Student ID: ______________

CS 151
Quiz 4

Name : ______________ , ______________
(Last Name) (First Name)

Student ID : ______________

Signature : ______________

Instructions:

1. Please verify that your paper contains 9 pages including this cover.
2. Write down your Student-Id on the top of each page of this quiz.
3. This exam is closed book. No notes or other materials are permitted.
4. Total credits of this quiz are 45 points.
5. To receive credit and for possible re-grade request you must show your work clearly.
6. For possible re-grade request make sure that your write clearly.
7. Calculators are NOT allowed.
Q1: [ALU Design] [10 points]

We want to design a 4-bit Arithmetic Unit (AU) with the following functional table:

<table>
<thead>
<tr>
<th>M</th>
<th>Function Name</th>
<th>F(A,B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Add A and 2*B</td>
<td>A+2*B</td>
</tr>
<tr>
<td>1</td>
<td>Subtract B from A</td>
<td>A-B</td>
</tr>
</tbody>
</table>

A = a1a0 and B = b1b0 are two 2-bit binary numbers which should be extended to 4-bit numbers a3a2a1a0 and b3b2b1b0. M is the control input to this AU.

For doing this, the blocks labeled “Black Box” and CE (Carry Extender) in the following block diagram should be designed:
Fill the following table for $y_3$, $y_2$, $y_1$, $y_0$, $a_3$, $a_2$ and $c_0$ based on the inputs of the AU which are $a_1$, $a_0$, $b_1$, $b_0$ and $M$. [10 points]

<table>
<thead>
<tr>
<th>$M$</th>
<th>$y_3$</th>
<th>$y_2$</th>
<th>$y_1$</th>
<th>$y_0$</th>
<th>$a_3$</th>
<th>$a_2$</th>
<th>$c_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$b_1$</td>
<td>$b_1$</td>
<td>$b_0$</td>
<td>0</td>
<td>$a_1$</td>
<td>$a_1$</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>$b_1'$</td>
<td>$b_1'$</td>
<td>$b_1'$</td>
<td>$b_0'$</td>
<td>$a_1$</td>
<td>$a_1$</td>
<td>1</td>
</tr>
</tbody>
</table>
Q2: [Data Path and Controller Design] [35 points]

Considering the following high-level state machine and assuming that CLR, LD and UD are one bit control inputs and SUM and I are 8-bit outputs of the circuit:
1. Design the data-path for this system. [15 points]
2. Design the interface of the system and the interface between the controller and the datapath. [5 points]
3. **Design the FSM of the controller. [15 points]**

HINT: There is no timing issue for this system so you do not have to consider timing issues in designing the controller’s FSM.