Studio #3

Name of Students in team (max 3) | Student ID Number(s) | Section
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3.1 Drill with Boolean Logic
Studio 3.1 – Getting to know the laws of Boolean algebra the old-fashioned way.

3.2 Drill with Computer Arithmetic
Studio 3.2 – Getting to know addition and subtraction with binary numbers

3.3 Summarize Your Reading
Studio 3.3 - Summarize key points from selected sections of Chapter 2 (Sections 2.2 and 2.3).

Hand in for Grading to your Studio TA:
Studio 3 (one per group of students: at most 3 per group).
Due at the beginning of the next studio session (week of Sept 18).

<table>
<thead>
<tr>
<th>3.1</th>
<th>3.2</th>
<th>3.3</th>
<th>Total</th>
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<tbody>
<tr>
<td>60 points</td>
<td>20 points</td>
<td>20 points</td>
<td>100 points</td>
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Grader’s Signature: ____________________
Studio 3.1

Getting to know the Boolean laws the old fashioned way:

1. (25 points) Prove the following simplification theorems using the first eight laws of Boolean algebra. For each case, indicate explicitly which rule from our table (for example, 2D) that you used. This table is in Section 2.2.1 of your book, and is also summarized on our course web page.

   (i) \((x + y)(x + \overline{y}) = x\)

   (ii) \(x(x + y) = x\)

   (iii) \((x + \overline{y})y = xy\)

   (iv) \((x + y)(\overline{x} + z) = xz + \overline{x}y\)

2. (25 points) Using the rules of Boolean algebra, derive the expressions on the right hand side by simplifying the expressions on the left.
   (i) \(ab(c + d\overline{e}) + abcde\overline{e} = ab + acd\overline{e}\)
(ii) \( a(b + \bar{c})d + \bar{b}cd = ad + \bar{b}cd \)

(iii) \( (ab + c)(\bar{d}e + \bar{g}) = \bar{a}\bar{c} + b\bar{c} + deg \)

(iv) \( (x\bar{y} + uvz + \bar{w}) = x\bar{w}\bar{z} + uvwy + uvw\bar{x} + wy\bar{z} \)

(v) \( z\bar{x} + y\bar{z} = (\bar{x}z)(\bar{y}z) = (x + \bar{z}) + (y + \bar{z}) \)
6. (5 points) Suppose that \( f(x, y) \) is a Boolean expression involving variables \( x, y \). Use a few examples to show that the following equation does not work.
\[
f(x, y) = \text{Dual}(f(x, y)).
\]

7. (5 points) Using DeMorgan’s, and other laws, draw a circuit that implements \( f(x, y, z) = xy + yz + \overline{z} \) using only NAND gates. No other kind of gate is allowed in this circuit.
Studio 3.2

Binary addition and subtraction:

a. (15 points) Consider the two 8-bit positive binary numbers $\alpha = CB_{16}$, and $\beta = 2A_{16}$. Calculate $\alpha + \beta$, $\alpha - \beta$, $\beta - \alpha$ in the spaces below using binary arithmetic, and show your work, including all carry and borrow bits explicitly.

<table>
<thead>
<tr>
<th>$\alpha + \beta$</th>
<th>$\alpha - \beta$</th>
<th>$\beta - \alpha$</th>
</tr>
</thead>
</table>

b. (5 points) By converting all of the numbers $\alpha, \beta, \alpha + \beta, \alpha - \beta, \beta - \alpha$, to decimal, or otherwise, demonstrate why your calculations in part (a) are correct. Note that when you subtract a larger number from a smaller one, the result looks strange. Don’t worry. We’ll learn how to interpret these results once we learn about two’s complement representations.
Studio 3.3

1. (10 points) Read and summarize the main points from Sections (2.2) of the Katz textbook in the space below.

2. (10 points) Read and summarize the main points from Sections (2.3) of the Katz textbook in the space below.