Ollscoil Mhá Nuad

Maynooth University

SEMESTER 2
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CS253FZ
Computer Architecture 2

Dr. Fook-Loong Lo, Dr. Joseph Timoney, Dr. Michael English

Time allowed: 2 hours

Answer ***four*** questions
Complete question 1, which is worth 40 marks. Choose 3 from the remaining 4 questions, each of which is worth 20 marks.

Instructions

	Yes	No
Log Books allowed		X
Formula Tables allowed		X
Other allowed *(enter details)* Scientific calculator	X	

General *(Enter Details)* An ASCII table is attached to the end of the paper.

QUESTION 1

Parts (a) to (d) refers to the assembly listing shown below.

```
                                    .MODEL  small
                                    .STACK
0000                                .DATA
0000                                .CODE
                                    .STARTUP

0017  B4  08          next:  mov  ah,08h
0019  CD  21                 int  021h       ;read in key pressed
001B  8A  D0                 mov  dl,al
001D  80  C2 10              add  dl,010h
0020  80  FA 40              cmp  dl,040h
0023  72  XX                 jb   next       ;jump below
0025  80  FA 4A              cmp  dl,04Ah
0028  73  ED                 jnb  next       ;jump if not below

002A  B4  02                 mov  ah,02h
002C  CD  21                 int  021h       ;show on screen
002E  80  FA 40              cmp  dl,040h
0031  74  YY                 je   exit       ;exit program
0033  EB  E2                 jmp  next
0035  90              exit:  nop
                             .EXIT
                             END
A     B   C                  D    E
```

(a) Choose the names of the items shown in the boxes from the following: labels, mnemonics, opcodes, operands and offsets. (5 marks)
(i) A (ii) B (iii) C (iv) D (v) E

(b) If the code segment register contains the value 26AE hex, what is the address in main memory pointed out by the label **exit**? (5 marks)

(c) Only certain characters will be displayed when keys are pressed. What are these characters? (5 marks)

(d) The hexadecimal values in locations 24h and 32h have been replaced with XX and YY. Write out these values. (5 marks)

(e) If abcABC123xyzXYZ890 is typed when the program is running, what will appear on the screen before the program terminates? (5 marks)

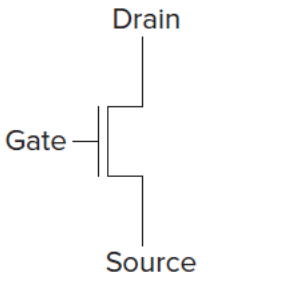
(f) (i) What is the main difference between a latch and a flip-flop? (2 marks)
(ii) What is the main difference between a level-triggered and an edge-triggered flip-flop? (3 marks)

(g) RISC computers often perform faster than CISC computers when running most programmes. Briefly explain why this can happen, and also when a CISC computer may perform better. (5 marks)

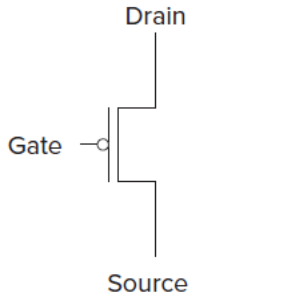
(h) Outputs to bi-directional data buses are often connected through tri-state buffers. Briefly explain why this is necessary. (5 marks)

QUESTION 2

Metal Oxide Semiconductor (MOS) Field Effect Transistors (FETs) can be used to make different digital components. The two main types of FETs are the N-type and P-type FETs. N-type FETs are turned on with a positive voltage at the gate, and P-type FETs are turned on when a 0 voltage is applied at the gate. A positive voltage is taken as logic 1 and 0 voltage is taken as logic 0.

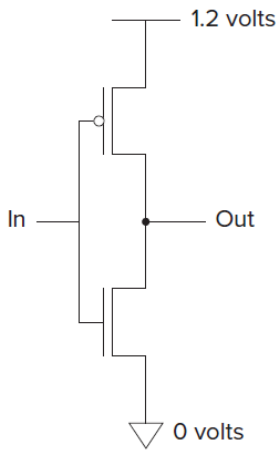


N-type MOS transistor

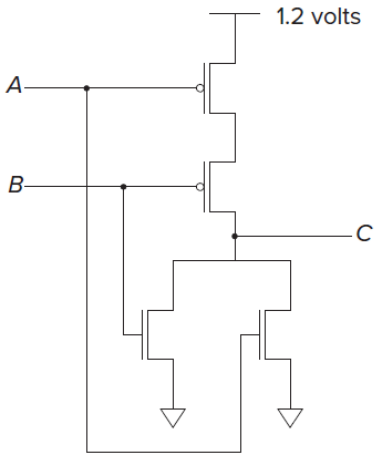


P-type MOS transistor

Consider the two digital components shown below:



Gate A



Gate B

(a) What type of logic gate is Gate A? (4 marks)

(b) (i) Write out the truth table of Gate B. (4 marks)

(ii) What type of logic gate is Gate B? (2 marks)

(c) Using 2 N-type FETs and 2 P-type FETs, design a circuit that performs the NAND function. (5 marks)

(d) Any digital circuits that produce an output which can be described by a sum-of-products or product-of-sums expression can be built using only AND, OR and NOT gates. NAND gates can be used to build all three gates and therefore are often called the universal gate.

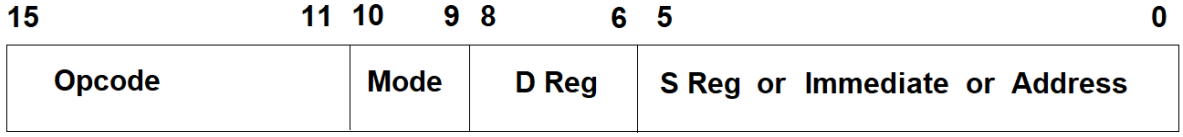
(i) Use one NAND gate to build a NOT gate. (1 mark)

(ii) Use 2 NAND gates to build an AND gate. (2 marks)

(ii) Use 3 NAND gates to build an OR gate. (2 marks)

QUESTION 3

A certain CPU uses 16-bit machine instructions with the bits assigned as shown below. It uses 8 registers, R0 to R7.



Bits 11 – 15: opcode of the instruction

Bits 10 – 9: addressing mode for source operand

00: operand from source register specified in value of bits 0 – 5

01: immediate, operand as 2's complement value in bits 0 – 5

10: offset address of operand as signed value in bits 0 – 5

11: full address of operand formed from bits 0-5 shifted 16 bits left and added to the 16-bit value following the instruction

Bits 8 – 6: destination register number

Bits 5 – 0: source operand to be fetched according to mode

(a) How many possible opcodes are there for this CPU? (3 marks)

(b) What is the range of values that can be moved to the destination register if immediate addressing mode is used? (3 marks)

(c) What is the size of main memory for this CPU? (3 marks)

(d) (i) If the MOV instruction has opcode 01001, and the decimal number negative twelve (-12) is to be moved into R5, work out the machine code. Give your answer in hex. (3 marks)

(ii) What is the machine code if the contents of R3 is to be moved to R0? Give your answer in hex. (3 marks)

(e) What is the maximum increment that the instruction pointer will undergo after fetching an instruction? (5 marks)

QUESTION 4

Examine the subroutine Print below which will display the decimal contents of the register AX.

```
Print:  push bx         ;Store registers
        push cx
        push dx
        mov  cx,5       ;5 digits
next:   mov  bx,10      ;for decimal
        mov  dx,0h
        div  bx
        or   dx,030h    ;change to ASCII
        push dx         ;digits in stack
        loop next
        mov  cx,5       ;5 digits
nxout:  pop  dx         ;digits out of stack
                        ;<<- HERE
        mov  ah,02h
        int  021h       ;print digit
        loop nxout
        pop  dx         ;restore registers
        pop  cx
        pop  bx
        ret
```

(a) If AX contains 12,345 decimal, what will be printed out by the subroutine? (3 marks)

(b) If AX contains 678 decimal, what will be printed out by the subroutine? (3 marks)

(c) If AX contains 13AC hexadecimal, what will be printed out by the subroutine? (3 marks)

(d) A student wishes to modify the subroutine to print out contents of AX in hexadecimal. She changes mov bx,10 at label **next** to mov bx,16. What will be displayed if AX contains 13ACh? (6 marks)

(e) To make the subroutine display the correct hexadecimal contents of AX, add a few lines of code at the location marked **HERE**. (5 marks)

QUESTION 5

(a) The data section of an x86 assembly language program is shown:

```
            .DATA
num         db      2,4,6
num2        dw      0345h
string      db      "DOG"
flnum       dd      2.625
```

(i) How many bytes are used to store these pieces of data? (2 marks)

(ii) If the label **num** points to location 10000h of main memory, show the contents of the following byte locations which contain the data. Remember that x86 uses little-endian convention. (6 marks)

(b) The stack in a computer working with a FILO order is especially suited for storing return addresses of interrupt routines.

(i) Briefly explain what is meant by FILO. (2 marks)

(ii) Briefly explain why it is especially suited for storing return addresses of interrupt routines. (4 marks)

(c) Briefly explain the main difference between vector processing and pipelining, two different ways of speeding up computation. (2 marks)

(d) The contents of the first few locations in the vector table of an x86 machine are shown:

Address	Contents
00-03	1B02:2389
04-07	0070:06F4
08-0B	193D:0016
0C-0F	0070:06F4
10-13	0070:06F4
14-17	F000:FF54

The print screen interrupt has interrupt number 5. Find the full address of the start of the print screen interrupt service routine. (4 marks)

ASCII Table

Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value	Hex	Value
00	NUL	10	DLE	20	SP	30	0	40	@	50	P	60	`	70	p
01	SOH	11	DC1	21	!	31	1	41	A	51	Q	61	a	71	q
02	STX	12	DC2	22	"	32	2	42	B	52	R	62	b	72	r
03	ETX	13	DC3	23	#	33	3	43	C	53	S	63	c	73	s
04	EOT	14	DC4	24	$	34	4	44	D	54	T	64	d	74	t
05	ENQ	15	NAK	25	%	35	5	45	E	55	U	65	e	75	u
06	ACK	16	SYN	26	&	36	6	46	F	56	V	66	f	76	v
07	BEL	17	ETB	27	'	37	7	47	G	57	W	67	g	77	w
08	BS	18	CAN	28	(	38	8	48	H	58	X	68	h	78	x
09	HT	19	EM	29	)	39	9	49	I	59	Y	69	i	79	y
0A	LF	1A	SUB	2A	*	3A	:	4A	J	5A	Z	6A	j	7A	z
0B	VT	1B	ESC	2B	+	3B	;	4B	K	5B	[	6B	k	7B	{
0C	FF	1C	FS	2C	,	3C	<	4C	L	5C	\	6C	l	7C	|
0D	CR	1D	GS	2D	-	3D	=	4D	M	5D	]	6D	m	7D	}
0E	SO	1E	RS	2E	.	3E	>	4E	N	5E	^	6E	n	7E	~
0F	SI	1F	US	2F	/	3F	?	4F	O	5F	_	6F	o	7F	DEL