Xi'an Jiaotong-Liverpool University

西交利物浦大學

PAPER CODE	EXAMINER	DEPARTMENT	TEL
CPT210	Jianjun Chen	Computer Science and Software Engineering	81889137

2nd SEMESTER 2021/22 FINAL EXAMINATION

Undergraduate – Year 3

Microprocessor Systems

TIME ALLOWED: 2 Hours

SUBMISSION TIME ALLOWED: 30 Minutes

INSTRUCTIONS TO CANDIDATES

1、 **This is an open-book examination.**

2、 **Total marks available are 100. This will count for 70% in the final assessment.**

3、 **Answer all questions.**

4、 **Only English solutions are accepted.**

5、 **All answers should be submitted to the LearningMall at the end of the exam.**

Question A (20 Marks)

In this question, we consider a non-standard floating point number representation, which is based on IEEE-754 but has different order and lengths of fields as shown below:

Mantissa (15 bits)	Sign (1 bit)	Exponent (16 bits)

Assume that the bias is still calculated based on the formula: $2^{exponent} - 1$.

1. Convert the following decimal numbers into the above non-standard representation form. Please write down all intermediate steps of the calculations of mantissa and exponent. Your answers should be written in hexadecimal form. (5 marks each)
    a. 21.875
    b. 1.384765625

2. Convert the following numbers which uses the non-standard representation form into their decimal values accurate to 5 significant figures. Please write down all intermediate steps. (5 marks each)
    a. 0x9D008002
    b. 0x70018009

Question B (20 Marks)

1. What is the function of the program counter? How does a branch instruction differ from most other instructions in relation to the program counter? (5 marks)

2. A "branch and link" instruction uses a special register called a link register. What is the purpose of the link register? How does a 'branch and link' instruction differ from a simple branch instruction? (5 marks)

3. What is the difference between a logical shift right and arithmetic shift right? (4 marks)

4. Explain why the instruction "MOV r0, #0x00110023" would give an error when executed? How could this value be moved into a register then? (6 marks)

Question C (30 Marks)

1. Write an ARM assembly language program to swap the position of the largest number and the smallest number stored in "my_numbers". Assume that the number of elements in "my_numbers" is always fixed to 10 and a same number will never appear twice. (15 marks)

   my_numbers DCD -15, 11, 7, -3, 2, 55, 4, 1, 21, -6

2. Write an ARM assembly language program that can rotate all Bytes separately to the right in register R9 once. (15 marks)

   R9 (example data)

0000 0001	0110 0111	0101 1010	1111 1110

   R9 rotated once

1000 000	1011 0011	0010 1101	0111 1111

Question D (30 marks)

Given the following piece of ARM code and also assume a three-stage pipeline:

```
            cmp         r1, #3
            blt         lt3
ge3         lsl         r8, r1, r4
            b           exit
lt3         lsl         r8, r1, #2
            orr         r8, r8, r5
            lsl         r8, r8, #2
            orr         r8, r8, r6
exit        lsl         r8, r8, #4
```

Assume that the values saved in R1 are always integers ranging from 1 to 8. In 80% of the cases, the values of R1 are 2, 3, 4 and 5 with an even distribution of chances. In the rest 20% cases, the values of R1 can be any other integers within the range with an even distribution of chances.

Your task:

1. Draw the pipeline diagrams of this ARM program. All cases of R1 must be considered. Please clearly indicate the status of each clock cycle and the number of cycles needed for the whole process. (16 marks)

2. Optimise the program by rewriting it. In your new program, you are only allowed to change the value of R8. Explain in details why the new design can reduce the average number of clock cycles and draw the new pipeline diagrams. (20 marks)

END OF FINAL EXAM