ECE 2030B Computer Engineering Spring 2009

4 problems, 5 pages Exam One 4 February 2009

Instructions: This is a closed book, closed note exam. Calculators are not permitted. If you have a question, raise your hand and I will come to you. Please work the exam in pencil and do not separate the pages of the exam. For maximum credit, show your work.
Good Luck!

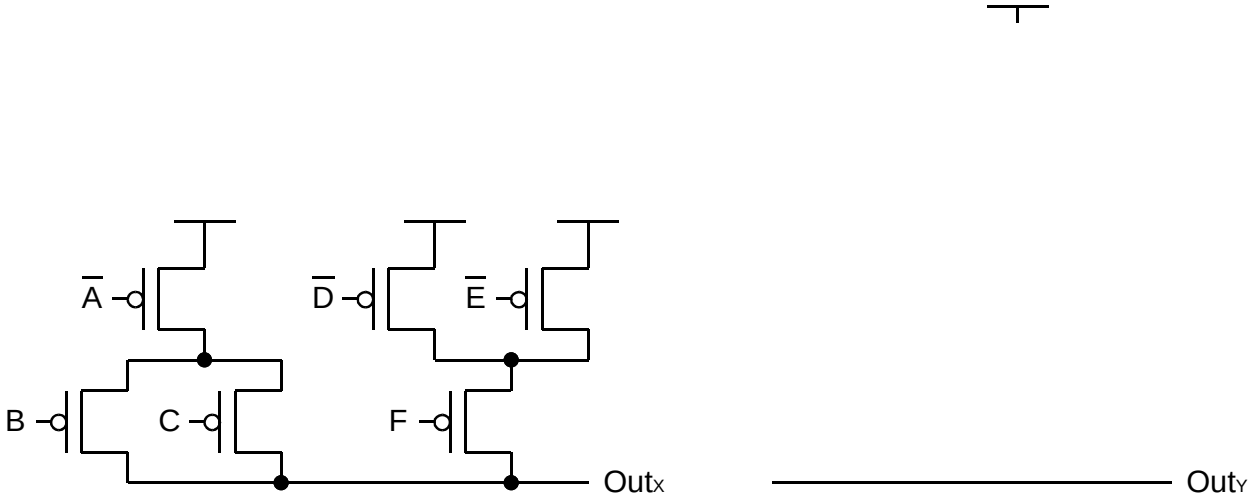
Your Name (***please print***) _____

1	2	3	4	total
20	28	22	30	100

Not 110 more weeks of winter!

Problem 1 (2 parts, 20 points) Switch-level Design

Several incomplete circuits are shown below. Complete each circuit by adding the needed switching network so the output is pulled high or low for all combinations of inputs (i.e., no floats or shorts). Complete each circuit (pull down, pull up, or both) and write the expression if one is not given. Assume both inputs and complements are available.



OUTx =

OUTy = $\overline{(\overline{A} + B \cdot \overline{C}) \cdot E \cdot F}$

Problem 2 (2 parts, 28 points) Mixed Logic Reengineering

For the following expressions, implement the Boolean expression using the specified gate type. Use correct mixed-logic notation. **Do not simplify the expression**. You may use multi-input gates. Minimize the total transistors (switches) required. When possible, use common subexpressions to reduce gate counts. Also determine the number of switches used in each implementation.

Part A (14 points) Implement $\overline{A \cdot (\overline{B} + C)} \cdot \overline{((\overline{B} + C) + \overline{D} + E)}$ using only **AND** and **NOT** gates.

switches = _____

Part B (14 points) Implement $\overline{\overline{A} + \overline{(\overline{B \cdot C} + D)} + \overline{E} \cdot F}$ using only **NAND** and **NOT** gates.

switches = _____

Problem 3 (2 parts, 22 points) Boolean Algebra

Part A (10 points) Transform each of the following Boolean expressions to a form where they are ready for switch level implementation (i.e., there should only be bars over input variables, not over operations). The behavior of the expression should remain unchanged. **Do not implement.**

$Out_X = \overline{(\overline{A+B}) \cdot (C+D) \cdot E + F \cdot \overline{G \cdot H}}$

$Out_Y = \overline{((A \cdot \overline{B} + C) \cdot \overline{D}) + (\overline{E} \cdot \overline{F})}$

Part B (12 points) For the behavior described by this truth table, (A) write the sum of products expression using minterms, (B) write the product of sums expression using maxterms, and (C) write the simplified sum of products expression (using any simplification technique).

A	B	C	Out
0	0	0	0
1	0	0	0
0	1	0	0
1	1	0	1
0	0	1	1
1	0	1	1
0	1	1	1
1	1	1	0

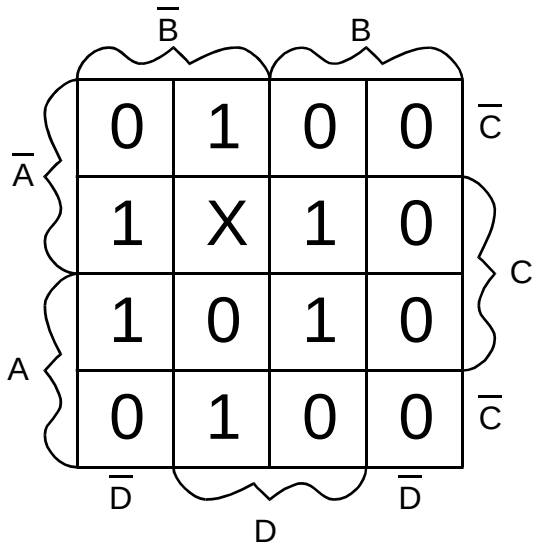
(A) SOP minterm expression

(B) POS maxterm expression

(C) simplified SOP expression

Problem 4 (2 parts, 30 points) Karnaugh Maps

Part A (12 points) Given the following Karnaugh Map, circle and list all the prime implicants for a *product-of-sums (POS)* expression, indicating which are essential. Derive the simplified *POS* expression.

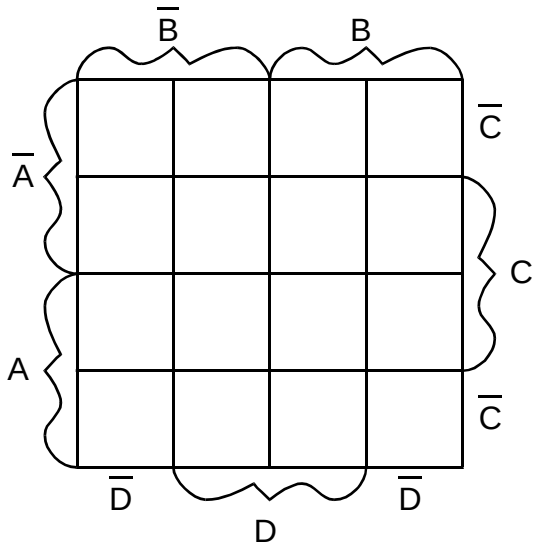


prime implicants	essential? yes	no
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐

simplified POS expression _____

Part B (18 points) For the following expression, derive a simplified ***sum of products*** expression using a Karnaugh Map. Circle and list all the prime implicants for a *sum-of-products (SOP)* expression, indicating which are essential.

$$Out = (B + D) \cdot (\overline{A} + B + \overline{D}) \cdot (A + \overline{B} + \overline{C})$$



prime implicants	essential? yes	no
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐
_____	☐	☐

simplified SOP expression _____