## **National University of Computer and Emerging Sciences**

# **Lab Manual**

### **Computer Organization and Assembly Language**



**Lab 04** 

Class CS3
Sections A, D, H, K
Semester Fall 2022

# Fast School of Computing

FAST-NU, Lahore, Pakistan

# **Objectives**

- How to interpret the different types of jumps
- How to use the different types of registers and how to manipulate them in assembly language
- How to perform arithmetic operations with registers and conditional jumps How to use the debugger for viewing the available registers and their function

## **Contents**

#### Objectives

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Note for all questions: You can make as many memory variables as you need

#### **ACTIVITY 1:**

Initialize ���� with last 4 digits of your roll number (for example, if your roll number is 16L-1105 then ���� should be initialized with 1105).

Once initialized, write a program to swap every pair of bits in the AX register as shown in **Table** below:

AX	Conten	ts of AX (\	our Roll #	<b>‡)</b>
Befor e	0000	0100	0101	0001
After	0000	1000	1010	0010

```
[org 0x0100]

mov ax, 1836h

mov cx, 0011001100110011b

and cx, ax

mov dx, 110011001100100b

and dx, ax

shl cx,2

shr dx,2
```

```
int 0x21
AX 1836
               SI 0000
                              CS 19F5
                                              IP 0115
                                                                Stack +0 0000
                                                                                       Flags 7204
BX 0000
               DI 0000
                              DS 19F5
                                                                          +2 20CD
CX 42C9
               BP 0000
                              ES 19F5
                                             HS 19F5
                                                                          +4 9FFF
                                                                                       OF DF IF SF ZF AF PF CF
DX 0201
               SP FFFE
                              SS 19F5
                                              FS 19F5
                                                                          +6 EA00
                                                                                         Θ
                                                                                             Θ
                                                                                                  1
                                                                                                       Θ
                                                                                                           0
                                                                                                                0
 CMD >
                                                                                                  2
                                                                                                       3
                                                                                                                5
                                                                                         0
                                                                                             1
                                                                                                           4
                                                                         DS:0000
                                                                                       CD 20 FF 9F 00 EA FF FF
0113 09D1
                              OR
                                         CX,DX
                                                                          DS:0008
                                                                                        AD DE
                                                                                                1B
                                                                                                     05
                                                                                                          C5
0115 B8004C
                              MOV
                                         AX,4C00
                                                                          DS:0010
                                                                                        18 01 10 01
                                                                                                          18
                                                                                                                   92
                                                                                                              01
0118 CD21
                                                                          DS:0018
                               INT
                                         21
                                                                                        01 01
                                                                                                01
                                                                                                     00
011A E489
                                                                          DS:0020
                                                                                       \mathbf{F}\mathbf{F}
                                                                                            \mathbf{F}\mathbf{F}
                                                                                                \mathbf{F}\mathbf{F}
                                                                                                     \mathbf{F}\mathbf{F}
                               ΙN
                                         AL,[89]
                                                                                                          \mathbf{F}\mathbf{F}
011C 46
                               INC
                                         SI
                                                                          DS:0028
                                                                                       \mathbf{F}\mathbf{F}
                                                                                            \mathbf{F}\mathbf{F}
                                                                                                \mathbf{F}\mathbf{F}
                                                                                                     \mathbf{F}\mathbf{F}
                                                                                                          \mathbf{EB}
                                                                                                                   E6
011D E6C7
                              OUT
                                         [C7],AL
                                                                          DS:0030
                                                                                       A2 01
                                                                                                14
                                                                                                     00
                                                                                                          18
011F 46
                               INC
                                                                         DS:0038
                                                                                       FF FF
                                                                                                \mathbf{F}\mathbf{F}
                                                                                                     \mathbf{F}\mathbf{F}
                                                                                                          00
                                         SI
                                                                                                              00 00 00
                                                                          DS:0040
                                                                                       05 00 00 00 00 00 00 00
0120 F60000
                              TEST
                                         [BX+SI],00
0123 8B46F6
                              MOV
                                         AX,[BP-0A]
                                                                          DS:0048
                                                                                       00 00 00 00 00 00 00 00
                0
                    1 2
                              3
                                  4
                                       5
                                            6
                                                7
                                                        8
                                                             9
                                                                 Ĥ
                                                                     В
                                                                         С
                                                                               D
                                                                                    E
DS:0000
               CD 20 FF 9F 00 EA FF
                                                                1B 05
                                              \mathbf{F}\mathbf{F}
                                                       AD DE
                                                                         C5 06 00 00
                                                                                                    f.n
                                                                                                               i . . + . .
DS:0010
               18 01 10 01
                                 18 01 92
                                               01
                                                       01 01
                                                                01 00
                                                                         02 FF
                                                                                  \mathbf{F}\mathbf{F}
                                                                                                . . . . . . . . . ff .
DS:0020
                   \mathbf{F}\mathbf{F}
                        \mathbf{F}\mathbf{F}
                            \mathbf{F}\mathbf{F}
                                 \mathbf{F}\mathbf{F}
                                      FF FF
                                                       \mathbf{F}\mathbf{F}
                                                            \mathbf{F}\mathbf{F}
                                                                \mathbf{F}\mathbf{F}
                                                                    \mathbf{F}\mathbf{F}
                                                                         EB 19
                                                                                                                     δ.μ
DS:0030
                                                                \mathbf{F}\mathbf{F}
                                                                    \mathbf{F}\mathbf{F}
                                                                         00 00 00 00
               AZ 01 14 00
                                 18 00 F5
                                               19
                                                       \mathbf{F}\mathbf{F}
                                                           \mathbf{F}\mathbf{F}
                                                                                                ó....J.
DS:0040
               05 00 00 00 00 00 00 00
                                                       00 00 00 00 00 00 00 00
               2ProcStep 3Retrie∨e 4Help ON 5BRK Menu 6
                                                                                       7 up 8 dn 9 le 16 ri
   Step
```

#### **ACTIVITY 2:**

mov ax, [0x4c00]

Modify your program in Activity 1 to swap two bits as shown in **Table** below:

AX	Conten	ts of AX (\	our Roll #	<b>†)</b>		
Befor e	0000	0100	0101	0001		
After	0000	0001	0101	0100		

```
[org 0x0100]

mov ax, 1836h

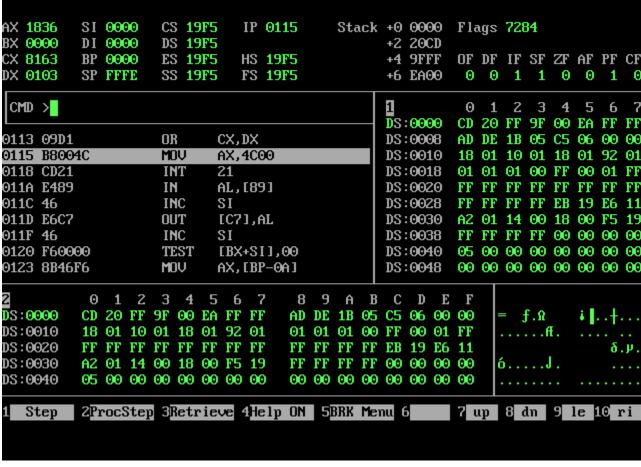
mov cx, 0000111100001111b

and cx, ax

mov dx, 1111000011110000b

and dx, ax
```

```
shr dx,4
or ex, dx
mov ax, [0x4c00]
int 0x21
```



#### **ACTIVITY 3**

Modify your program in Activity 1 & 2 to swap two nibbles as shown in **Table** below:

AX	Conten	Contents of AX (Your Roll #)											
Befor e	0000	0100	0101	0001									
After	0100	0000	0001	0101									

=-----

mov ax, 5273h

[org 0x0100]

shl cx,4

```
mov bx, 1111000011110000b
nov dx, 0000111100001111b
and bx,ax
and dx,ax
shr bx,4
shl dx,4
or bx,dx
mov ax,bx
mov ax, 0x4c00
int 21h
AX 2537
                                IP 0117
          SI 0000
                     CS 19F5
                                             Stack +0 0000
                                                             Flags 7200
BX 2537
          DI 0000
                     DS 19F5
                                                    +2 20CD
CX 0000
                                                    +4 9FFF
          BP 0000
                     ES 19F5
                                HS 19F5
                                                             OF DF IF SF ZF AF PF CF
DX 2030
          SP FFFE
                     SS 19F5
                                FS 19F5
                                                    +6 EA00
                                                              0
                                                                 0
                                                                     1
                                                                        Θ
                                                                           Θ
                                                                              0
                                                                                 Θ
                                                                        3
CMD >
                                                              0
                                                                 1
                                                                     2
                                                                           4
                                                                               5
                                                                                 6
                                                    DS:0000
                                                             CD 20 FF 9F 00 EA FF FF
0115 89D8
                     MOV
                             AX,BX
                                                    DS:0008
                                                             AD DE 1B 05
                                                                          C5
                             AX,4000
0117 B8004C
                     MOV
                                                    DS:0010
                                                             18 01 10 01
                                                                          18
                                                                             01 92
011A CD21
                                                    DS:0018
                                                             01 01 01 00 FF
                                                                              00 01 00
                     INT
                             21
                                                             01 FF FF FF FF
                             SI
                                                    DS:0020
011C 46
                     INC
011D E6C7
                             [C7],AL
                                                    DS:0028
                     OUT
                                                             FF FF FF FF
                                                                          \mathbf{EB}
                                                                             19
011F 46
                     INC
                                                    DS:0030
                                                             A2 01
                                                                       00
                             SI
                                                                    14
                                                                          18
0120 F60000
                     TEST
                             [BX+SI1,00
                                                    DS:0038
                                                             FF FF FF
                                                                       FF 00 00 00 00
0123 8B46F6
                     MOV
                             AX.[BP-0A]
                                                    DS:0040
                                                             05 00 00 00 00 00 00 00
0126 D1E0
                     SHL
                             AX,1
                                                    DS:0048
                                                             00 00 00 00 00 00 00 00
                  2
                     3 4 5 6
                                 7
                                          9
                                                    С
                                                        D
                                                           E
           0 1
                                        8
                                             Ĥ
                                                В
DS:0000
          CD 20 FF 9F 00 EA FF FF
                                      AD DE 1B 05 C5 06 00 00
                                                                     f.n
                                                                              i . . + . .
DS:0010
                       18 01 92
          18 01 10 01
                                 01
                                      01 01 01
                                                00
                                                   FF 00
                                                          01 00
                                                                   . . . . . . . . ff .
DS:0020
          01 FF FF
                    FF FF
                          FF FF
                                             FF FF EB 19 E6 11
                                 \mathbf{F}\mathbf{F}
                                      FF FF
                                                                                  δ.μ
DS:0030
          A2 01 14 00 18 00 F5
                                19
                                      FF FF FF FF 00 00 00 00
                                                                   ó....J.
DS:0040
          05 00 00 00 00 00 00 00
                                      00 00 00 00 00 00 00 00
1 Step
          2ProcStep 3Retrie∨e 4Help ON 5BRK Menu 6
                                                             7 up 8 dn 9 le 16 ri
```

**ACTIVITY 4:** 

Initialize ��� with last 4 digits of your roll number (for example, i $\underline{\underline{f}}$  your roll number is

16L-1105 then  $\diamond\diamond\diamond\diamond$  should be initialized with 1105). Store  $\diamond\diamond\diamond\diamond$  in  $\diamond\diamond\diamond\diamond$ . Make a memory variable  $\diamond\diamond$ , initialize it with 0 and compute

|| is bitwise OR operation, && is bitwise AND operation whereas ⊙ is bitwise XOR operation.

**—**-----

[org 0x0100]

mov ax, 5380

mov cx, 1111111111111111b

mov bx, ax

xor bx, cx

or bx, ax

mov cx, ax

xor ax, 1BCDh

mov dx,ax

and cx,dx

mov ax , 0x4c00

int 21h

ΑX	ΘE	C9	SI	00	90	CS	3 19	9F5		ΙP	0115		St	ack	+0	000	90	Flā	ags	720	94				
BX	$\mathbf{F}\mathbf{F}$	FF	DI	00	90	DS	3 19	9F5								200			_						
CX	04	00	BP	00	90	ES	3 19	9F5	I	4S	19F5				+4	9F]	$\mathbf{F}\mathbf{F}$	$\mathbf{OF}$	DF	IF	SF	ZF	ΑF	PF	CF
DΧ	0E	C9	SP	FF	FE	SS	3 19	9F5	]	FS	19F5				+6	EA(	90	Θ	Θ	1	0	Θ	Θ	1	0
CI	TD	>												Т	1			0	1	2	3	4	5	6	7
L														$\dashv$		000	90	CD	20	$\mathbf{F}\mathbf{F}$	9F	00	ΕA	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$
<b>01</b> :	13	21D1				ΑÌ	٩D	(	(,XC	DX					DS	:000	98	ΑD	DE	<b>1B</b>	05	<b>C5</b>	<b>06</b>	00	00
		B800				M			λX,	4C0	0				DS	:00:	10	18	01	10	01	18	01	92	01
		CD21					Tr		21							:00:		01	01		00			01	00
		E489				ΙÌ			ΉL,	[89	]					:000		01	<b>00</b>	01	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$		$\mathbf{F}\mathbf{F}$	FF
<b>01</b> :	1C	46					1C		3 I						DS	:000	28	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	EB	19	E6	11
		E6C7					JT		[C7]	],A	L					:000		AZ	01	14	<b>90</b>	18	<b>00</b>		19
	1F						1C		31							:00:		$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$		<b>00</b>		00
		F600					EST				1,00					:004		05	00	<b>00</b>	<b>00</b>		<b>90</b>		<b>00</b>
017	23	8B46	F6			MC	JV	f	ìΧ,	[BP	-0A]				DS	:004	<del>1</del> 8	00	00	<b>00</b>	<b>00</b>	00	00	00	00
2			0	1	2	3	4	5	6	7	8	9	Á	В	С	D	Е	F	П						
	00	100	CD	20	$\mathbf{F}\mathbf{F}$	9F	00	ΕA	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	ΑD	DE	1B	05	C5	<b>06</b>	00	00	-  -	= ;	f.Ω		i I	+	
DS	:00	10	18	01	10	01	18	01	92	01	01	01	01	00	$\mathbf{F}\mathbf{F}$	00	01	<b>00</b>			1	Ŧ.			
DS	:00	20	01	<b>00</b>	01	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	FF	$\mathbf{F}\mathbf{F}$	FF	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	EB	19	E6	11						δ	ψ.
DS	:00	30	AΖ	01	14	$\Theta\Theta$	18	00	F5	19	FF	FF	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	90	00	00	90	- Į ć	ó.,		J.			
DS	:00	40	05	<b>00</b>	<b>00</b>	<b>00</b>	<b>00</b>	<b>00</b>	<b>00</b>	00	00	00	00	<b>00</b>	<b>00</b>	<b>00</b>	<b>00</b>	00				• •			
1	St	ер	ZР	roc	Ste	3	Reti	rie	ле <sup>2</sup>	1He	lp ON	<b>1</b> 5	BRK	Men	nu (	6		7 u	ιp	8	dn	9	le	10 1	ri

#### **ACTIVITY 5:**

Initialize ���� with last 4 digits of your roll number (for example, if your roll number is

16L-1105 then ���� should be initialized with 1105). Store ���� in ����. Make a 32-bit memory variable ��, initialize it with 0 and compute

 $\times$  is **Multiplication** operation, + is **Addition** operation whereas  $\{ \diamondsuit \diamondsuit, \diamondsuit \diamondsuit \}$  concatenates 16-bit **A** and **B** to form **32-bit** number.

\_\_\_\_\_\_

[org 0x0100]
mov ax,5380

mov bx, ax

```
not bx
mov word [multiplicand], ax
mov word [multiplier], bx
mov cl, 16
mov bx, 1
checkbit:
    test bx, [multiplier]
    jz skip
    mov ax, [multiplicand]
    add [result], ax
    mov ax, [multiplicand + 2]
    adc [result + 2], ax
    skip:
        shl word [multiplicand], 1
       rcl word [multiplicand + 2], 1
       shl bx , 1
jnz checkbit
mov ax, 5380
mov bx, ax
```

```
not bx
   add bx, [result]
   adc ax, [result+2]
   mov [f], bx
   mov [f+2], ax
   mov ax, 0x4c00
f: dd 0
multiplicand: dd 5380
multiplier: dw 0
result: dd 0
```

ΑX	7F	85	S	[	000	90	CS	3 19	9F5		IP 6	14B		Sta	ack	+0	000	90	Fla	aas	72	90				
	76		D	[	000	90	DS	3 1	9F5								200			J						
CX	00	000	BI	•	000	90	ES	3 1	9F5	ŀ	4S 1	9F5				+4	9FI	FF	OF	DF	ΙF	SF	ZF	ΑF	PF	$\mathbf{CF}$
DΧ	00	000	SI	•	FFI	E	SS	3 1	9F5		FS 1					+6	EAG	90	0	0	1	0		0	0	0
	MD	>													Т	1			0	1	2	3	4	5	6	7
Ľ															_		000	90	CD	20	$\overline{FF}$	9F	00	EΑ	$\overline{FF}$	$\mathbf{F}\mathbf{F}$
01	48	A35	201				MC	JU		[015	521,	ΑX					:000		ΑD	DE	1B	05		06	00	00
			)04C				M				1C00						:00:		18	01	10		18	01		
01	4E	CDZ	:1					T		21					_		:00:		01	01	01	00	$\mathbf{F}\mathbf{F}$	00	01	00
	50						DI			03							: 000		01	00	01	00	01	$\mathbf{F}\mathbf{F}$	FF	$\mathbf{F}\mathbf{F}$
01	51	708	35				JO	)	- (	90D8	3					DS	: 000	28	$\mathbf{F}\mathbf{F}$	FF	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	EB	19	<b>E6</b>	11
01	53	<b>7E</b> 6	00				Jì	1G	- (	9159	5					DS	:000	30	A2	01	14	99	18	99	F5	19
01	55	000	)4				ΑI	DD		[SI]	],AL					DS	:000	38	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	00	00	00	00
01	57	15F	BEA				ΑI	C	1	AX,I	EAFB	i				DS	:004	10	05	00	00	00	00	00	00	00
01	5A	D88	35806	59			ES	3C	- (	90,I	[698	0+DI	1			DS	:004	<del>1</del> 8	<b>00</b>	00	00	<b>00</b>	00	<b>00</b>	00	<b>00</b>
2			(	)	1	2	3	4	5	6	7	8	9	A	В	С	D	E	F	Т						
	00	000	CI	)	20	$\mathbf{F}\mathbf{F}$	9F	00	ΕA	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	AD	DE	<b>1B</b>	05	<b>C5</b>	<b>06</b>	00	00		= :	f.n		i I	+	
DS	:00	10	18	3	01	10	01	18	01	92	01	01	01	01	00	$\mathbf{F}\mathbf{F}$	00	01	00	-1		1	Ŧ.	- 7		
DS	:00	20	01	L	00	01	$\Theta\Theta$	01	$\mathbf{F}\mathbf{F}$	$\mathbf{E}\mathbf{B}$	19	<b>E6</b>	11	-1					δ	, μ.						
DS	:00	30	AZ	2	01	14	<b>00</b>	18	90	F5	19	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	$\mathbf{F}\mathbf{F}$	00	00	$\Theta\Theta$	$\Theta\Theta$		ó		J.			
DS	:00	40	05	5	00	00	<b>00</b>	00	<b>00</b>	00	00	00	<b>00</b>	<b>00</b>	<b>00</b>	00	<b>00</b>	00	00							
1	St	ер	2	'n	ocS	Ster	3	Ret	rie	ve 4	Hel	p ON	<b>1</b> 5i	BRK	Men	nu (	6		7 u	ιp	8	dn	9	le	10	ri
		1																		1						

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#### **ACTIVITY 6:**

Differentiate between Near, Far and Short Jumps. Write your own assembly language programs and demonstrate how these jumps have been taken.

#### **REFERENCES**

- "http://www.dosbox.com/download.php?main=1
- <a href="http://sourceforge.net/projects/nasm">http://sourceforge.net/projects/nasm</a>
- <a href="http://www.nasm.us/">http://www.nasm.us/</a>
  - <a href="http://www.programmersheaven.com/download/21643/download.aspx">http://www.programmersheaven.com/download/21643/download.aspx</a> (AFD)