Midterm November 5, 2020
Deadline October 6, 2020 by 2pm Pacific Time

## Problem 1 (10 points)

How many bits are required to encode a color spectrum capable of supporting 16 million colors using:

        a: Decimal digits in BCD
        b: Hexadecimal representation

which representation is more efficient and why?

## Problem 2 (10 points)

Fill in the missing entries

| Radix | Value | Value in decimal |
|-------|-------|------------------|
| 16 | (5 1 7) | |
| 8 | (5 1 7) | |

True or False:
a: A bubble on the output of a logic gate indicates that the output is active HIGH
b: Bubbles on the input lines of logic gates indicate that these inputs are active LOW
c: The Boolean expression for a logic circuit is A' + B' = X  (A' is complement A)
This tells us both inputs are active LOW and the output is active HIGH.

## Problem 3 (10 points)

Given $E(a, b, c, d) = (ab + c)' (ac + (b' + c' + a'cd)') + a((b + c)(b + d) + c)'$, which of the following represents the same function as $E(a, b, c, d)$? Show all your work.

1. $a+b+c+d'$             2. $a' + b + c$            3. $b + c' + d$

4. $a'b'c'd$                 5. $ab'c'$               6. $b'cd'$

## Problem 4: (10 points)

a: Explain Gray Codes and their characteristics and explain conversion of GC to Binary with an example
b: What is X-3 code and explain the self complementary property of it.
c: Subtract $(-25)_8$ from $(25)_{10}$ using 2's complement and explain the results in octal and decimal

d: realize XOR gate using NOR gates only.

**Problem 5: (10 points)**

Given the following simplification of a boolean expression, answer the following.

$$
\begin{aligned}
& (ab' + c')'(b' + c)(a + bc') && (1) \\
={} & (ab')'c'(b' + c)(a + bc') && (2) \\
={} & (a' + b)c'(b' + c)(a + bc') && (3) \\
={} & (a' + b)c'(ab + ac + bb'c' + bcc') && (4) \\
={} & (a' + b)c'(ab + ac) && (5) \\
={} & (a' + b)(ab + ac)c' && (6) \\
={} & (aa'b + abb + aa'c + abc)c' && (7) \\
={} & abc' + abcc' && (8) \\
={} & abc' && (9)
\end{aligned}
$$

a: (4 points) There is at least one mistake in this simplification. Find all steps that are derived incorrectly from its previous step (for example, write (8)→(9) if equation (9) is derived incorrectly from (8)).

b: (6 points) Show the correct simplification of (1)

**Problem 6: (20 points)**

**a**: Express the given expression in a product of maxterms:

$$F = xy + x'z$$

**b**: simplify the following boolean function and realize it using NOR gates

$$F = (A,B,C,D) = A'B'D' + A'CD + A'BC$$
$$d(A,B,C,D) = A'BC'D + ACD + AB'D'$$

**c**: simplify the Boolean function in SOP and POS form
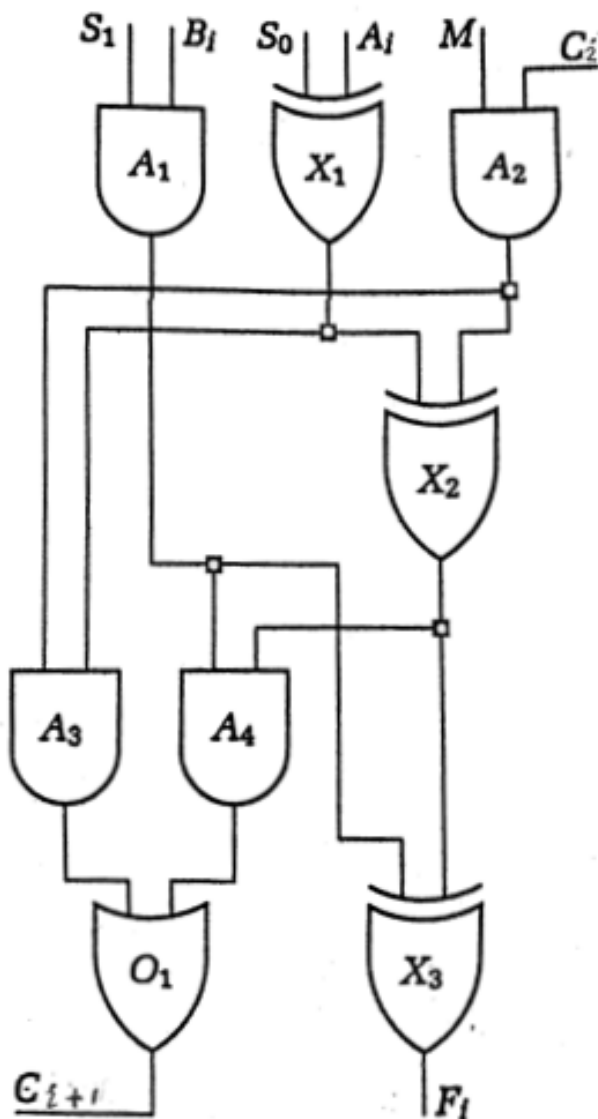$$F = \Sigma\,(0,1,2,5,8,9,10)$$

**Problem 7: (20 points)**

a: Draw the logic diagram for a four-bit comparator and explain the $\geq$ block.

b: explain the BCD-to-7-segment decoding logic for "g" segment

c: explain Decimal to BCD priority encoder, draw it partially and show the truth table for inputs 3 and 6.

**Problem 8: (10 points)**

Consider the following gate network:



Determine the switching expressions for the outputs $F_i$ and $C_{i+1}$. Using AND, OR, NOT, XOR expressions as appropriate fill in the following table:

| $M$ | $S_1 S_0$ | Expression for $F_i$ | Expression for $CI+1$ |
|---|---|---|---|
| 0 | 00 | | |
| 0 | 01 | | |
| 0 | 10 | | |
| 1 | 10 | | |
| 1 | 11 | | |