Homework #7
Due Su. 11/05

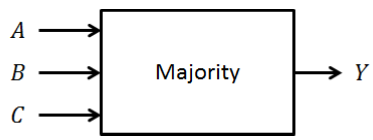
Note: Do not use a calculator or computer to complete the following exercises. You must show all your work and put a box around your final answer to receive credit. Messy or unreadable submissions will receive no credit.

Homework will only be accepted at the beginning of class and all pages must be stapled together.

Total Points: 125

1. (0 points) How long did it take you to complete the homework? This will not affect your grade (unless omitted) but it helps gauge the workload for this and future semesters. If you do not answer this question you will get -5 points.

2. (8 points) Consider a module (i.e. circuit) whose output Y is TRUE when a majority of its 3 inputs (A, B, and C) are TRUE. The overall module is shown below as a "black box" (representation of circuit only showing the input/output interfaces).

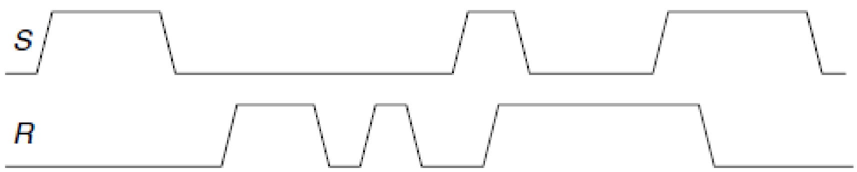


   (a) (2 points) Write the the truth table for the majority function.
   (b) (3 points) Give the minimized Boolean equation of this function.
   (c) (3 points) Sketch the two-level circuit that implements this function using a minimized number of gates.

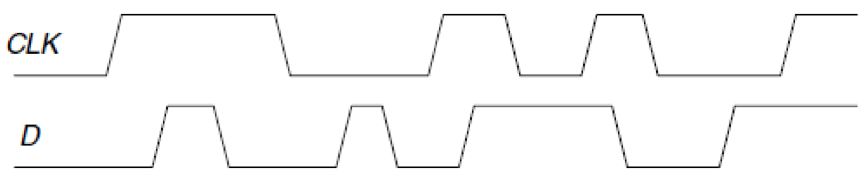
3. (15 points) Consider a module (i.e. circuit) that performs the addition of two bits. The inputs are A and B (two bits to be added) and the output is S (sum of the bits) and C_{out} (the carry-out) from addition.
   (a) (2 points) Draw the black box representation of this circuit.
   (b) (2 points) Do hand addition for all possibilities of A and B and give both output values of S and C_{out}.
   (c) (3 points) Write the the truth table for this function.
   (d) (4 points) Give the minimized Boolean equations of this function.
   (e) (4 points) Sketch the two-level circuit that implements this function using a minimized number of gates.

4. (15 points) The previous circuit is called a half-adder because it performs addition but without C_{in} (carry-in) input. Build a full-adder that has inputs A, B and C_{in} and outputs S and C_{out}.
   (a) (2 points) Draw the black box representation of this circuit.
   (b) (2 points) Do hand addition for all possibilities of A, B and C_{in} and give both output values of S and C_{out}.
   (c) (3 points) Write the the truth table for this function.
   (d) (4 points) Give the minimized Boolean equations of this function.
   (e) (4 points) Sketch the two-level circuit that implements this function using a minimized number of gates.

5. (8 points) Use multiple full-adders to implement 4-bit addition in hardware. (Note: this is an example of abstraction and hierarchy to make design faster and easier). The inputs to the module should be the 4-bit values to be added: $A_3A_2A_1A_0$ in shorthand $A_{3:0}$ and $B_{3:0}$. The outputs should be the 4-bit sum $S_{3:0}$ and a single carry-out bit C_{out}.
   (a) (2 points) Draw the black box representation of this circuit.
   (b) (6 points) Sketch a circuit to implement the 4-bit addition using the full-adder circuits (black-box representation) that you designed previously. *Hint*: Each bit can be handled by a full-adder with carry-out passed to the next bit as when you do the 4-bit addition by hand.
6. (15 points) Harris 2.41
7. (10 points) Harris 2.44
8. (8 points) Given the following input waveforms, sketch the output Q of an SR latch. Your answer should show both the S and R signals and the output Q waveform below.



9. (16 points) Consider the input waveforms below. Give the output for the following state elements. Your answer should show both the CLK and D signals and the output waveforms below.



   (a) (8 points) Sketch the output Q_1 for a D latch.
   (b) (8 points) Sketch the output Q_2 for a D flip-flop.
10. (5 points) The toggle (T) flip-flop has one input, CLK and one output, Q. On each rising edge of CLK, Q toggles to the complement of its previous value. Draw a schematic for a T flip-flip using a D flip-flop and an inverter.
11. (25 points) Hand's On Design: Full Adder

    Full instructions on the website

    `http://www.ee.unlv.edu/~b1morris/cpe100/docs/comp02.pdf.`

    Your homework solution should include answers to the following below.
   (a) (0 points) How many hours did you spend on the lab?
   (b) (10 points) A printout of the Quartus II schematic.
   (c) (10 points) A print out of the ModelSim simulation of the circuit.
   (d) (5 points) A brief paragraph (2-4 sentences) highlighting what you learned on this lab assignment. List any difficulties you encountered.