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ITI 1100-B Digital Systems I

Mid-Term Examination

First Name: Ali

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Student #: Sample Solution

Signature: _____

Professor: Ali Karime **Exam Duration: 90 minutes**

Instructions

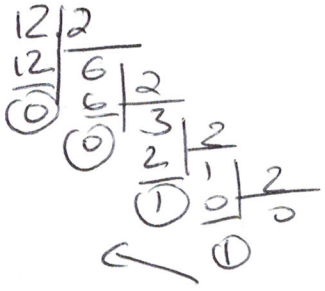
- Closed book examination. The maximum score is 100 points.
- Use the provided space to answer the questions. If more space is required, use the back of the page.
- Show all the steps to obtain marks.
- Calculators are **NOT allowed**.
- It is strongly recommended that you write down your solutions step by step. This is the only way it is possible for you to earn full marks.
- Cheating will be penalized in accordance with University of Ottawa regulations.

Question 1	(35)	
Question 2	(10)	
Question 3	(55)	
Total	/100	

Question 1 (35 points)

(a) Convert the following two decimal numbers: A = 12.25 and B = 16.50 to signed binary numbers (use a signed magnitude presentation). Use the necessary bits to represent the integer part and use **2 bits** for the fractional part and an additional bit for the sign. **[15 points]**

A = 12.25



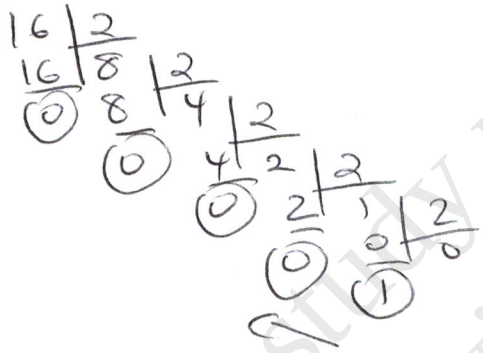
$0.25 \times 2 = 0.5$ 0 ↓

$0.5 \times 2 = 1$ 1

5 points

$A = (1100.01)_2$

B = 16.50



$0.5 \times 2 = 1$ 1

$B = (10000.1)_2$ 5 points

Now in signed magnitude representation, we can write A and B as follows

$A = 00\,1100.01$ and $B = 0\,10000.10$

2.5 points 2.5 points

Here, we use 1 sign bit, 5 bits for the integer part and 2 bits for fractional part (8 bits in total)

(b) Perform the following binary arithmetic operations using **1's complement**.

(i) C = A - B **[7.5 points]**

(ii) D = A + B **[7.5 points]**

i) 1's{B} = 1's{010000.10} = 101111.01

A - B = A + 1's{B}

```
  0 0 1 1 0 0 . 0 1
+ 1 0 1 1 1 1 . 0 1
-----------------------
1 1 1 0 1 1 . 1 0
```

7.5

Sign — 1's complement magnitude form

So the answer in magnitude is − 00100.01

ii)

```
  0 0 1 1 0 0 . 0 1
+ 0 1 0 0 0 0 . 1 0
-----------------------
0 1 1 1 0 0 . 1 1
```

7.5

(b) Convert the binary number **(10 0110.11)2** to hexadecimal. **[5]**

(0010 0110. 1100)

(2 6 . C)16

=> (100110.11) = (26.C)16

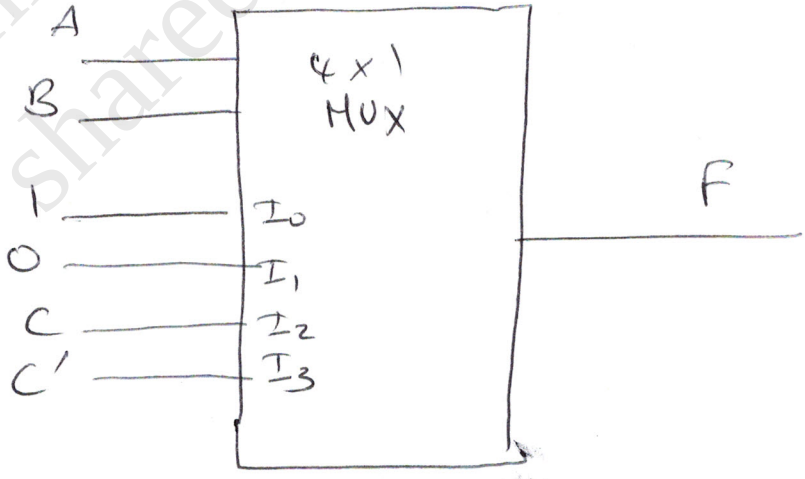
Question 2 (10 points)

Consider the following truth table A, B and C are input variables and F is the output function

A	B	C	F	
0	0	0	1	F=1
0	0	1	1	
0	1	0	0	F=0
0	1	1	0	
1	0	0	0	F=C
1	0	1	1	
1	1	0	1	F=C'
1	1	1	0	

4 points for properly determining the value of F at each pair of combinations

a) Implement the function F using a 4-to-1 multiplexer.



6 points for properly drawing the circuit.

Question 3: (55 points)

Given the logic function $F(A,B,C,D) = \Sigma m(1, 3,5,12)$ together with the *don't care* conditions $d(A,B,C,D) = \Sigma d(2,7,8,11,14,15)$,

(a) Write the truth table of the logic function. Use the Karnaugh-map method to find the simplest sum-of-products expression of function F. **[20 points]**

10 points

A	B	C	D	F
0	0	0	0	0
0	0	0	1	1
0	0	1	0	X
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	X
1	0	0	0	X
1	0	0	1	0
1	0	1	0	0
1	0	1	1	X
1	1	0	0	1
1	1	0	1	0
1	1	1	0	X
1	1	1	1	X

AB \ CD	00	01	11	10
00	0	1	1	X
01	0	1	X	0
11	1	0	X	X
10	X	0	X	0

the simplified f is not unique

① $f = A'D + AC'D'$

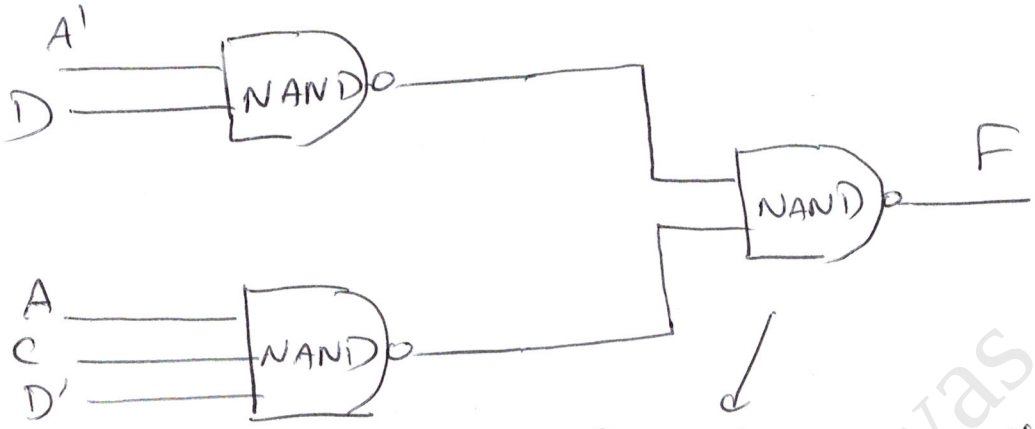
or

② $f = A'D + ABD'$

10 pts

Student may give any of the 2 answers.

(b) Implement the minimized function with NAND gates only. Note: You can use NAND gates with any number of inputs you may need. Assume, as well, that the input variables are available in both true and complemented form. [**10 points**]



(Student may use the following symbol here

10 pts

(c) Express the same logic function in a product of sums form (give the non-simplified form of the function). [**5 points**]

Looking in the truth table for the maxterms, we find

$$F=(A+B+C+D)(A+B'+C+D)(A+B'+C'+D)(A'+B+C+D')$$
$$(A'+B+C'+D)(A'+B'+C+D')$$

5 pts)

(d) Simplify your function in product of sums. **[10 points]**

We symplify by grouping 0's first and then finding f
(N.B: Simplification is not unique)

$F' = A'D' + AD + AC$

or $F' = A'D' + AD + AB'$ or $F' = A'D' + AD + CD'$

if $F = A'D' + AD + AC$ is chosen, then

$f = F'' = (A+D)(A'+D')(A'+C')$

10 pts

(e) Implement your function *F* employing a 4-to-16 **active low decoder** (see the following block diagram) and AND gate (with required number of inputs) only. **[10 points]**

$f = \Pi(0, 4, 6, 9, 10, 13)$

10 pts