Name of the person on your left: ________________________________

Name of the person on your right: ________________________________

1. 10 points
2. 10 points
3. 20 points
4. 20 points
5. 20 points
6. 20 points
Total (100 pts.)

- Do not start the exam until you are told.
- Write your name and PID at the top of every page. Write the names of people on your left and right on the first page.
- Turn off and put away all your electronics. This is a closed-book, closed-notes. You may only refer to one 8 ½ x 11” page of your handwritten notes.
- By turning in this exam for grading you are stating that you have followed the UCSD’s academic honesty policies. Do not look at anyone else’s exam or talk to
anyone but an exam proctor.

- If you have a question, raise your hand and an exam proctor will come to you.
- You have 80 minutes to finish the exam. When the time is finished, you must stop writing.

Write your answers in the space provided. To get the most partial credit, clearly show all the steps of your work. Full credit may not be given for correct answers with no work shown.
Problem 1 (10pts)
Timing characteristics of the components in the circuit below are as follows:

Flip flop: PD – 65ps, CD – 35ps, setup time – 40ps, hold time – 45ps
Logic gates (AND, OR, XOR, INV, NOR): PD – 40ps, CD – 30ps
Half adder: PD – 65ps, CD – 55ps
Clock skew: ZERO

PD: Propagation Delay; CD: Contamination Delay

(a) What is the maximum clock frequency of operation for this circuit?

(b) Is the hold constraint met? If not, how would you ensure it is?
Problem 2 (10pts)
The counter shown below goes through a repeating sequence starting from 0000.

(a) How many clock cycles does it take before the sequence repeats? List all the transitions in the sequence.

(b) Derive a Boolean expression that outputs a logic ‘1’ when a palindrome is detected on the current value of “WXYZ”. List all palindromes that you observe in the first 10 transitions of the sequence.

A palindrome is a string which reads the same in both directions. For example, 10101 is a palindrome whereas 1100 is not as it is 0011 backwards.

Problem 3 (20pts)
Design a mealy FSM with minimum number of states that outputs a logic one only when the remainder of division by 8 of the input received to that point is equal to 1. The bits that are received sooner are the more significant bits, for example number eleven is received as 1, 0, 1, 1. Here is sample input and output:

sequence (MSB): 01000101001
output: 01000100001

(a) Draw the state diagram for the FSM

(b) Provide an excitation table. Use binary encoding for the states, so state S0=00, S1=01, S2=10 etc.

(c) Implement the circuit for LSB of the next state logic.
Problem 4 (20pts)
For the given circuit draw the waveform for outputs ‘A’ and ‘B’ based on the given signals ‘inp’ and ‘clk’. Assume that all circuits have near zero delay.
\[ S = B' \lor BA \]
<p>| | | | |</p>
<table>
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| 0 | 0 | 1 | $S = B + C$
     |   |   | (Addition) |
| 0 | 1 | 0 | $S = A \ XOR \ C$
| 0 | 1 | 1 | $S = (B \ OR \ C)'$
| 1 | 0 | 0 | $S = A \ XNOR \ C$
| 1 | 0 | 1 | $S = \ NOT \ B$
| 1 | 1 | 0 | $S = B' \ OR \ AB$
| 1 | 1 | 1 | $S = B \ OR \ C$

**Problem 5 (20pts)**

Design an ALU with three 8-bit operands A, B and C and control inputs x, y and z, which implements the bitwise operations described in the table. You must use one of each of the following components and minimum number of other gates.

- 8:1 MUX
- 8-bit adder
- 2:1 MUX
**Problem 6 (20pts)**
The following pattern detector has an input B. Once it detects a pattern, it sets OUT equal to ‘1’. Use the partially filled out state diagram and state table to do the following:

(a) Fill in the missing entries in the state table and complete the FSM.

*S*$_1$S$_0$ is the encoding of the state. S$_1$S$_0^*$ is the next state.

<table>
<thead>
<tr>
<th>S$_1$</th>
<th>S$_0$</th>
<th>B</th>
<th>S$_1^*$</th>
<th>S$_0^*$</th>
<th>OUT</th>
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![State Diagram](image)
(b) Which pattern is detected by this FSM?

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