EECS 281: **Homework h7 & Lab L2 & L3** **Due: Thursday, April 7, 2005**

Name: ________________________ Email: ______________________ Grade: _____ (100 points max)

0. Practice Wakerly 4.9a-b, 4.13a-b, 4.14a-b, 4.19a-b, 4.15a. Solutions are located at http://www.wakerly.com

00. Using the k-map software tool (i.e. http://www.puz.com/sw/karnaugh/) Practice Wakerly 4.16b,d, e, f. To use Maxterms in the k-map tool use **View** ⇒ **POS**.

1. (X points) Given the following recurrent equation: $t_n = t_{n-1} + t_{n-2}$ where $t_0 = 1$ and $t_1 = 1$. (a). Give the values for t(0) upto t(8). (b). Translate the equation into a C function.

1c. Translate the the C function into 8051 assembler which works with the following calls where the function passes the argument in register A and returns the value in register A. The function can use any registers but must save them on the stack before use and restore them before returning.

```
main:      mov A,#3            ; A=3;        /* input argument to function T */
           acall T             ; A=T(A);     /* same as A=T(3); */
           add A,#’0’          ; A+=’0’;     /* convert binary digit to ASCII */
           acall putchar       ; putchar(A); /* print return value in ASCII */
           mov A,#5            ; A=5;
           acall T             ; A=T(A);     /* same as A=T(5); */
           add A,#’0’          ; A+=’0’;
           acall putchar       ; putchar(A);
           mov A,#6            ; A=6;
           acall T             ; A=T(A);     /* same as A=T(6); */
           add A,#’0’          ; A+=’0’;
           acall putchar       ; putchar(A);
halt:      ajmp  halt          ; loop forever
T:         ...                 ; write your code here:
           ret
```

LAB2. Run the 1c using the 8051 simulator and submit the source code and screen shot of the final register values and UART output

2. (X points) A programmer as written the following C code fragment **see hint on page 4)**:

```
f=1;
if      (a ^ b) { if (c) { f=0; } }
else if (b & c) { f=0; }
else if ( ~c)   { f=0; }
```

2a. Give the truth table for the variable f (assume that a, b, c are boolean values only):

2b. Give the optimal k-map of 2a.

	$\bar{b}\bar{c}$	$\bar{b}c$	bc	$b\bar{c}$
$\bar{a}$				
a				

2c. Give the MSOP of the k-map: ________________________

2d. Re-write as optimal C code:

3a. (X points) Show the optimal mimimal circling in the k-map in minterm function
$f(a,b,c,d) = \overline{a}cd + a \oplus \overline{b} + \overline{a}cd + bcd$.

	$\bar{c}\bar{d}$	$\bar{c}d$	cd	$c\bar{d}$
$\bar{a}\bar{b}$				
$\bar{a}b$				
ab				
$a\bar{b}$				

3b. Give the $\sum_{abcd} =$ ________________________________

3c. Give MSOP= ________________________________

4a. (X points) Show the optimal multi-output mimimal circling the terms and in the k-map in minterm function $F = \sum_{abcd} = (4, 12, 13, 15)$ and $G = \sum_{abcd} = (6, 13, 14, 15)$. Indicate which circle belongs to what function.

F	$\bar{c}\bar{d}$	$\bar{c}d$	cd	$c\bar{d}$
$\bar{a}\bar{b}$				
$\bar{a}b$				
ab				
$a\bar{b}$				

G	$\bar{c}\bar{d}$	$\bar{c}d$	cd	$c\bar{d}$
$\bar{a}\bar{b}$				
$\bar{a}b$				
ab				
$a\bar{b}$				

4b. Give the common term of multi-output MSOP = ________________________________

4c. Give the multi-output MSOP of F= ________________________________

4d. Give the multi-output MSOP of G= ________________________________

4e. Fill in the PLA using Wakerly Figure 5-22 on page 338.

5. (X points) Please answer the following True or False in the context of Boolean Algebra:

T	F	$\overline{a} + b = \overline{a\overline{b}} + b$	(hint: k-map or truth table)
T	F	$a\overline{a} = a \oplus a$	(Wakerly section 5.8.1 page 410-413)
T	F	$\sum_{ab}(1,2) = a \oplus b$	(hint: use truth table)
T	F	$a = ab + \overline{b}a$	
T	F	$\sum_{abc}(0,2,4,5,6) = a\overline{b} + \overline{c}$	(hint: use k-map)
T	F	$b + \overline{b} = \overline{a\overline{a}}$	
T	F	$\sum_{abc}(1,3,5,7) = \prod_{abc}(2,4,6)$	
T	F	$a + \overline{a}b = a + b$	
T	F	$\overline{a + \overline{a}} = \overline{c}c$	(see MIT problem set 1 #22)
T	F	$\prod_{abc}(1,2,5) = (a+b+\overline{c})(a+\overline{b}+c)(\overline{a}+b+\overline{c})$	(Wakerly, pg 208)

6. (X points) Use Boolean Algebra to establish the identity. Show the Theorem numbers (i.e. T1-T13) for each step of your proof:

Theorem	Expression
	$c = \overline{(b+\overline{c})(a+\overline{c})} + cb + c\overline{b}$
...	...

7a. (X points). Do the Quine-McCluskey Algorithm of $\sum_{a,b,c,d}(0,1,2,3,4,5,7,14,15)$ (hint: Wakerly Figure 4-34 page 229).

Group	Minterms	0-cubes	Minterms	1-cubes	Minterms	2-cubes
G_0						
G_1						
G_2						
G_3						
G_4						

7b. Fill in the covering table

EPI?	Needed?	PI-cubes							
		Covered?							

7c. Give the MSOP= ________________________________

7d. Show the optimal k-map:

LAB3a Run *espresso*: compare with your solution hand-in source code and screen shot of output.

	$\bar{c}\bar{d}$	$\bar{c}d$	cd	$c\bar{d}$
$\bar{a}\bar{b}$				
$\bar{a}b$				
ab				
$a\bar{b}$				

7e. Give the MSOP of the k-map: ________________________________

8a. (X points) Given $\sum_{a,b,c,d}(0,1,6,7,14,15)$ and the don't cares (2, 8, 10), show the optimal k-map. (b). Give the MSOP of the k-map: ________________________________

	$\bar{c}\bar{d}$	$\bar{c}d$	cd	$c\bar{d}$
$\bar{a}\bar{b}$				
$\bar{a}b$				
ab				
$a\bar{b}$				

LAB3b Run *espresso*: compare with your solution hand-in source code and screen shot of output.

```
int main(void) {   int a, b, c, d, f, i; /* Problem 2 Hint: double check solution */
  for(i=0; i<=15; i++) {
    f=1; a=(i>>3)&1; b=(i>>2)&1; c=(i>>1)&1; d=i&1; /* a=bit3 b=bit2 c=bit1 d=bit0 */
    if      (a ^ b)   { if (c) { f=0; } }
    else if (b & c)   { f=0; }
    else if ((~c)&1)  { f=0; } /* why do I need to "&1" after ~c */
    if (f) { printf("minterm=%d=%d%d%d%d %d\n", i, a, b, c, d, f); }
} }
```

Theorem	Relationship	Dual	XOR	Property
T1	$a1 = a$	$a + 0 = a$	$a \oplus 0 = a$	Identity
T2	$a0 = 0$	$a + 1 = 1$	$a \oplus 1 = \overline{a}$	Domination
T3	$aa = a$	$a + a = a$	$a \oplus a = 0$ $a \oplus a \oplus a = a$	Idempotency
T4	$\overline{\overline{a}}$			Involution
T5	$a\overline{a} = 0$	$a + \overline{a} = 1$	$a \oplus \overline{a} = 1$	Complement
T6	$ab = ba$	$a + b = b + a$	$a \oplus b = b \oplus a$	Commutative
T7	$(ab)c = a(bc)$	$(a + b) + c = a + (b + c)$	$(a \oplus b) \oplus c = a \oplus (b \oplus c)$	Associative
T8	$(a + b)(a + c) = a + bc$	$a(b + c) = ab + ac$	$a(b \oplus c) = ab \oplus ac$	Distributive
T9	$a(a + b) = a$	$a + ab = a$	$a \oplus ab = a\overline{b}$	Absorption Covering
T10	$(a + b)(a + \overline{b}) = a$	$ab + a\overline{b} = a$	$ab \oplus a\overline{b} = a$	Combining
T11	$(a + b)(\overline{a} + c)(b + c) = (a + b)(\overline{a} + c)$	$ab + \overline{a}c + bc = ab + \overline{a}c$		Consensus Proof by k-map
T12	$a + a + \cdots + a = a$	$aa \cdots a = a$	$a \oplus a \oplus \ \cdots \oplus a_{odd} = a$ $a \oplus a \oplus \ \cdots \oplus a_{even} = 0$	Generalized Idempotency
T13	$\overline{a + b} = \overline{a}\overline{b}$	$\overline{ab} = \overline{a} + \overline{b}$	$\overline{ab} = \overline{a} \oplus \overline{b} \oplus \overline{a}\overline{b}$	DeMorgan
XOR	$ab = a \oplus \overline{b} \oplus \overline{a}\overline{b}$	$a + b = a \oplus b \oplus ab$	$a \oplus b = \overline{a} \oplus \overline{b} = a\overline{b} + \overline{a}b$	Definition