**BIRZEIT UNIVERSITY**

**ENCS2380- Computer Organization and Microprocessor**

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Quiz #3

December 13, 2021

**Student Name:** ……………………………………………………

**Student ID:** ………………………………………………………..

**Quiz Time:** 20 minutes

**Question #1 (15 Points):** consider a processor to be developed with the following characteristics

- It has multiple instruction formats; each instruction is 32-bit.
- It has a register set; each register is 32-bit.
- It has a unified byte-addressable memory

The following is the R-Type arithmetic and logic instruction format

| Opcode (6 bits) | Rd (5 bits) | Ra (5 bits) | Rb or Signed Immediate (16 bits) |
|---|---|---|---|

The following is the load/store instruction format

| Opcode (6 bits) | Rd (5 bits) | Memory Address (21 bits) |
|---|---|---|

The following is a snapshot of a part of this processor's memory. Assume that instructions start at address 200, data start at address 217, and the memory content is in hexadecimal

| Address | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | 211 | 212 | 213 | 214 | 215 | 216 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Content | 18 | 01 | 88 | 12 | FA | 0E | 3B | 5E | 00 | 12 | 45 | 87 | FA | 0B | A3 | 55 | 60 |
| Address | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 |
| Content | 45 | AB | FF | 39 | C4 | 48 | E0 | 1F | 79 | 08 | 01 | 20 | EC | FD | 19 | 03 | 11 |

Answer the following questions:

1. **(2 points)** What is the maximum number of instructions this processor can have?

The maximum number of instructions = maximum number of possible opcodes
$$= 2^{number\ of\ bits\ to\ represent\ opcode}$$
$$= 2^6 = 64 \text{ instructions}$$

2. **(2 points)** What is the maximum number of registers this processor can have?

The maximum number of registers $= 2^{number\ of\ bits\ to\ represent\ register\ number}$
$$= 2^5 = 32 \text{ registers}$$

3. **(2 points)** What is the maximum memory size (in MB) this processor can address?

The maximum addressable memory size $= 2^{number\ of\ bits}$ in the memory address
$$= 2^{21} = 2 \text{ MB}$$

4. **(2 points)** What is the range of the signed immediate operand value this processor can have?

The data has 16-bit width. Thus range is:

$-2^{n-1}$ ➔ $2^{n-1} - 1$ ➔ $-2^{15}$ ➔ $2^{15} - 1$

5. **(4 points)** Assume that **lb** instruction loads one byte from memory to the least significant part of the destination register, **lh** loads half word, and **lw** loads one word. Assume little endianness, what is the content of the first five registers in hexadecimal after executing the following sequence of instructions, assuming the initial values of registers are zeros?
   ```
   lw R1, 220
   lb R0, 220
   lh R4, 230
   lw R7, 210
   ```

| Register No. | Content in Hexadecimal |
|:---:|:---:|
| R0 | **0x00000039** |
| R1 | **0xE048C439** |
| R2 | **0x00000000** |
| R3 | **0x00000000** |
| R4 | **0x000019FD** |

6.  (**3 points**) Assume PC = 200, what is the content of the PC and the IR registers after executing the instruction that the PC points to

| PC | **204** |
|:---|:---|
| IR | **0x18018812** |