University of Waterloo

ECE 124 digital circuits and systems
Quiz #1
4:30-5:15
February 4, 2015

Instructor: Andrew Kennings — Time Allowed: 45 minutes

Name :	
ID :	

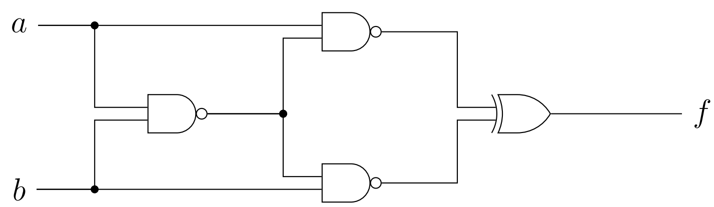
Instructions:

1. Answer all questions.
2. Calculators are permitted. Cell phones and all other electronic devices must be turned off.
3. The quiz is closed book.
4. Show all steps in your solutions to receive full marks.
5. Write in pen. Quizzes written in pencil will not be considered for remarking under any circumstances.

Q1	Q2	Q3	Total

Q1: This question is multiple choice. Each part has only **one correct answer**. Selecting an answer without showing work will be considered a wrong answer. A correct answer will receive full marks while an incorrect answer will receive zero marks.

(a) [4 MARKS] Which of the following Boolean functions is equal to the logic function f illustrated below:



(A) $f = a'b'$
(B) $f = a'b' + ab$
(C) $f = a'b + ab'$
(D) $f = a + b$
(E) $f = a'b$

Your answer is: $\boxed{}$

(b) [4 MARKS] Assume that you **only** have AND, OR and NOT gates available to you. The gates can have any number of inputs. Input variables are available in **uncomplemented form only**.

What would be the minimum number of logic gates required to implement the Boolean function $f = (xy + z + w)(z' + w)(z' + w + v)$?

(A) 0

(B) 1

(C) 2

(D) 3

(E) 4

Your answer is: $\boxed{}$

(c) [4 MARKS] You are given the logic function $f(a, b, c) = (a' + c)(b + c')(a + b + c)$. Which of the following is the proper product-of-maxterms representation of f?

(A) $f(a, b, c) = \Pi(0, 1, 4, 5, 6)$
(B) $f(a, b, c) = \Pi(1, 2, 3, 6, 7)$
(C) $f(a, b, c) = \Pi(0, 1, 2, 3, 5, 7)$
(D) $f(a, b, c) = \Pi(0, 2, 3, 6)$
(E) $f(a, b, c) = \Pi(1, 2, 4, 5, 7)$

Your answer is: $\boxed{}$

Q2: (a) [6 MARKS] Shown below is a truth table for a 3-input function f. Draw a minimized 2-level circuit implementation for f which uses only NOR gates with any number of inputs. Assume all inputs are available both complemented and uncomplemented. What is the cost of your circuit assuming each gate costs 1 and each gate input costs 1?

x	y	z	f
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

(b) [6 MARKS] Consider the 4-input function $f = abc + abd + a'c'd + a'b'c$ which is expressed as a minimized sum-of-products. Implement f using **only 2-input** NAND gates. Fewer NAND gates is better. No gate may be used to implement a NOT gate. Assume all inputs are available both complemented and uncomplemented. How many NAND gates do you require?

Q3: (a) [6 MARKS] Shown below is a Karnaugh map for a four input function f. Derive both a minimized sum-of-products and a minimized product-of-sums for f.

ab \ cd	00	01	11	10
00	X	X	X	X
01	0	1	1	0
11	1	0	0	1
10	0	0	0	0

(b) [6 MARKS] Shown below are the Karnaugh maps for two, 4-input functions f and g. Draw the lowest cost circuit that implements both f and g as sum-of-products expressions assuming that every logic gate costs 1 and every gate input costs 1. Assume all inputs are available both complemented and uncomplemented. What is the final cost of your circuit?

ab \ cd	00	01	11	10
00	0	1	0	0
01	1	1	1	1
11	0	0	1	1
10	1	1	0	0

f

ab \ cd	00	01	11	10
00	1	1	1	1
01	0	0	1	1
11	0	0	1	1
10	1	0	1	0

g