جامعة بيرزيت

BIRZEIT UNIVERSITY

Electrical and Computer Engineering

ENCS238 - Computer Organization
Midterm Exam

Spring Semester 2016 Date: Sunday 17/4/2016

Name: Solution ID: .

Section: (please circle): Dr. Abualsoud (9:00 – 10:00), Dr. Abualsoud (1:00 – 2:00), Dr. Hanna (12:00-1:00)

Instructions:

- **You have 90 minutes (1.5 hours), budget your time carefully!**
- **Turn off your mobile.**
- **To make sure you receive credit, please write clearly and show your work.**

Question	Maximum	Mark	ABET SO
1	20		
2	12		C
3	12		A
4	14		E
5	12		C
Total	70		

Question 1 (20 marks)

1. Which of the following is not part of the processor

   a. the ALU
   b. the CU (Control Unit)
   c. the registers
   (d) the system bus

2. It is a(n) _____ design issue whether a computer will have a multiply instruction.

   (A) architectural (B) memory (C) elementary (D) organizational

3. When perform the following instructions, how will the FLAGS bits be set.

```
MOV AL, 0A3h
MOV BL, 0C2h
ADD AL, BL
```

   (A) CF=0, OF=0
   (B) CF=1, OF=0
   (C) CF=0, OF=1
   (D) CF=1, OF=1

4. Given that the BL register contains 1111 0000, the effect of the following instruction **OR BL, 0000 1111** is to
   a. clear BL
   (b) store 1111 1111 in BL
   c. store 0000 1111 in BL
   d. leave BL unchanged

5. A Stack-organized Computer uses instruction of
   (A) Indirect addressing
   (B) Two-addressing
   (C) Zero addressing
   (D) Index addressing

6. The JMP instruction modifies
   (a) the instruction pointer register
   b. flags register
   c. CX register
   d. none of the previous

7. A computer's memory is composed of 32K bytes. How many bits are required for memory address if smallest addressable unit is one byte?
   (A) 13
   (B) 14
   (C) 15
   (D) 16

8. Which of the following is an illegal instruction
   a. MoV Ax, 30000
   (b) iNc Al, 1
   c. aNd bx, bx
   d. add ax, 30

9. As the density of integrated circuits increases, the speed of the digital logic decreases.
   (A) True
   (B) False

10. An assembly language program is typically
   (a) non-portable
   b. shorter than an equivalent HLL program
   c. harder to read than a machine code program
   d. slower to execute than a compiled HLL program

1	2	3	4	5	6	7	8	9	10
D	A	D	B	C	A	C	B	B	A

Question 2:(12 points)

a) A computer system has a 16-bit word size. Each machine language instruction or each datum has to fit in 16 bits. This computer also has a single 16-bit data register, a 16-bit instruction register, and a 12-bit program counter register. Each instruction consists of two fields: 4 bits for the opcode and 12 bits for the address of a single operand in memory (the single data register will be used for a second operand, if necessary). Use this information to answer the following questions. You may use powers of two in your answers (2^{24}, for example). [7.5pts]

1. What is the largest unsigned integer value (decimal) that can be stored in this computer?

16-bit $\Rightarrow$ largest unsigned value $= 2^{16}-1$

2. Signed integers are represented in twos complement form. What are the largest positive and negative signed integer values (decimal) that can be stored in this computer?

16-bit signed numbers

$-2^{15} \longrightarrow +2^{15}-1$

3. How many words of memory (decimal) does this computer have?

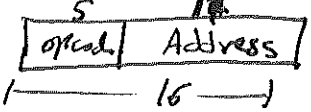
Address = 12 bits $\Rightarrow$ memory size = 2^{12} words = 4k words

4. How many distinct opcodes (decimal) does this computer allow in its instruction set?

4 bits for opcodes $\Rightarrow$ # of opcodes = $2^4 = 16$

5. If we want to upgrade this computer to support up to 32 distinct opcodes. The computer's word size and the number of registers must remain the same. If you need to make changes to this design to accommodate this upgrade, describe what they would be. Include in your answer any consequences that might affect your answers to questions (1-4) above.

32 opcodes $\Rightarrow$ we need 5 bits for opcode. i.e.



① largest value (unsigned) will not be changed because word size = 16 bits remains the same

② signed range will not be changed " " " " " " "

③ memory size ~~remains the same because~~ will be changed because address bits becomes 11 bits.

$\Rightarrow$ mem. size = 2^{11} words = 2k words.

b) A memory unit has a capacity of 256K words of 32 bits each. The instruction code is divided into four parts: an indirect mode bit, operation code, 5 bits that specify a processor register, and memory address part. [4.5pts]

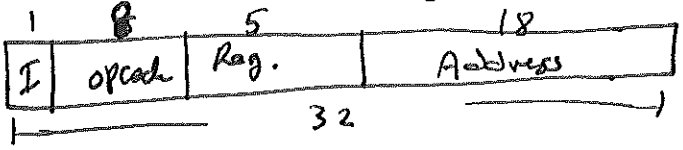
1) What is the maximum number of operations that can be incorporated in the computer if an instruction is stored in one memory word? mem. address = 18 bits.

$256k = 2^8 \cdot 2^{10} = 2^{18}$

So, opcode = 32 − (1+5+18) = 8 bit

$\Rightarrow$ Max. no. of operations = $2^8 = 256$

2) Draw the instruction word format indicating the number of bits and the function of each part.



3) How many bits are there in MBR, MAR, and PC?

MAR → 18 bits.

PC → 18 bits.

MBR → 32 bits.

Question 3: (12 points)

a) In an 8086 computer system, the initial values of registers and memory locations is as follows. [6pts]

AX = 0000H; BX = 0045H; CX = 000AH; DX = 0000H; SI = 5200H; DI = 5300H;

IP = 0100H; CS = 1EF2H; DS = 0A34H

Physical Address	Content	Physical Address	Content
0F540H	FFH	0F640H	F0H
0F541H	00H	0F641H	B0H
0F542H	ABH	0F642H	0BH
0F543H	45H	0F643H	4FH
0F544H	00H	0F644H	00H
0F545H	24H	0F645H	25H
0F546H	8CH	0F646H	8DH
0F547H	88H	0F647H	77H

Fill in the following table to show the source, destination, data size, and value written for each instruction. Assume that the instructions are executed sequentially in the order given below.

Instruction	Source	Destination	Data size (in bytes)	Value written
MOV BX, [SI]	mem. address 0F540H	Register BX	2	00FFH
XOR WORD PTR [DI], 255	Immediate 255 and mem. address 0F640H	mem. address 0F640H	2	B00FH
CMP AX, [DI + 4]	AX and mem. address 0F644H	None (only Flags)	2	None
ADD BX, [5305H]	BX and mem address F645	BX	2	8E24H
JMP [9000H]	Immediate 9000H	IP Register	2	9000H
DEC AX	AX	AX	2	FFFFH

b) The content of PC in the basic computer is 3AF (all numbers are in hexadecimal). The content of AC is 7EC3. The content of memory at address 3AF is 932E. The content of memory at address 32E is 09AC. The content of memory at address 9AC is 8B9F. [6pts]

Instruction Format:

Opcode – 4bits	Memory address – 12bits

Opcode Symbol	Code [Hex]	Description
AND	8xxx	AND memory word to AC
ADD	9xxx	ADD memory word to AC
Load	Axxx	Load memory word to AC
Store	Bxxx	Store content of AC to memory
BR	Cxxx	Branch unconditionally
BSA	Dxxx	Branch and save return address
ISA	Exxx	Branch and skip if zero

a) What is the instruction that will be fetched and executed next? Next Instruction is 932EH

Which is ADD memory word at address 32EH to AC Register.

i.e. AC = AC + [32EH].

b) Show the binary operation that will be performed in the AC when the instruction is executed

7EC3 = 0111 1110 1100 0011

09AC = 0000 1001 1010 1100 +

886F = 1000 1000 0110 1111

c) Give the contents of registers PC, MAR, MBR, AC and IR in hexadecimal at the end of the instruction cycle.

PC = 3AFH = 3B0H

MAR = 32EH

MBR = 09ACH

AC = 886FH

IR = 932EH

Question 4 (14 points)

a) For the following assembly language program, find the contents of each register after the execution of each instruction: [8pts]

```
.MODEL SMALL
.DATA
M       DB      4,6,8,3,2,9
.CODE
START:
MOV     AX, @data
MOV     DS, AX
LEA     BX, M
MOV     DL, [BX]      → DL = 4
ADD     DL, [BX+2]    → DL = 12 or CH
SUB     DL, [BX+4]    → DL = 10 or AH
MOV     DL, [BX+1]    → DL = 6
ADD     DL, '0'       → DL = 54 or 36H
MOV     SI, 2         → SI = 2
ADD     DL, [BX][SI]  → DL = 62 or 3EH
ADD     DL, 5         → DL = 67 or 43H
MOV     AH, 4ch
INT     21h
END     START
```

'0' = 30H or 48.

b) Consider the following assembly code fragment. What are the contents of the ax, bx and cx registers after the code fragment has been executed? Show your work. [6pts]

```
.data
x DD 32
y DD 17
.code
mov bx, offset x
mov ax, [bx]
mov cx, [bx + 4]
add ax, [x]
add cx, ax
mov bx, [bx]
```

32 = 00000020H

17 = 00000011H

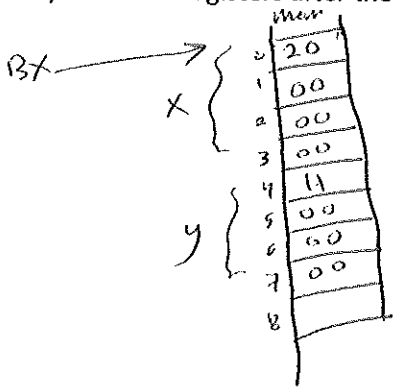
ax = 0020H

cx = 0011H

ax = 0020 + 0020 = 0040H

cx = 0011 + 0040 = 0051H

bx = 0020



ax = 0040 H or 64 bx = 0020 H or 32 cx = 0051 H or 81

Question 5 (12 points)

Write an assembly program which reads a string from keyboard and prints its length (number of characters) on the screen. You can assume string length is no more than 99 characters.

Notes:

Function 01 reads single char from keyboard in AL

Function 02 displays single character in DL on the screen

Function 09 displays a $ terminated string on the screen. String should be pointed by DX

Function 0AH reads string from keyboard and stores it into an array pointed by DX.

using 0AH function

```
.model small
.stack 100H
.data
msg DB "please enter a string", '$'
Buf DB 100, ?, 100 dup(0)
.code
Mov AX, @data
Mov DS, AX        } or .startup

lea DX, msg
Mov AH, 02
Int 21H

lea DX, Buf
Mov AH, 0AH
Int 21H

Mov AL, [Buf+1]
Mov BL, 10
Mov AH, 0
Div BL
ADD AL, 30H
ADD AH, 30H
Mov BX, AX
Mov AH, 02
Mov DL, BL
Int 21H
Mov DL, BH
Int 21H

mov AH, 4CH
nt 21H            } or .exit
nd
```

or using 01H function

```
.model small
.stack 100
.data
Array DB 100 dup(?)
.code
.startup
Mov CX, 0
Lea BX, Array
XOR SI, SI
Next: Mov AH, 01H
Int 21H
cmp AL, 0DH  → enter ASCII. 0DH or 13
JE skip
Mov [BX+SI], AL
Inc CX
Jmp Next
Mov AX, CX
Mov BL, 10
Div BL
ADD AX, 3030H
Mov BX, AX
Mov AH, 02
Mov DL, BL
Int 21H
Mov DL, BH
Int 21H

.exit
end
```