```

Address	Contents
0x80084024	0x00111100
0x80084020	0x44555544
0x8008401C	0x88999988
0x80084018	0xCCDDDDCC
0x80084014	0x11333311
0x80084010	0x22444422
0x8008400C	0xAACCCCAA

Solution:

r5 = 0x00111100
r4 = 0x44555544
r2 = 0x88999988
sp = 0x80084024

3. Simple Coding

Consider the following short coding questions.

(a) (5 points) Rewrite the following sequence of instructions to be more efficient (i.e., use less instructions):

```
start:  mov r3, r3, LSL #2
        add r2, r2, r3
        add r1, r1, #1
        cmp r1, #5
        bge end
        b start
end:    swi 0x11
```

Solution:

```
    start:  add r2, r2, r3, LSL #2
            add r1, r1, #1
            cmp r1, #5
            blt start
            swi 0x11
```

(b) (10 points) Write a short program which implements the following line of high level language pseudocode. Assume all source registers may be used as scratch registers.

```
r0 := (r3 * 1023) / 4 + (r4 + 65) / 32 - r5
```

Solution:

```
mov r5, #1023
mul r3, r5, r3
mov r3, r3, asr #2
add r4, r4, #65
mov r4, r4, asr #5
add r0, r3, r4
sub r0,r0, r5
```

4. (15 points) Arrays

Consider the following definition of median adapted from Wikipedia:

> The median is the value separating the higher half of a data sample, a population, or a probability distribution, from the lower half. In simple terms, it may be thought of as the "middle" value of a sorted data set. For example, in the data set {1, 3, 3, 6, 7, 8, 9}, the median is 6, the fourth number in the sample. The median is a commonly used measure of the properties of a data set in statistics and probability theory.

Write a subroutine called `find_median_sum` that returns the sum of all values in the array that are less than the median. (In the example above, the median_sum would be $1 + 3 + 3 = 7$). Your subroutine should follow the conventions specified by the AAPCS. Your answer should include only the subroutine.

You should *not* assume the array is already sorted. However, you may assume that a subroutine called `sort` exists and that you can use it to sort an array. `sort` takes as parameters the address of the array to sort as well as the number of elements in the array. Assume that `sort` follows the AAPCS.

Parameters for `find_median_sum`:

- Address of an array of integers.
- Number of elements in the array. (Guaranteed to be odd.)

Return value of `find_median_sum`:

- The sum of all values in the array that are less than the median.

Solution:

```
; r4 contains address of array
; r0 contains # of elements
find_media_sum:
    stmfd sp!, {sp, lr}

    bl sort

    mov r1, #0 ; counter
    mov r2, #0 ; running sum

    ; Calculate the stopping point
    mov r0, r0, LSR #1

    loop:
        cmp r1, r0
        bgt end
```

```
        ldr r3, [r4], #4
        add r2, r2, r3

        add r1, r1, #1
        b loop
    end:
        ldmfd sp!, {r4, lr}
        mov r3, r0
        bx lr
```

End of Exam.

Extra Work Page 1.
If you need more space to write your answer to a problem, then write it here and make a note on the problem's main page referring to this space.

Extra Work Page 2.
If you need more space to write your answer to a problem, then write it here and make a note on the problem's main page referring to this space.