ECE2030A Fall 2008
Introduction to Computer Engineering
Exam #1

50 min in-class exam.
Close books, close notes.
NO calculator.

This exam is given under the Georgia Tech Honor Code System. You must observe and sign the Honor Pledge: “I have neither given nor received aid on this exam.” Your print name and signature below signifies your compliance with this honor code.

Name (Print): _____ SOLUTION __________

Signature: _________________________________________________

1. _____________ (15 pts)
2. _____________ (15 pts)
3. _____________ (30 pts)
4. _____________ (10 pts)
5. _____________ (30 pts)

Total (100 pts) ___________
1. (15%) Number representation. Please fill in the question marks assuming a “signed number system” using 2’s complement. Please derive your results step by step.

1.1. \((21)_{10} = (\ ?)_{2} = (\ ?)_{16}\)

\[
= 16 + 4 + 1 = (0001\ 0101)_{2} = (15)_{16}
\]

1.2. \((EC)_{16} = (\ ?)_{2} = (\ ?)_{10}\)

\[
= (1110\ 1100)_{2}
\]

MSB = 1, thus it is negative. To find out the decimal positive counterpart, we perform 2’s complement

\[
= (0001\ 0100) = 16 + 4 = 20
\]

Therefore, \((EC)_{16} = (1110\ 1100)_{2} = (-20)_{10}\)

1.3. What is the Hamming distance between the following two Hex numbers X and Y?

\[
X = D201 \\
Y = E62C
\]

The Hamming distance is the minimum number of substitutions required to change one into the other

\[
1101 \ 0010 \ 0000 \ 0001 \\
1110 \ 0110 \ 0010 \ 1100
\]

\[
0011 \ 0100 \ 0010 \ 1101 \\
\rightarrow 7 \text{ is the Hamming distance.}
\]
2. (15%) Fill in the truth table of the following Boolean logic \( F = A \oplus B \oplus C \)

2.1. (8%) Fill in the output of the truth table below.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

2.2. (7%) What do you think this function is used for?

Even/odd detection. The output indicates the even/odd number of a given 3-bit input
3. (30%) Draw the CMOS implementation of the following Boolean expressions.

\[ F = A + B + C \cdot (B \cdot D) \]

**Preferred route:**

PUN: \[ F = \overline{A} \cdot \overline{B} + C \cdot (B + \overline{D}) \]

**The other route:**

PDN: \[ \overline{F} = (A + B) \cdot C \cdot (B \cdot D) \]

\[ \overline{F} = (A + B) \cdot (C + (B \cdot D)) \]
4. (10%) Given a Boolean equation below. Convert this equation into a canonical Product-Of-Sum form. (You can use any method you like.)

\[ F = \overline{A} + A \cdot \overline{B} \cdot C \]

\[ F = \overline{A} + A \overline{B} \overline{C} \]

\[ = (\overline{A} + A)(\overline{A} + \overline{B} \overline{C}) \]

\[ = \overline{A} + \overline{B} \overline{C} \]

\[ = (\overline{A} + \overline{B})(\overline{A} + C) \]

\[ = (\overline{A} + \overline{B} + \overline{C})(\overline{A} + \overline{B} \overline{C} + C) \]

\[ = (\overline{A} + \overline{B} + C)(\overline{A} + \overline{B} + \overline{C})(\overline{A} + \overline{B} + C) \]

\[ \therefore F = \prod M(4, 6, 7) \]
5. (30%) Given the following canonical SOP form (with don’t care component) in $\mathcal{B}^4$.

$$F(A, B, C, D) = \sum m(0, 2, 5, 6, 8, 10, 14, 15) + d(7)$$

5.1. (15%) Construct the corresponding Karnaugh map based on $F$. Identify the “essential prime implicants” by circling the 1’s.

Find the essential PI’s.

5.2. (15%) what is the minimized SOP Boolean expression?

$$F = \overline{B} \cdot \overline{D} + \overline{A} \cdot B \cdot D + B \cdot C$$