Cpr E 281 HW04
ELECTRICAL AND COMPUTER ENGINEERING
IOWA STATE UNIVERSITY

Minimization and Karnaugh Maps
Assigned: Week 4
Due Date: Sep. 22, 2025

P1 (20 points): Given the behavioral Verilog code below:

```
module Q1(f, a, b, c);
    output f;
    input a, b, c;
    assign f = (~(a | c) & b) | ~(c | ~(a & b);
endmodule
```

a. Draw the circuit diagram.
b. Rewrite using structural Verilog.

P2 (20 points): Given the logic expression $F(w,x,y,z) = \sum m(1,5,12,14)$

a. Draw the circuit for the expression F.
b. Use a K-map to derive the simplest SOP expression for F.
c. Redraw the circuit for F using the simplified SOP expression from b.
d. Compare the costs of the circuits implementing the expressions in parts a and c in terms of the total number of gates plus the total number of inputs.

P3 (15 points): Given the expression $Q = \bar{A}BC\bar{D} + A\bar{B}C + A\bar{D}B + A\bar{B}\bar{C}\bar{D}$

a. Use a K-map to derive the simplest POS expression for Q.
b. Use a K-map to derive the simplest SOP expression for Q.
c. Determine which circuit would produce a lower cost and draw that circuit.

P4 (15 points): Use Karnaugh Maps to derive the simplified POS expressions that correspond to the following expressions:

a. $F(W,X,Y,Z) = \sum m(3,5,6,7,11,13,14,15)$
b. $Q(A,B,C,D) = (\bar{B}+C+D)(\bar{A}+B+C+D)(C+\bar{B})(\bar{C}+\bar{A}+\bar{D})$
c. $Z(J,K,L,M) = M\bar{K}\bar{L} + \bar{J}L\bar{K} + \bar{K}L$

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P5 (20 points): Design a logic circuit with four inputs: $a_1, a_0, b_1,$ and b_0. Let a_1, a_0 represent the two-bit number A, while b_1, b_0 represents the two-bit number B. The output of the circuit, F, should be 1 if and only if the sum of the two-bit values A + B is an even non-zero sum. Otherwise, F should be 0.

a. Construct the truth table for this function, F.
b. Using a K-Map, derive the simplest SOP expression.
c. Draw the logic circuit based on the simplified SOP expression.
d. Implement your simplified expression in Verilog.

P6 (10 points): For each expression below, derive the simplest POS expression using don't care terms for simplification wherever possible:

a. $Q_1(A, B, C) = \prod M(0,2,6,7) + D(4,5)$
b. $Q_2(W, X, Y, Z) = \sum m(0,1,5,8,10,11,15) + D(3,4,13,14)$