CS2102 02 Digital Logic Design Midterm 1 (1:20pm-3:10pm, Apr 2nd)

Name: _____ **ID:** 103062203 **(Return this with your answer sheet)**

$(x+y)' = x'y'$
$= 1(x'y')$
$= (x'+1)(x'y')$

Truth or False (30%):

(Write down T or F. You don't need to give the reason.)

1. F Digital signals can be only in the form of electrical voltage.
2. T For sequential logic circuits, the output depends not only on the current inputs, but also on the internal state.
3. T Boolean algebra can be derived from algebra over two element, {0, 1}, with two operators, AND and OR.
4. T The two DeMorgan's Laws, $\overline{(x \wedge y)} = \overline{x} \vee \overline{y}$ and $\overline{(x \vee y)} = \overline{x} \wedge \overline{y}$, are dual to each other.
5. _____ With a function of n variables, there are 2^n maxterms.
6. F Let $f(c,b,a) = \sum m(0,4,6)$. Then $\overline{f(c,b,a)} = \prod M(1,2,3,5,7)$.
7. F NAND gate is a universal gate but NOR gate is not.
8. F Any sum-of-products form is also sum-of-minterms, which is called the normal form.
9. T Sum-of-products form of Boolean equation can be implemented directly by two-level AND-OR circuit.
10. T The Boolean property, $x \vee (y \wedge z) = (x \vee y) \wedge (x \vee z)$, is called distributive property.

$x'y' + x'y'$

$x'(x'+y')$

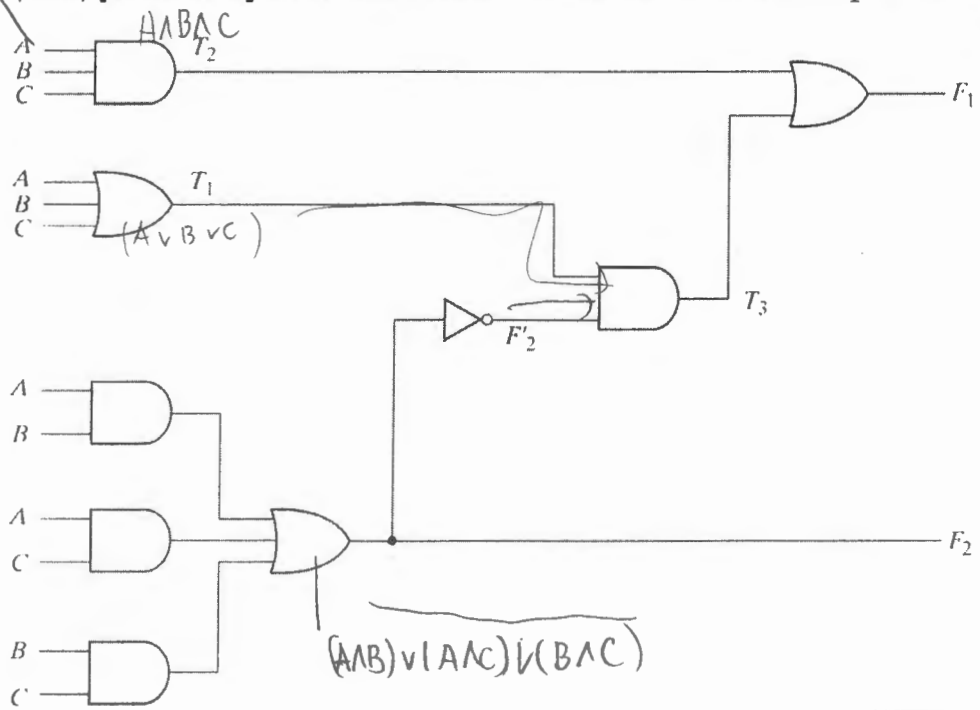
$= (x(xy))'$

$(\bar{x} \wedge 1) \wedge (\bar{y} \wedge 1)$

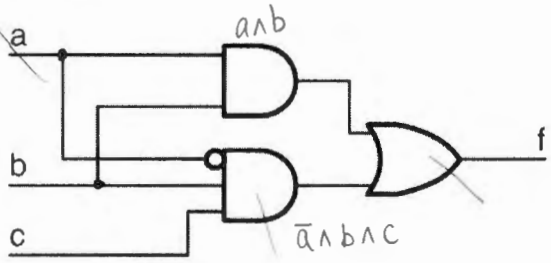
Answer the following questions: (70%)

(Write down your intermediate results. Do not give the final answer only.)

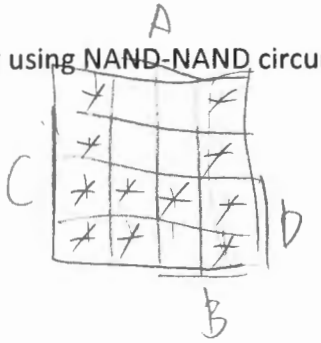
1. (5%) **[Algebra]** Prove the DeMorgan's Law $\overline{(x \vee y)} = \overline{x} \wedge \overline{y}$ by perfect induction.
2. (10%) **[Expression]** Reduce the following Boolean expression to a minimum number of literals:
   $(x \wedge y) \vee (y \wedge \overline{w}) \vee ((w \vee z) \wedge (w \vee \overline{z}))$
3. (10%) **[Schematic]** Write down the sum-of-minterms form for F_1 in the following logic circuit:

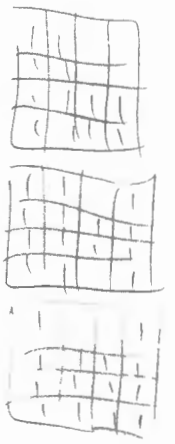


4. (10%) **[Implicant]** Simplify the function: $f(z, y, x) = 1$ if either one or two inputs are 1.
   (a) (3%) List all the prime implicants.
   (b) (3%) List the essential prime implicants if any.
   (c) (4%) List all the possible simplified sum-of-products forms.
5. (10%) **[Don't-Care]** Simplify the Boolean function with don't-care conditions, $f(d, c, b, a) = \sum \mathrm{m}(1, 5, 9, 11, 15) + D(0, 3, 6, 13)$, in product-of-sums form. And then implement the simplified function with a two-level OR-AND circuit.
6. (10%) **[Hazard]** Fix the hazard that may occur in the following circuit by redesign it:



7. (15%) **[Design]** Design a comparator of two 2-bit integers, $n_2 = \{d, c\}$ and $n_1 = \{b, a\}$. The output of the comparator will be 1 when $n_2 \geq n_1$.
   (a) (5%) List the truth table of the comparator.
   (b) (5%) List the simplified sum-of-products form.
   (c) (5%) Draw the logic diagram of the comparator by using NAND-NAND circuit.





$(\overline{a \wedge b}) = \bar{a} \vee \bar{b}$

Good Luck and Happy Children's Day!!

If you have too much time left, there is a joke for you:

A professor was giving the first midterm exam one day to his students. Once the test was over, the students all handed the tests back in. The professor noticed that one of the students had attached a $1000 bill to his test with a note saying

"Ten dollars per point!"

The next class the professor handed the tests back out. This student got back his test, an envelope with $650 change, and a note saying "Thanks."