CS 211 Computer Architecture

Assignment 3

1. Consider the logic equation:

$$x_1\bar{x}_3 + \bar{x}_2\bar{x}_3 + x_1x_3 + \bar{x}_2x_3 = \bar{x}_1\bar{x}_2 + x_1x_2 + x_1\bar{x}_2$$

Prove this relation.

2. Consider the following equation:

$$f(x_1, x_2) = x_1\bar{x}_2 + \bar{x}_1\bar{x}_2 + \bar{x}_1x_2$$

Show its circuit form using only ***AND***, ***OR***, ***NOT*** gates.

3. Consider the following truth table:

x_1	x_2	x_3	$f(x_1, x_2, x_3)$
0	0	0	**1**
0	0	1	**0**
0	1	0	**1**
0	1	1	**1**
1	0	0	**0**
1	0	1	**0**
1	1	0	**0**
1	1	1	**1**

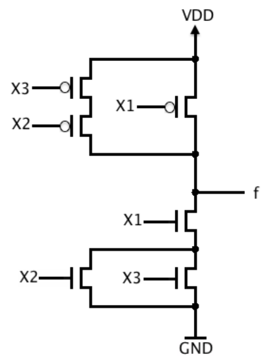
Which minterms are equal to **1**?
Which maxterms would be used to specify the product of sums form?

4. Consider the following specification for a digital circuit. Assume that you are in a large room with three doors and that there is a switch next to each door, controlling the light in the room. Let x_1, x_2, x_3 be input variables denoting the state of each switch. Assume the light is off if all switches are open. Closing any of the switches will turn the light on. Then, turning a second switch will turn off the light. Thus, the light will be on if exactly one switch is closed and will be off if two (or no) switches are closed. If the light is off when two switches are closed, then it must be possible to turn it on by closing the third switch. If $f(x_1, x_2, x_3)$ represents the state of the light, ***show its truth table***. Also, show its SoP and PoS realizations in circuit form. You do not need to provide minimal forms, just scan them using the minterms and maxterms.

5. Use algebraic manipulation to find the minimum-cost sum of products form for $\Sigma M(1,2,4,7)$. Confirm using a Karnaugh Map that you have the right solution.

6. Design the simplest product of sums that implements:
$f(x_1, x_2, x_3) = \Pi M(0,2,5)$. Confirm using a Karnaugh Map that you have the right solution.

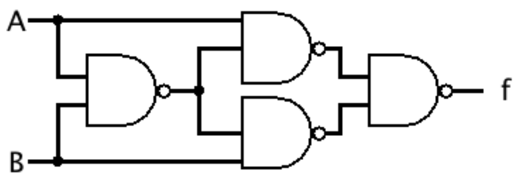
7. What is the truth table for this CMOS circuit?



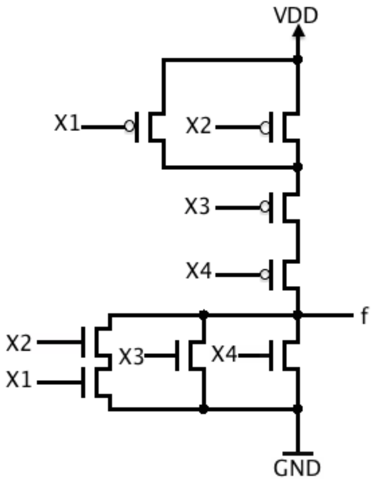
What is the minimal-cost expression for this truth table?

8. Design the CMOS equivalent of an XNOR gate using a series of AND, OR and NOT gates.

9. What is the logic operation realized by this circuit?

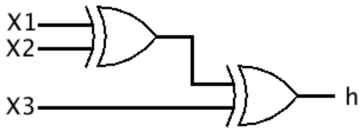


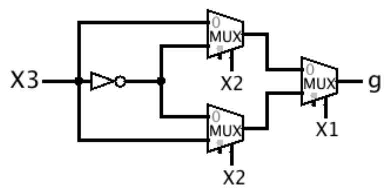
10. Consider the following CMOS circuit. What is its truth table?



What is the minimum product of sums form?

11. What is the relationship between these two circuits?





12. Determine the number of gates needed to implement an n-bit carry lookahead adder, assuming unbounded inputs per gate.
Use **AND, OR, XOR** gates with any number of inputs.

13. Build a 4-16 decoder using five 2-4 decoders

14. Realize the function:

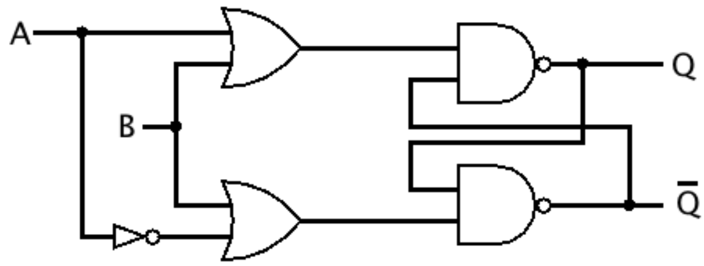
$$f(w_1, w_2, w_3) = \Sigma M(0,2,3,6)$$

Using gates with arbitrary number of inputs.

15. A MUX-NOT flip-flop (MN flip-flop) behaves as follows. If M=1 the flip-flop complements the current state. If M=0, the next state of the flip-flop is equal to N. Derive the truth table and excitation table for an M-N flip-flop.

16. Realize a D flip-flop using gates and a T flip-flop.

17. Derive the truth table for the following circuit:



18. Design an UP-Counter counting from 0 to 5 using T flip-flops

19. How are a latch and a flip-flop different?

20. Show how a J-K flip-flop can be constructed using a T flip-flop and other logic gates