EE 4305 Computer Architecture
Homework #1

The main objective of this HW is to understand how the MIPS instructions are designed. The best way of learning the instruction set design is to decode few instructions and also disassemble few. Make sure to install the MARS assembler on your computer and verify your machine codes. If your computer does not recognize Mars4_5.jar file, a simple solution is installing the NetBeans IDE.

1: Instruction Decoding

The MIPS source code is given below. Hand assemble these instructions on the given space using the MIPS Reference called “Green Sheet.” Verify the hand-assembled codes using the MARS assembler. Set “Settings/Memory Configuration/Configuration” to “Default” which starts the user code memory (text area) at 0x400000.

```
for1: slt $t0, $s0, $s3
    beq $t0, $zero, for1
    addi $s1, $s0, -1
    slti $t0, $s1, 0
    bne $t0, $s1, exit2
    sll $t1, $s1, 2
    add $t1, $s2, $t1
    jal smap
    addi $s1, $s1, -1

exit2: lh $s2, 100($t0)
        lui $s2, 200
        j for1

smap: sh $s2, 200($t0)
        lw $t0, 4($t1)
        sw $t0, 4($t1)
        jr $ra
```

Mark the instruction fields, fill in the binary bit patterns, and write in hex. Verify the machine code using MARS. Follow the example shown for the first instruction.

```
for1: slt $t0, $s0, $s3
Address in hex: 400000
Machine code in binary:

<table>
<thead>
<tr>
<th>31</th>
<th>30</th>
<th>29</th>
<th>28</th>
<th>27</th>
<th>26</th>
<th>25</th>
<th>24</th>
<th>23</th>
<th>22</th>
<th>21</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
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</tr>
</tbody>
</table>

Machine code in hex: 0213 402a
```

------------------------------------------------------------------------------------------
```
beq $t0, $zero, for1
Address in hex: 400004
Machine code in binary:

31  27  23  19  15  11  7  3  0

Machine code in hex:

éli $s1,$s0,-1
Address in hex:
Machine code in binary:

31  27  23  19  15  11  7  3  0

Machine code in hex:

slti $t0,$s1,0
Address in hex:
Machine code in binary:

31  27  23  19  15  11  7  3  0

Machine code in hex:

bne $t0,$s1, exit2
Address in hex:
Machine code in binary:

31  27  23  19  15  11  7  3  0

Machine code in hex:
```
sll  $t1,$s1,2
Address in hex:
Machine code in binary:

```
31  27  23  19  15  11  7  3  0
```

Machine code in hex:

```
\ldots\ldots\ldots\ldots
```

add  $t1,$s2,$t1
Address in hex:
Machine code in binary:

```
31  27  23  19  15  11  7  3  0
```

Machine code in hex:

```
\ldots\ldots\ldots\ldots
```

jal  smap
Address in hex:
Machine code in binary:

```
31  27  23  19  15  11  7  3  0
```

Machine code in hex:

```
\ldots\ldots\ldots\ldots
```

addi  $s1,$s1,-1
Address in hex:
Machine code in binary:

```
31  27  23  19  15  11  7  3  0
```

Machine code in hex:

```
\ldots\ldots\ldots\ldots
```
exit2:  lh  $s2, 100($t0)
Address in hex:
Machine code in binary:

Machine code in hex:

lui  $s2, 200
Address in hex:
Machine code in binary:

Machine code in hex:

j     for1
Address in hex:
Machine code in binary:

Machine code in hex:

smap: sh   $s2, 200($t0)
Address in hex:
Machine code in binary:

Machine code in hex:
lw $t0,4($t1)
Address in hex:
Machine code in binary:

```
19 23 31 0 27 3 7 11 15
```

Machine code in hex:

```
-------------------------------
```

sw $t0,4($t1)
Address in hex:
Machine code in binary:

```
19 23 31 0 27 3 7 11 15 23 19
```

Machine code in hex:

```
-------------------------------
```

jr $ra
Address in hex:
Machine code in binary:

```
31 27 23 19 15 11 7 3 0
```

Machine code in hex:

```
-------------------------------
```
2: Disassemble the given machine code to an assembly code

MIPS machine code: 0x3c1101f4
Binary:

<table>
<thead>
<tr>
<th>31</th>
<th>27</th>
<th>23</th>
<th>19</th>
<th>15</th>
<th>11</th>
<th>7</th>
<th>3</th>
<th>0</th>
</tr>
</thead>
</table>

Assembly instruction:

MIPS machine code: 0x02538822
Binary:

<table>
<thead>
<tr>
<th>31</th>
<th>27</th>
<th>23</th>
<th>19</th>
<th>15</th>
<th>11</th>
<th>7</th>
<th>3</th>
<th>0</th>
</tr>
</thead>
</table>

Assembly instruction:

MIPS machine code: 0x08100011
Binary:

<table>
<thead>
<tr>
<th>31</th>
<th>27</th>
<th>23</th>
<th>19</th>
<th>15</th>
<th>11</th>
<th>7</th>
<th>3</th>
<th>0</th>
</tr>
</thead>
</table>

Instruction: Since the corresponding label is not provided, show it in the form of direct address, i.e., j 0x######. Assume that the current PC is at 0x400200, and show the address using a 32-bit byte address in hex.)

Print this form, fill in by hand, check and correct your translation using MARS assembler, add your name at the top of the first page, then submit.