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Student ID:

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BLG231E Digital Circuits
MIDTERM I

Duration: 120 Minutes

Grading: 1) 15%, 2) 20%, 3) 30%, 4) 20%, 5) 15%

Exam is in closed-notes and closed-books format; calculators are allowed

For your answers please use the space provided in the exam sheet

GOOD LUCK!

1) Consider a 4-variable Boolean function $f(x_1, x_2, x_3, x_4) = \prod(0,2,7,8,10,14)$; x_1 is the most significant bit. Obtain a minimal sum-of-products (SOP) expression for f using a **Karnaugh** map. Show all prime and essential prime implicants.

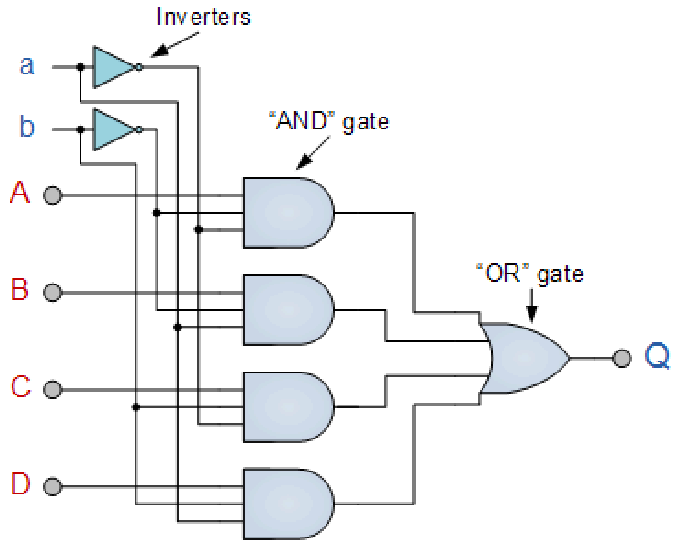
2) Consider a 4-variable Boolean function $f(x_1, x_2, x_3, x_4) = \sum(0,4,5,6,7,8,9,10,11,13,14,15)$; x_1 is the most significant bit.

- **a)** Using a **Quine-McCluskey** method, sketch the prime implicant table and show the essential prime implicants in the table.
- **b)** Using the table in a), obtain a minimal sum-of-products (SOP) expression for f.

3) Consider a 6-variable Boolean function $\boldsymbol{f = f_1(x_1, x_2, x_3, x_4) + f_2(x_4, x_5, x_6)}$ where $\boldsymbol{f_1}=\sum(1,2,3,5,7,12,14)$ - $\boldsymbol{x_1}$ is the most significant bit, and $\boldsymbol{f_2}=\sum(3,4,5,6,7)$ $\boldsymbol{x_4}$ is the most significant bit.

- **a)** Obtain a minimal sum-of-products (SOP) expression for $\boldsymbol{f}$.
- **b)** Implement $\boldsymbol{f}$ using only **two-input NAND** (NAND-2) gates; use minimal number of gates. Use only variables as inputs (**not their negated forms)**.

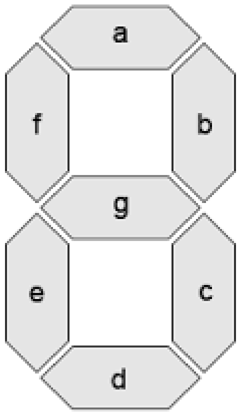
4) Consider a circuit with 6 inputs **a**, **b**, **A**, **B**, **C**, and **D**, and an output **Q**.



a) Convert this circuit to a NAND-2 based circuit.

b) If the input **a** is always logic 0, **a**=0 then simplify your NAND-2 based circuit by deleting unnecessary gates.

5) Consider a 7-segment display as shown below. It has 7 segments corresponding to 7 outputs **a**, **b**, **c**, **d**, **e**, **f**, and **g**. If an output is logic 1 then the corresponding segment is illuminated or lit. For example, if **a**=**b**=**c**=**d**=**e**=**f**=**g**=1 then all segments are lit that shows a digit 8. Digits 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 are aimed to be displayed such that when there is a binary input corresponding to a digit, the digit is shown in the display.



a) How many inputs should a display at least have? Is there any “don’t” care condition?
b) Obtain the truth table.