CMSC 311 Final - Fall 1994

Name ____________________________________ Signature __________________________________

(1) This exam is closed book, closed notes, and closed neighbor.

(2) You have 110 minutes to complete this exam. If you finish early, you may turn in your exam at the front of the room and leave. However if you finish during the last ten minutes of the exam please remain seated until the end of the exam so you don't disturb others.

(3) Write all answers on the exam. If you need additional paper, I will provide it. Make sure your name is on any additional sheets.

(4) Partial credit will be given for most questions assuming I can figure out what you were doing.

(6) Please write neatly. Print your answers if your handwriting is hard to read. If you write something, and wish to cross it out, simply put an X through it. Please indicate if your answer continues onto another page.

(7) When showing multiple lines connected between the same two components, use a single line to represent all lines. Make sure you label the connections at each component.

(8) Tables listing the instructions in Mano's machine, and a subset of the MIPS instructions appear on the last page of the exam booklet.

Question	Possible	Score
1	20	
2	20	
3	25	
4	25	
5	45	
6	20	
7	45	
Total	200	

Name of the person Sitting to your

left ___________________________________ right ___________________________________

1.) (20 points) Define the following terms:

Assembly Language

Cache (memory)

Interrupt

Load/Store Architecture

2.) (20 points) Show that NOR is functionally complete (can implement the other 7 basic gates).

3.) (25 points) Many of the instructions in Mano's machine are not necessary because they could be emulated by a sequence of other instructions. For each of the instructions shown, write a subroutine to emulate it. The subroutines should have no side affects (i.e. no net change to the AC unless the instruction is defined to change the AC).

a) INC

b) CLE

c) SPA

d) CIL

4.) (25 points) Write a recursive function, in the subset of MIPS assembly language shown at the end of the exam, that reads a line of input and prints it backwards. For example, an input of MIPS\n should produce SPIM as output (note the missing newline). You may assume that the subroutines getchar and putchar are available. (getchar reads a character and returns it in v0, and putchar prints the character in a0).

5.) (45 points) This question concerns adding a stack to the Mano computer. PUSH should push the value in the AC onto the stack. POP should pop the top item off the stack and put in into the AC.

a.) One way to add the stack is to write PUSH and POP subroutines. Write these two routines in Mano's assembly language. The stack pointer is stored in a memory location whose label is (SP). The stack grows up from the label BASE until it reaches the label LIMIT. Stack underflow and overflow should cause the subroutine whose address is in the location STK_ERR to be called.

b.) Extend Mano's machine to have PUSH (op code F020) and POP (op code F010) instructions. Show the RTL for each of these instructions. Three new registers have been added to the basic machine: SP, BASE, and LIMIT. Stack underflow and overflow should cause an interrupt (by setting a Flip-flop, R). Recall that the instruction specific part of the micro-sequence starts at T_3, and that instructions whose first nibble (4 bits) is F have the control function D_7IB_n. Assume that a signal UNDERFLOW is available and indicates $SP < BASE$, and another signal OVERFLOW indicates $SP > LIMIT$.

c.) Give one advantage of implementing the stack in software and one of implementing it in hardware.

6.) (20 points) The function table for an ALU is shown below. Design an implementation of the ALU using a 4x1 MUX and one or more of the eight basic gates. Show only the ith bit position where is a middle bit. For this problem + is the addition operator.

ALU Function Table		
f1	f0	Function
0	0	A + B
0	1	A
1	0	A ˆ B
1	1	NOT A

7.) (45 points) Design a sequential circuit with one input and one output. When the input sequence 011 occurs, the output becomes 1 and remains 1 until the sequence 011 occurs again in which case the output becomes 0. The output then remains 0 until 011 occurs a third time, etc. Derive the state table, and then implement the circuit using D Flip-Flops. Use K-maps to minimize the inputs to the D Flip-Flops. Show the boolean expressions for the inputs to the D Flip-Flops and the output. **Do not draw the circuit**.

Mano Instructions

Symbol	Hexadecimal code I = 0	I = 1	Description
AND	0xxx	8xxx	AND memory word to AC
ADD	1xxx	9xxx	Add memory word to AC
LDA	2xxx	Axxx	Load memory word to AC
STA	3xxx	Bxxx	Store contents of AC in memory
BUN	4xxx	Cxxx	Branch unconditionally
BSA	5xxx	Dxxx	Branch and save return address
ISZ	6xxx	Exxx	Increment and skip if zero
CLA	7800		Clear AC
CLE	7400		Clear E
CMA	7200		Complement AC
CME	7100		Complement E
CIR	7080		Circulate right AC and E
CIL	7040		Circulate left AC and E
INC	7020		Increment AC
SPA	7010		Skip next instruction if AC positive
SNA	7008		Skip next instruction if AC negative
SZA	7004		Skip next instruction if AC zero
SZE	7002		Skip next instruction if E is 0
HLT	7001		Halt computer
INP	F800		Input information and clear flag
OUT	F400		Output information and clear flag
SKI	F200		Skip if input flag is on
SKO	F100		Skip if output flag is on
ION	F080		Turn interrupt on
IOF	F040		Turn interrupt off

MIPS (SPIM) Instructions

Instruction	Description
la Rdest, address	Load Address
lb Rdest, address	Load Byte
lw Rdest, address	Load Word
li Rdest, imm	Load Immediate
sb Rsrc, address	Store Byte
sw Rsrc, address	Store Word
move Rdest, Rsrc	Move
addu Rdest, Rsrc1, Src2	Addition (without overflow)
subu Rdest, Rsrc1, Src2	Subtract (without overflow)
jal label	Jump and Link
jr Rsrc	Jump Register
beq Rsrc1, Src2, label	Branch on Equal
bne Rsrc1, Src2, label	Branch on Not Equal
beqz Rsrc, label	Branch on Equal Zero
bge Rsrc1, Src2, label	Branch on Greater Than Equal
bgt Rsrc1, Src2, label	Branch on Greater Than

Registers: t0-t9, s0-s7, a0-a3, v0-v1, sp, fp, ra.