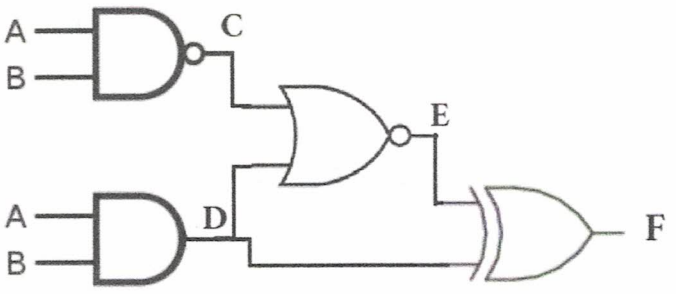
***Detailed solutions will be provided in discussion***

# CS M51A, Winter 2021, Assignment 2
# (8 Pages, Total Mark: 110 points, 11% )

Due: Wed Jan 20, 10:00 AM Pacific Time

Student Name:
Student ID:
**Note:** You must complete the assignments entirely on your own, without discussing with others.

1. (a) (8 points) Derive the truth table for the following system, filling in the intermediate gate outputs in the table below.



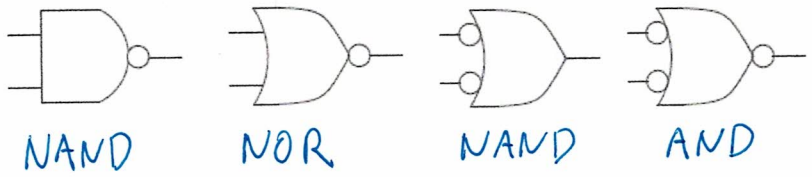

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 1 | 0 | 1 | 0 | 1 |

(b) (4 points) State a logical expression for F and simplify it as much as possible.

F = ((A NAND B) NOR (AB)) XOR (AB)

F = AB

2. (4 points) What is the equivalent operation (please select from these four: `OR`, `NOR`, `AND`, or `NAND`) for each of the following gates?




3. (a) (2 points) For 3 inputs $A$, $B$, $C$, construct the truth table for the function $F$ that is 1 when the binary number $ABC$ is a digit in your student ID. For example, if you student ID is 20340259, the rows 000, 010, 011, 100, and 101 should be 1, while the other entries should be 0 (we are ignoring 8's and 9's in your student ID).

   Write your student number here:

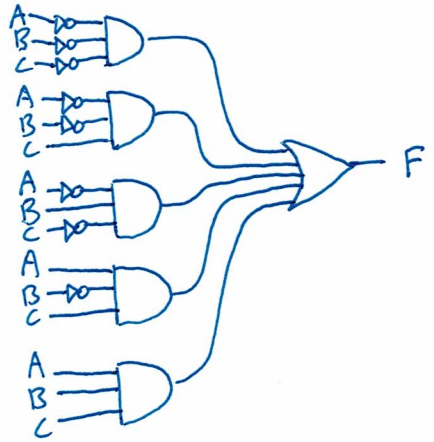
| $A$ | $B$ | $C$ | $F$ |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 |

Example:
015 928 781

(b)(4 points) Give the sum of minterms expression for $F$.

$F = A'B'C' + A'BC + AB'C + ABC$

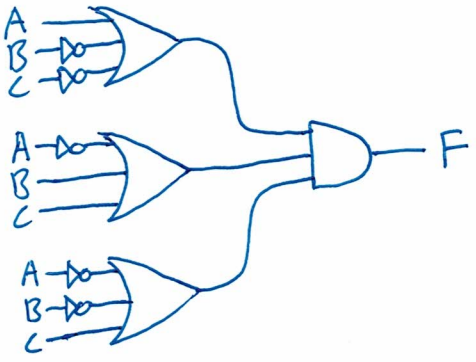
(c) (4 points) Draw the gate symbol design that implements $F$ from part (b).



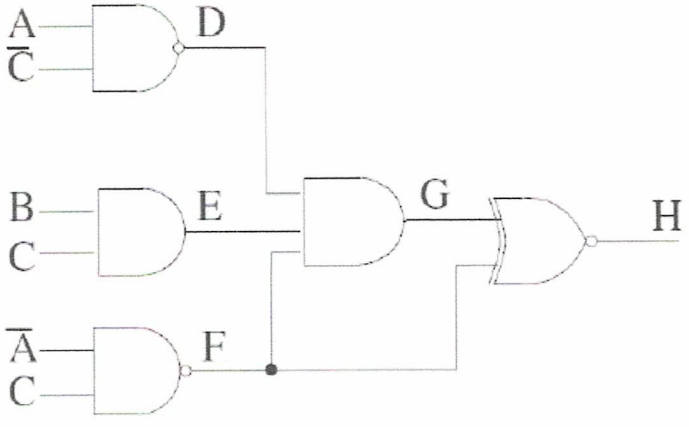
(d) (4 points) Give the product of maxterms expression for $F$.

$F = (A + B' + C')(A' + B + C)(A' + B' + C)$

(e) (4 points) Draw the gate symbol design that implements $F$ from part (d).




4. (a) (10 points) Complete the truth table table for H in the following system, giving the truth table values for the internal variables D, E, F, and G as intermediate steps.



| $A$ | $B$ | $C$ | $D$ | $E$ | $F$ | $G$ | $H$ |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

(b) (4 points) Give simplified boolean formulas for G and H in terms of A, B, and C. Then try to reduce and simplify these functions as much as possible.

$G = ABC$

$H = A'B'C + A'BC + ABC$

$H = A'C + BC$

5. Using boolean algebra, Simplify the following expression as much as possible.

(a) (4 points) F= AB+ ABC + A' + B' + BC

$F = 1$

(b) (4 points) F= A + A'B + A'B'C + A'B'C'D + A'B'C'D'E

$F = A + B + C + D + E$

(c) (4 points) F= A'B' + AB + A'B

F = A' + B

(d) (4 points) F = (AB' + C')(B' + C)(A + BC')

F = AB'

(e) (4 points) F= A' + A(A'B + B'C)'

F = A' + B + C'

(f) (4 points) (A'B' + C)(A+B)(B'+AC)'

F = A'BC

6. (4 points) For a system with two inputs (A,B), convert (A+B')·(A'+B') to a sum of minterms expression.

A'B' + AB'

7. (4 points) For a system with three inputs (A,B,C) Convert A'B'C' + A'BC' + AB'C + ABC to a product of maxterms expression.

$(A+B+C')(A+B'+C')(A'+B+C)(A'+B'+C)$

$$\sum m(0,2,5,7) = \prod M(1,3,4,6)$$

8. Design a system that takes as input 4 bits (A1 A0 B1 B0) that is treated as two separate 2 bit integer values A: A1A0 and B: B1B0. The output F of the circuit will be a 1 if the value of A is equal or greater than the value of **B** (i.e. $A \geq B$) and false otherwise.

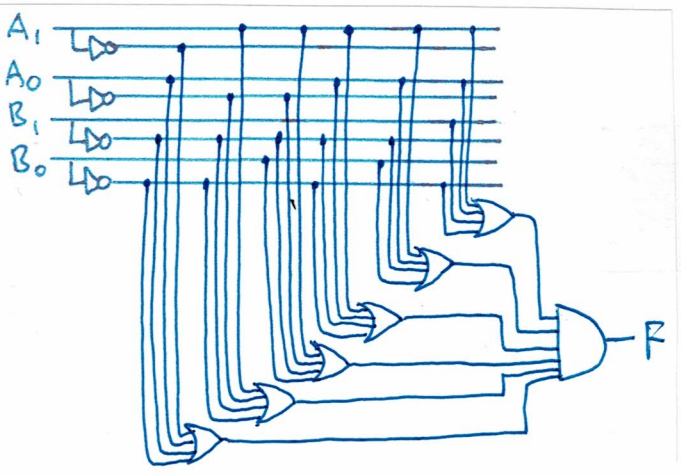
   (a) (6 points) First fill in the truth table below and implement the output function F.

| $A_1$ | $A_0$ | $B_1$ | $B_0$ | $F$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 1 | 1 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 |

   (b) (4 points) Give the product of maxterms expression for F

$F = (A_1+A_0+B_1+B_0')(A_1+A_0+B_1'+B_0)(A_1+A_0+B_1'+B_0')(A_1+A_0'+B_1'+B_0)(A_1+A_0'+B_1'+B_0')(A_1'+A_0+B_1'+B_0')$

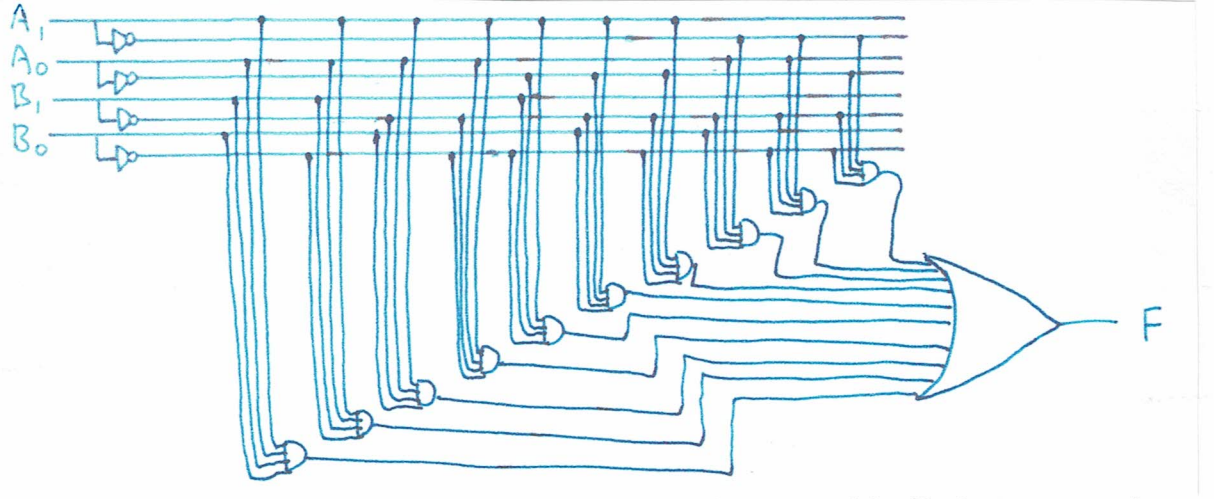
(c) (4 points) Draw the gate symbol design that implements F from part (b)




(d) (4 points) Give the sum of minterms expression for F.

$F = A'_1A'_0B'_1B'_0 + A'_1A_0B'_1B'_0 + A'_1A_0B'_1B_0 + A_1A'_0B'_1B'_0 + A_1A'_0B'_1B_0 + A_1A_0B'_1B'_0 + A_1A_0B'_1B_0 + A_1A_0B_1B'_0 + A_1A_0B_1B_0$

(e) (4 points) Draw the gate symbol design that implements F from part (d)




(f) (4 points) Simplify the expression for F as much as possible (It does not need to be in the form of sum of minterms or product of maxterms).

$F = A_1A_0 + A_1B'_1 + A_1B'_0 + A_0B'_1 + B'_1B'_0$

(g) (4 points) Draw the gate symbol design that implements F from part (f)