Name(Pinyin):
Email(Prefix):

Computer Architecture Homework 4
2018 Spring March.26

Instructions:

Homework 4 covers the content of SDS and FSM, please refer to the lecture slides. You can print it out and write on it, and <u>scan</u> it into a pdf. Or you can take photos or edit the pdf if you want, just remember: you must create a **PDF** and upload to the **Gradescope**. Please assign the questions properly on Gradescope, otherwise you will lose 25% of points.

Question Set 1. Simple CMOS Network (15pt)

Design a NOR gate using n\p-channel transistors. Draw a concise diagram and a truth table using the given variable name (input) $\overline{X + Y} = Z$ (output)

Question Set 2. Finite State Machine and Truth
Tables (35pt)

You are playing a strange Pacman Game, start from 0 score.
- If you eat a **food**, you get 2 points.
- If you eat a **capsule**, you get 3 points.
- If you got eaten by a **ghost**, your score just minus 2 but will
  not die.
- If your score is larger than or equal to **4,** you win.
- **Note** that You will **not** get a negative score, for example,
  when you only have 1 score and got eaten by a ghost, you
  get 0.
- **Note** that when you **win**, you scores goes to 0 and game
  restart.

2.A Represent the whole game as a finite state machine (FSM). Draw the FSM diagram satisfying
the following requirements.(15pt)
- Use 2-bits to represent each state.
- The outputs are 1-bit. (1: win, otherwise 0)
- On each edge, exactly one action will be taken.
- The Inputs are 2-bits, "00": eat a food. "01": eat a capsule. "10": eaten by a ghost.
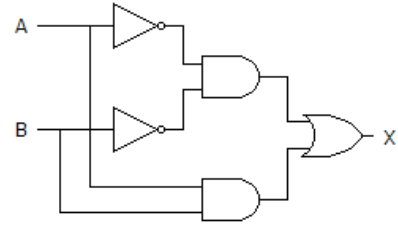- Example of the FSM diagram:
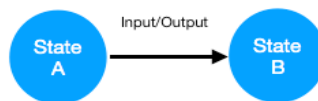
2.B Represent it as an Truth table. Hint: Input, State A, State B -> Output (10pt)

2.C Find out the MOST simplified SOP (Sum of Product) Expression to represent the output with state and input. Write down the expression. (10pt)

Question Set 3. Boolean Algebra(20pt)

3.A Write down the Boolean expression of the circuit. What is this gate? (5pt)

3.B Simplify the following expression step by step (as simple as possible). (5pt)
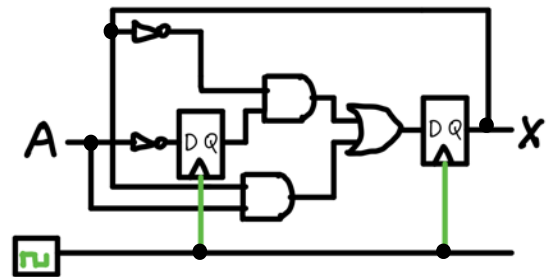
$$F = \overline{\overline{AB} + \overline{\overline{C}}} + A\overline{C} + B$$

3.C "Life is a simple line with pulses". (10pt)
See! I made some changes in the 3.A and what a fancy diagram!
Look:

A. NOT gates have 2ns delay, all other logic gates have 3ns delay.
B. The input A is stable 2 ns after the clock edge.
C. Register setup time is 3 ns.
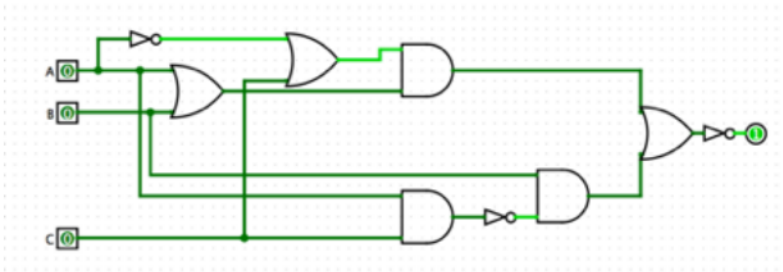D. Hold time is 2 ns.

3.C_i ----- How long could you live?
Assuming clk-to-q delay is 1 ns, what is the maximum possible clock frequency at which we can run this circuit correctly? (Show me how to calculate)

Answer: _____Hz

3.C_ii ----- How long can you sleep?
If the clock period is 15ns, what is the maximum clk-to-q delay?

Answer: _____ns

Question Set 4. Boolean Algebra Again (30pt)

4.A Fill out the truth table for this circuit. You aren't allowed to use the blank columns.

A	B	C							Out
0	0	0							
0	0	1							
0	1	0							
0	1	1							
1	0	0							
1	0	1							
1	1	0							
1	1	1							

4.B Given your truth table from part a, use sum of products to write the UN-simplified, Boolean expression for this circuit. This question will be graded independently of the correctness of part a. DO NOT simplify the expression.

Answer:

4.C Using Boolean logic, simplify the expression further so that it uses as few gates as possible. Draw the new circuit that corresponds the simplified expression. You may only use binary (2 inputs) NOT, AND, and OR gates