Due Wednesday, October 11th. Written to the ECS 154A box in 2131 Kemper at 4pm. Submit authors.csv, 1.circ, 2.circ, 3.circ, 4.circ, 5.circ, 6.circ, 7.circ from the Logisim section to the p1 directory of cs154a by 11:59pm using handin.

Authors.csv.txt should be in the format:
First line: <e-mail of first partner> <comma> <family name of first partner> <comma> <given name of first partner>
Second line (if needed): <e-mail of second partner> <comma> <family name of second partner> <comma> <given name of second partner>

For example:
hpotter@ucdavis.edu, Potter, Harry
fflintstone@ucdavis.edu, Flintstone, Fred

Some terminology, in case it is not clear:
• $!x = \overline{x}$
• $\sum(3, 5, 6, 7) = m_3 + m_5 + m_6 + m_7$
• For a three input circuit $x_1$ is the 4-bit, $x_2$ is the 2-bit, and $x_3$ is the 1-bit, so $m_0 = x_1!x_2!x_3$, $m_4 = x_1!x_2x_3$.
• $D_1 = $ Don't Care at Truth Table location 1, $D_5 = $ Don't Care at 5, etc.

Written Assignment (36 points, 3 points each):

1. Use algebraic minimization to prove that $(A+B) \cdot (A+\overline{B}) = A$
2. Does $B!C!D + ABD + ABC + ABC = B!D + A\overline{B} + BC$? (show how you made your decision!)
3. Simplify $f(A, B, C) = \sum(3, 5, 6, 7)$ using a Karnaugh map.
4. Simplify $f(A, B, C) = \sum(1, 4, 5, 6, 7)$ using a Karnaugh map.
5. Simplify $f(A, B, C, D) = \sum(1, 4, 5, 6, 7, 8, 9)$ using a Karnaugh map.
6. Simplify $f(A, B, C, D) = \sum(0, 2, 4, 5, 6, 7, 8, 10, 13, 15)$ using a Karnaugh map.
7. Simplify $A!BC + B!C!D + BCD + AC!D + A!BC + AB!CD$
8. List all of the prime implicants, and determine which are essential for $f(A, B, C, D) = \sum(0, 2, 7, 8, 9, 10, 12, 13, 14, 15)$
9. Simplify $f(A, B, C) = \sum(D_0, D_1, m_2, m_3, m_4, D_5, m_6, m_7)$
10. Simplify $f(A, B, C, D) = \sum(D_0, m_1, D_2, m_3, m_8, D_9, m_{10}, m_{15})$
11. For the timing diagram below, synthesize the function $f(A, B, C)$ in the simplest sum-of-products form.

A
\hspace{1cm}
B
\hspace{1cm}
C
\hspace{1cm}
f

12. The following 12 bit patterns are received from memory.

1. 0 0 0 0 1 1 0 1 0 1 1 1
2. 0 1 1 1 1 0 0 0 1 0 0 0

Assuming the same single error correcting code we used in class, give the correct 8-bit data value for each pattern.
Show Your Work.
Logisim Assignment (39 points):

You may only use AND, OR, and NOT gates for the Logisim circuits unless specified otherwise. Make sure your pins and outputs have labels matching those specified, e.g. A, B, C, D. You should copy a testing circuit from ~ssdavis/154/p1 into its corresponding circuit, and connect it, before submitting your circuit. You should place the names of the author(s) in a file named authors.csv. All of the circuits MUST be submitted from the account of only one member of a team. The names of each circuit will be simply the problem number, i.e. 1.circ, 2.circ, … 7.circ.

1. (4 points) Create a circuit for the following functions.
   \( f = B!C!D + !ABD + !ABC + ABC \), \( g = B!D + !AB + BC \)

2. (4 points) Derive a minimum-cost circuit that implements the function \( f(A, B, C, D) = \sum(m4, m7, m8, m11, D12, D15) \)

3. (4 points) Suppose that we want to determine how many of the bits in a six-bit unsigned number are equal to 1. Design the simplest circuit that can accomplish this task. Input will be A,B,C,D,E,F, and output will be \( X_0, X_1, X_2 \) with \( X_0 \) being the least significant bit. You may use anything from Logisim libraries for this question.

4. (4 points) Show how the function \( f(A, B, C) = \sum(1, 2, 3, 5, 6) \) can be implemented using a 3-to-8 binary decoder and an OR gate. Please consider \( A \) to be the most significant bit, and \( C \) to be the LSB.

5. (4 points) Consider the function \( f = !A!C + B!C + !AB \). Derive a circuit for \( f \) that uses a 2-to-1 multiplexer.

6. (10 points) Given the following BCD-to-7-segment display code converter, derive minimal sum-of-products expressions for the outputs \( a, b, c, d, e, f, \) and \( g \) of the 7-segment display, and then implement the resulting circuit in Logisim. You must submit your seven Karnaugh maps with your written homework to receive credit for this problem.

   ![Karnaugh Map](image)

7. (9 points) Implement in Logisim the circuit to calculate the check bits and correct incoming errors using the format we used in class. You can check your work by making sure the bit patterns of problem 12 come out correctly. You may use any Logisim components you wish for this circuit. Use the following naming convention:
   (Left to right, most significant to least significant bit)
   
   \[ \begin{array}{ccc|ccc|ccc|ccc|ccc|ccc|ccc}
   w_3 & w_2 & w_1 & w_0 & a & b & c & d & e & f & g \\
   \hline
   0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
   0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 0 \\
   0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 \\
   0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 1 \\
   0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\
   0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 \\
   0 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \\
   0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\
   1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\
   1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\
   \end{array} \]

   msb  lsb
   Input Pins: D7 D6 D5 D4 D3 D2 D1 D0 -- Data Bits
   C3 C2 C1 C0 -- Check Bits
   Output Pins: Z7 Z6 Z5 Z4 Z3 Z2 Z1 Z0 -- Output Data Bits (corrected)