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Computer Organization Test 2

Question 1. (12 points) Select the best answer to the following true-or-false questions:	**Circle the correct answer**	
a. A jump instruction changes the flow of execution by changing the PC.	(True)	False
b. Registers are storage locations within the CPU itself.	(True)	False
c. The main memory (RAM) is faster to access than registers.	True	(False)
d. Only the AC register in MARIE can be used to hold arbitrary data.	(True)	False
e. One assembly language instruction generally translates to one machine language instruction.	(True)	False
f. One high-level language (e.g., Ada, C++, Java, etc.) instruction generally translates to many machine language instruction.	(True)	False

Question 2. (18 points) Translate the following high-level language code segment to MARIE assembly language. Use the variable labels indicated in the code.

```
SUM = 0
INPUT  COUNT
FOR I = 1 TO COUNT DO
    INPUT  X
    SUM = SUM + X
END FOR
```

```
           CLEAR
           STORE SUM
           INPUT
           STORE COUNT
           LOAD ONE
           STORE I
FOR,       LOAD I
           SUB COUNT
           SKIPCOND 000
           JUMP FOR_BODY
           JUMP END_FOR
FOR_BODY,  INPUT
           STORE X
           LOAD SUM
           ADD X
           STORE SUM
           LOAD I
           ADD ONE
           STORE I
           JUMP FOR
END_FOR,   HALT

SUM,    DEC 0
I,      DEC 0
X,      DEC 0
COUNT,  DEC 0
```

Question 3.

a) (5 points) For the below MARIE program, complete the symbol table.

Symbol	**Address of Symbol (in hex.)**
END_WHILE	108
SUM	10A
WHILE	100
X	109

b) (10 points) Translate the given MARIE assembly language into machine language.

Address	**Label**	**Assembly Language**	**Machine Language** (in hex)
100_{16}	WHILE,	LOAD X	1109
101_{16}		SKIPCOND 000	8000
102_{16}		JUMP END_WHILE	9108
103_{16}		ADD SUM	310A
104_{16}		STORE SUM	210A
105_{16}		INPUT	5000
106_{16}		STORE X	2109
107_{16}		JUMP WHILE	9100
108_{16}	END_WHILE,	HALT	7000
109_{16}	X,	DEC 10	000A
$10A_{16}$	SUM,	DEC 0	0000

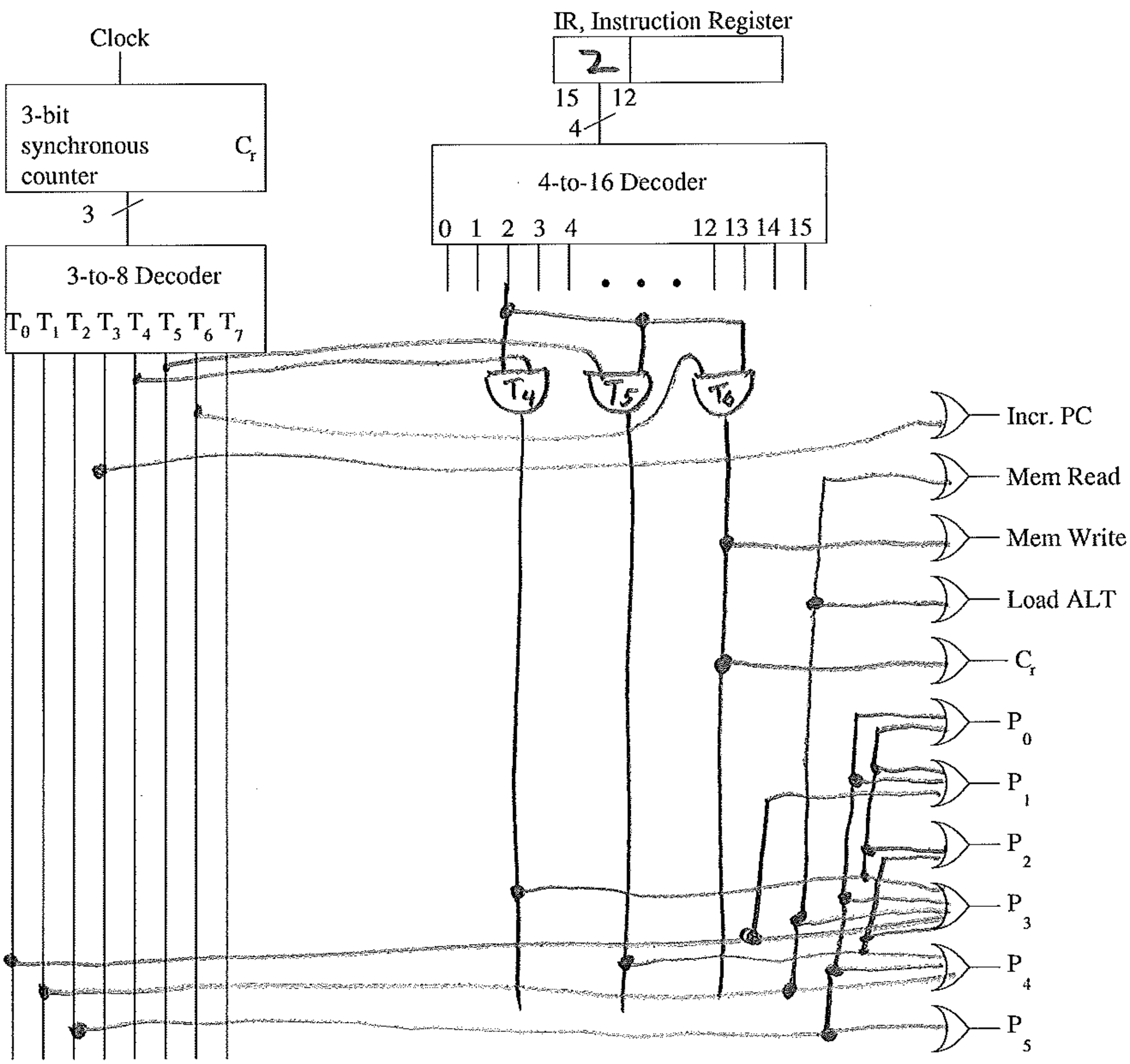
c) (10 points) Translate the above MARIE assembly language into high-level language "pseudo" code.

```
while X < 0 do
    Sum = X + Sum
    INPUT X
End while
```

Question 4. (10 points) Which control signals should contain a "1" for each steps in the STORE X instruction?

Step	RTN	Step #	P_5 (4)	P_4 (2)	P_3 (1)	P_2 (4)	P_1 (2)	P_0 (1)	C_r	Incr PC	Mem Read	Mem Write	Load ALT
Fetch	MAR ← PC	T_0	0	0	1	0	1	0	0	0	0	0	0
	MBR ← M[MAR]	T_1	0	1	1	-	-	-	0	0	1	0	1
	IR ← MBR	T_2	1	1	1	0	1	1	0	0	0	0	0
Decode IR[15-12]	PC ← PC + 1	T_3	0	0	0	-	-	-	0	1	0	0	0
Get operand	MAR ← IR[11-0]	T_4	0	0	1	1	1	1	0	0	0	0	0
Execute	MBR ← AC	T_5	0	1	1	1	0	0	0	0	0	0	0
	M[MAR] ← MBR	T_6	0	0	0	-	-	-	1	0	0	1	0
		T_7											

Question 5. (10 points) Draw the partial combinational logic of the hardwired control unit to handle the STORE X (opcode 2_{16}) instruction.



Question 6. Recall that the microprogrammed version of MARIE executes a fixed microprogam to perform the fetch-decode-execute cycle. The instruction format for the microinstructions look like:

MicroOp1	MicroOp2	Jump	Dest
17 13	12 8	7	6 0

MicroOp1 encodes the type of register transfer notation (RTN) to perform (e.g., AC ← 0 is 00010_2)

MicroOp2 is used only when decoding the instruction. It contains the binary codes for each instruction to allow comparison to the IR opcode. (Since the MARIE opcodes are only 4-bits long, only bits 12 - 9 are used and bit 8 is unused.

Jump is a single bit indicating that the value in the **Dest** field is a valid micro-address and should be placed in the microsequencer; if **Jump** is "FALSE" (0), then increment to the next microinstruction.

Table 4.8. Microoperation Codes and Corresponding MARIE RTN (p. 221)

MicroOp Code	Microoperation	MicroOp Code	Microoperation
00000	NOP	01100	MBR ← M[MAR]
00001	AC ← 0	01101	OutREG ← AC
00010	AC ← AC - MBR	01110	PC ← IR[11-0]
00011	AC ← AC + MBR	01111	PC ← MBR
00100	AC ← InREG	10000	PC ← PC + 1
00101	IR ← M[MAR]	10001	If AC = 00
00110	M[MAR] ← MBR	10010	If AC > 0
00111	MAR ← IR[11-0]	10011	If AC < 0
01000	MAR ← MBR	10100	If IR[11-10] = 00
01001	MAR ← PC	10101	If IR[11-10] = 01
01010	MAR ← X	10110	If IR[11-10] = 10
01011	MBR ← AC	10111	If IR[15-12] = MicroOp2[4-1]

We need to augment this table to include a few omitted microoperations and because we modified Figure 4.9 to remove the Memory from direct connection to the datapath. The following additional microoperations are used.

MicroOp Code	**Microoperation**
00101*	IR ← MBR
11000	AC ← MBR

* This microop code is being reused.

a) (10 points) Explain why a microprogrammed control unit is slower than a hardwired control unit?

Hardwired uses a circuit with one RTN being done per clock cycle. The micropgmmed control unit needs to read the microinstr (one cycle) and interpret to generate the control signals (another cycle). Plus, extra RTN microinstr. to decode ML instr.

b) (15 points) Extend the partial microprogram below to include microoperations to decode and implement the execution of the instructions: STORE X and CLEAR. **(Fill in only the bolded boxes)**

Revised Figure 4.21 Partial Microprogram

Part of Cycle	RTN (of MicroOp1)	μAddr	MicroOp1	MicroOp2	Jump	Dest
Fetch	MAR ← PC	0	01001	0000	0	0
	MBR ← M[MAR]	1	01100	0000	0	0
	IR ← MBR	2	00101	0000	0	0
	PC ← PC + 1	3	10000	0000	0	0
Decode	If ADD, Jump	4	10111	00110	1	
	If LOAD, Jump	5	10111	00010	1	
("Jump	If STORE, Jump	6	10111	00100	1	17_{10}
Table")	If SKIPCOND, Jump	7	10111	10000	1	
	If SUBT, Jump	8	10111	01000	1	
	If JUMP, Jump	9	10111	10010	1	
	If ADDI, Jump	10	10111	10110	1	
	If CLEAR, Jump	11	10111	10100	1	20
	If JNS, Jump	12	10111	00000	1	
	If JUMPI, Jump	13	10111	11000	1	
	If INPUT, Jump	14	10111	01010	1	
	If OUTPUT, Jump	15	10111	01100	1	
	If HALT, Jump	16	10111	01110	1	
Execute STORE X	MAR ← IR[11-0]	17	00111	00000	0	0
	MBR ← AC	18	01011	00000	0	0
	M[MAR] ← MBR	19	00110	00000	1	0
Execute CLEAR	AC ← 0	20	00001	00000	1	0
		21				
		22				
		23				
		24				

NOTE: Used page 4 of test's microop. table and NOT the yellow sheet handout from edition 3 of textbook.