**Course Details:**



Sections 2 and 4

Instructor: **Prof. Adil Ibrahim**

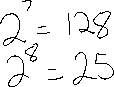
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**Problem 1 (3 points)**

Consider the following instruction format in a 32 bit instruction set and answer the following questions:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Opcode | DR | 000 | SR1 | SR2 |

1. If there are a total of 125 registers. What is the minimum number of bits required to represent a single register? How many different instructions are possible?



1. Write the binary form of the multiplication instruction MUL R3, R1, R2 assuming the opcode of this instruction to be 24 in decimal.



**Problem 2 (2 points)**

If there are 224addressable locations in memory and in each location 4 byte of data is stored, what will be the size of:

1. MAR
2. MDR



**Problem 3 (6 points)**

1. Describe the difference between data movement, control and operate instructions.



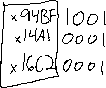
1. Classify each of the following instructions into one of the above three categories: AND, JMP, LEA, STI, TRAP, NOT



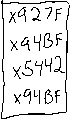
**Problem 4 (4 points)**

Write LC3 instructions for the following tasks in hex.

1. Subtract the value of R2 from R3 and store the result in R3. (R3 <- R3 - R2)

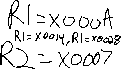


1. Take the OR of R1 and R2 and store the result in R2. (R2 <- R1 OR R2)



**Problem 5 (10 points)**

1. Write what each instruction does in the “comment” section. The first one is completed for you **(6 points)**



|  |  |  |
| --- | --- | --- |
| **Address** | **Instruction** | **Comment** |
| x3000 | 0101 0000 0010 0000 | **R0 <- R0 AND 0** |
| x3001 | 0001 0000 0010 0011 |  |
| x3002 | 1010 0010 0000 1010 |  |
| x3003 | 1010 0100 0000 1010 |  |
| x3004 | 0001 0010 0100 0001 |  |
| x3005 | 0001 0100 1010 0001 |  |
| x3006 | 0001 0000 0011 1111 |  |
| x3007 | 0000 0011 1111 1100 |  |
| x3008 | 0001 0000 0100 0010 |  |
| x3009 | 1011 0000 0000 0011 |  |
| x300A | 0011 0010 0000 0010 |  |
| x300B | 0011 0100 0000 0010 |  |
| x300C | 1111 0000 0010 0101 |  |

1. The following table shows the initial values at certain memory locations (i.e, before the execution of the program begins). What are the final values at these memory locations after the program completes? **(4 points)**

|  |  |  |
| --- | --- | --- |
| **Address** | **Initial** | **Final** |
| x300D | x4000 |  |
| x300E | x4001 |  |
| x4000 | x0005 |  |
| x4001 | x0006 |  |

**Problem 6 (3 points)**

Assume the current value in the PC to be **x401A**.

1. Write the **BR** instruction to **unconditionally** branch to the instruction located at an offset of **x0EF**.



1. What will the PC point to after the **BR** statement in (a) is executed? Show the hexadecimal representation.



1. If unconditional branching is possible using **BR**, why do we need the **JMP** instruction?



**Problem 7 (4 points)**

List four LC3 instructions that cause the condition codes to change.

