CSE 140 Midterm 1 version A
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Spring 2015

Name of the person on your left: ____________________________

Name of the person on your right: __________________________

- Do not start the exam until you are told.
- Write your name and PID at the top of every page. Write the names of people on your left and right on the first page.
- Turn off and put away all your electronics. This is a closed-book, closed-notes. You may only refer to one 8½ x 11” page of your handwritten notes.
- By turning in this exam for grading you are stating that you have followed the UCSD’s academic honesty policies. Do not look at anyone else’s exam or talk to anyone but an exam proctor.
- If you have a question, raise your hand and an exam proctor will come to you.
- You have 80 minutes to finish the exam. When the time is finished, you must stop writing.
- Write your answers in the space provided. To get the most partial credit, clearly show all steps of your work.

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Problem 1
Universal Gates

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a) Given the above K-Map, derive the minimal Boolean expression in SOP.

\[ bc + a'b \]

b) Implement the same expression using only NAND gates and inverters.

![Diagram]

c) How many transistors does the NAND/INV implementation require?

14 transistors (or 16 transistors if did not use INV)
Problem 2  
K-Maps

Perform two-level logic size optimization for $F(a,b,c,d) = a'b'cd + a'bcd + abcd + abcd' + ab'cd'$ using a Kmap, assuming $c$ and $d$ can never be both 0.

a. List all the prime implicants

The Kmap of $F(a,b,c,d) = a'b'cd + a'bcd + abcd + abcd' + ab'cd'$ is

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Prime implicants: $a'cd, bcd, abc, ad'$

b. List all the essential primes

Essential implicants: $a'cd, ad'$

c. Show the minimal cover in Boolean equation format.

Minimal cover: $a'cd + ad' + bcd$ OR $a'cd + ad' + abc$
Problem 3
Boolean Logic

A logic network has three inputs (A, B, C) and one output (Z). In the following situations we set the output Z to either a logic zero or one:
1. The output Z is logic 1 when the binary value of ABC is greater than 3 and odd.
2. When the binary value of ABC is greater than 3 and even, Z is a logic 0
3. When the binary value of ABC is less than 3, the output Z follows the result of the expression B⊕C

a. Fill in the truth table

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Z</th>
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b. Write the canonical SOP of function Z using standard ∑ m( ) + DC( ) notation:
   \[ Z(A,B,C) = \sum m(1,2,5,7) + DC(3) \]

c. Write the minimum SOP expression for the function Z:
   \[ Z(A,B,C) = C + A'B \]
Problem 4
Logic minimization

Derive the minimal form of the following function using Boolean algebra (or Shannon’s expansion).

\[ f(A,B,C) = (a + c)(a + b)(b + c') \]

one possible result:
\[
\begin{align*}
    f(A, B, C) &= (a + c)(a + b)(b + c') \\
    &= (a + ab + ac + bc)(b + c') \\
    &= ab + ac' + ab + abc' + abc + acc' + bc + bcc' \\
    &= ab + ac' + bc \\
    &= ab + ac' + cb + cc' \\
    &= (ab + ac') + (cb + cc') \\
    &= a(b + c') + c(b + c') \\
    &= (a + c)(b + c')
\end{align*}
\]
Problem 5
Circuit Analysis

Z is a function of inputs A, B and C as shown in the circuit below.

a) Fill in the truth table.

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b) Write the minimum size Boolean equation for Z.

\[ Z(A,B,C,D) = ((A + B' + C)' \cdot B)' \cdot B \]
\[ = ((A'.B.C') \cdot B)' \cdot B \]
\[ = (A'.B.C') \cdot B = \]
\[ = (A + B' + C) \cdot B \]
\[ = A.B + B.C \]
\[ = B.(A + C) \text{ OR } AB + BC \]
Problem 6
Multiplexers

For the Boolean function \( f(a,b,c) = \Pi M(1,6,7) \) find the missing inputs to the multiplexers. Assume \( EN = 1 \).

Answer:

```
EN   EN
1     1
?
1     1
0     0
a     b
?
0
a'    1
c'    f
0
f

Answer:

EN   EN
1     1
1     a'
0     0
a     b
1
0
a'    1
c'    f
0
f
```
First Name:    Last Name:    PID:    

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