National University of Computer and Emerging Sciences

Lab Manual

Computer Organization and Assembly Language

Lab 01

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Class	CS3
Sections	A1, D1, H1, K2
Semester	Fall 2022

Fast School of Computing

FAST-NU, Lahore, Pakistan

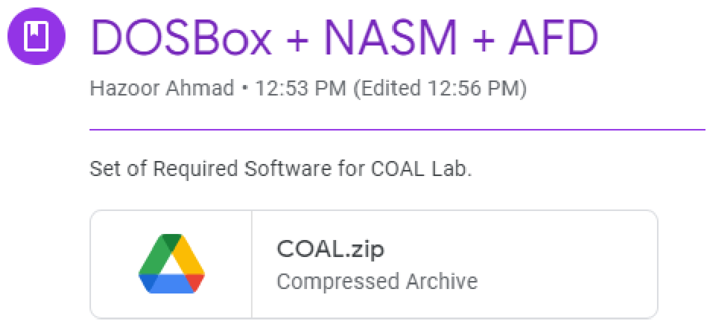
Objectives

- To setup DOSBOX, NASM and AFD
- Running your first program in Assembly
- Practicing few basic programs in Assembly
- Explaining basic functions in debugger

Contents

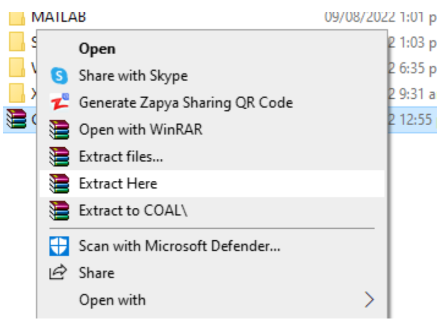
ACTIVITY 1: INSTALLATION & IMPORTANT COMMANDS

1. First, make sure that there is no folder named "COAL" in "D:\" Drive of your system.
2. Once you ensure step 1, Sign into the classroom for downloading the set of software required for this lab. Your Class Post seems like below

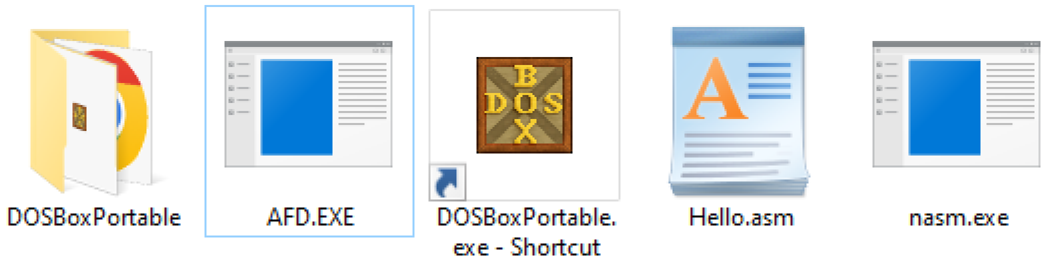


DOSBox + NASM + AFD
Hazoor Ahmad • 12:53 PM (Edited 12:56 PM)
Set of Required Software for COAL Lab.
COAL.zip
Compressed Archive

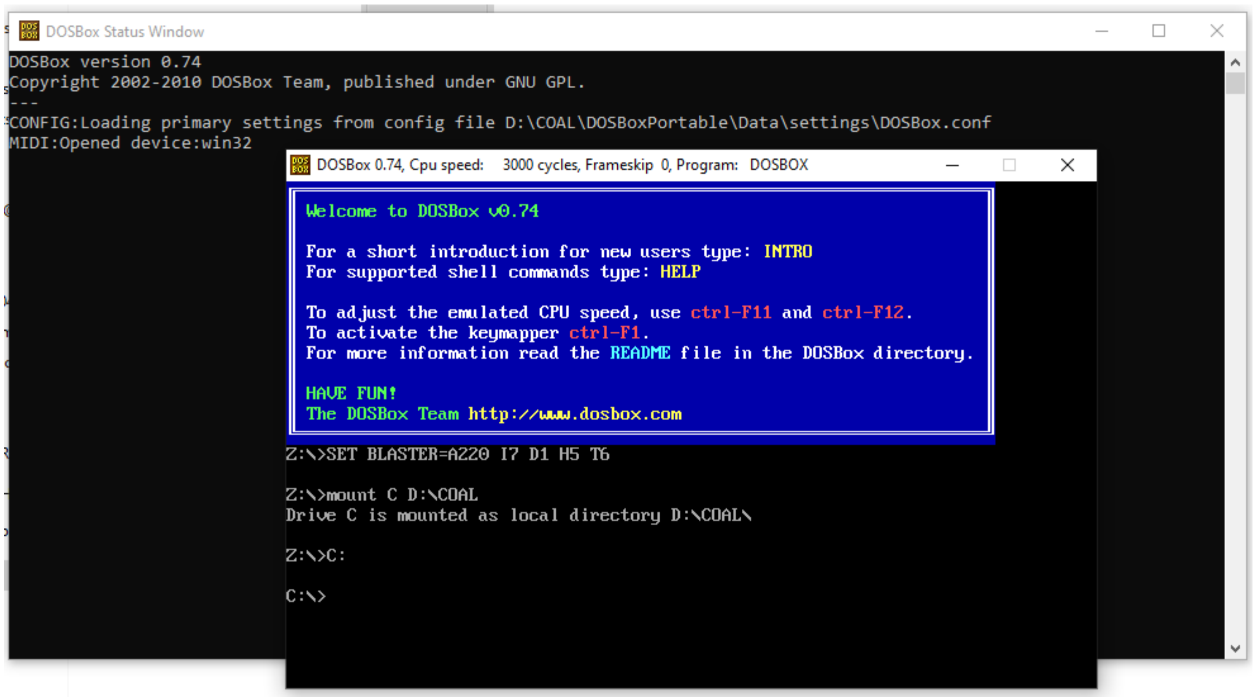
3. Download and take the file to the "D:\" Drive of your system.
4. Right Click on the file and press "Extract Here" [if you have WinRAR installed] as shown.



5. After extracting you will see a “D:\COAL” folder in “D:\” Drive of your system.
6. Open that folder and you will see the following contents



7. This folder has everything ready for you, you just click on “DOSBoxPortable.exe” to start.
8. Once DOSBox is started it will look like the following:


DOSBox Status Window
DOSBox 0.74, Cpu speed: 3000 cycles, Frameskip 0, Program: DOSBOX

```
DOSBox version 0.74
Copyright 2002-2010 DOSBox Team, published under GNU GPL.
---
CONFIG:Loading primary settings from config file D:\COAL\DOSBoxPortable\Data\settings\DOSBox.conf
MIDI:Opened device:win32
```

```
Welcome to DOSBox v0.74

For a short introduction for new users type: INTRO
For supported shell commands type: HELP

To adjust the emulated CPU speed, use ctrl-F11 and ctrl-F12.
To activate the keymapper ctrl-F1.
For more information read the README file in the DOSBox directory.

HAVE FUN!
The DOSBox Team http://www.dosbox.com
Z:\>SET BLASTER=A220 I7 D1 H5 T6

Z:\>mount C D:\COAL
Drive C is mounted as local directory D:\COAL\

Z:\>C:

C:\>
```

9. Your environment [already set] has following abstractions:
   a. DOSBox is already mounted at “D:\COAL”.
   b. You must make all your assembly language programs in the folder “D:\COAL”.

    c. In case you want to change the path see “MOUNT Command” in step 10.
    d. DOSBox requires “nasm.exe” and “afd.exe” which should be present to the folder you mounted.

10. **MOUNT Command**: The format of MOUNT command is as follows:

    ```
    mount<space>Mount_Name<space>Mount_Path
    ```

    you can specify any name to the mount command and any existing path from your system. One example is shown below:

    ```
    mount<space>C<space>D:\COAL
    ```

    You can specify more than one mount points to the DOSBox but keep “nasm.exe” and “afd.exe” at every mount point.
    You can change mount point by specifying a Mount_Name a suffix of “:”, as shown below

    ```
    C:
    ```

11. **NASM Command**: The Netwide Assembler, NASM, is an 80x86 and x86-64 assembler designed for portability and modularity. You can perform following operations using assembler

    Compile: To compile “hello.asm” program type the following command

    ```
    nasm<space>hello.asm
    ```

    Assemble: To assemble “hello.asm” program type the following command

    ```
    nasm<space>hello.asm<space>-o<space>hello.com
    ```

    Listing File: To generate listing file from “hello.asm” program type the following command

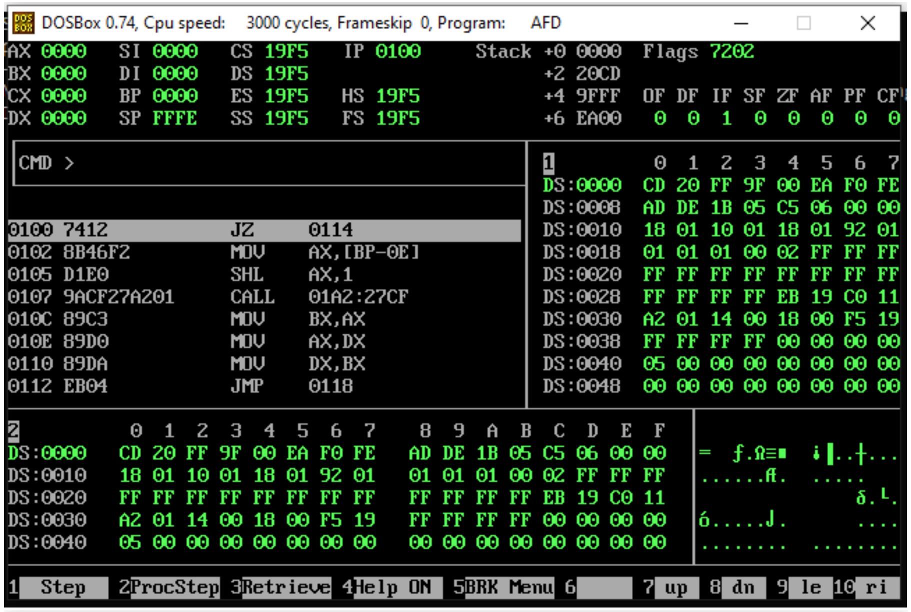
    ```
    nasm<space>hello.asm<space>-l<space>hello.lst
    ```

    Other Controls: To have more controls type the following command

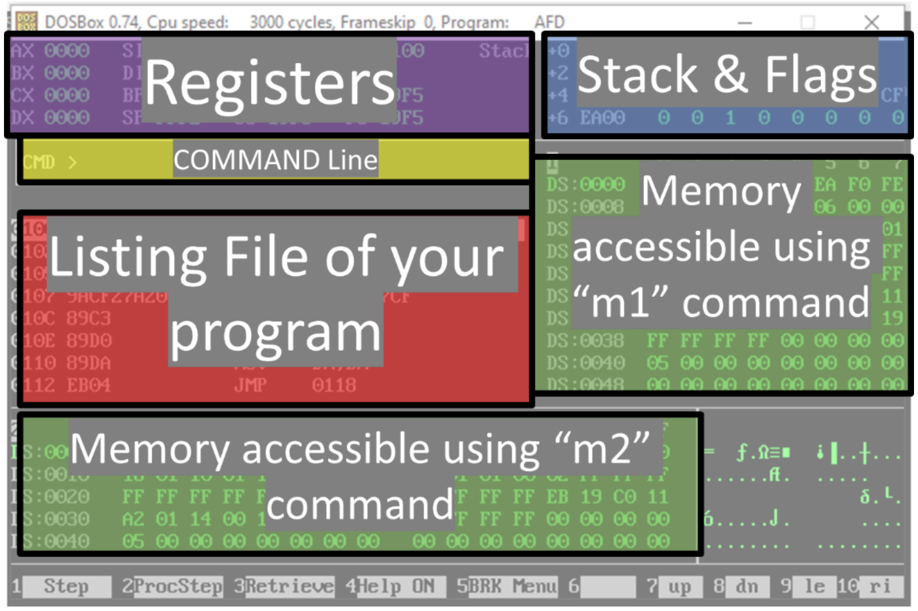
    ```
    nasm<space>-h
    ```

16. **AFD Command**: To launch the debugger of “hello.com” file generated in your environment you should run the following command

    ```
    afd<space>hello.com
    ```



```
DOSBox 0.74, Cpu speed:   3000 cycles, Frameskip  0, Program:    AFD
AX 0000   SI 0000   CS 19F5   IP 0100      Stack +0 0000  Flags 7202
BX 0000   DI 0000   DS 19F5                      +2 20CD
CX 0000   BP 0000   ES 19F5   HS 19F5      +4 9FFF  OF DF IF SF ZF AF PF CF
DX 0000   SP FFFE   SS 19F5   FS 19F5      +6 EA00   0  0  1  0  0  0  0  0

CMD >                                        1        0  1  2  3  4  5  6  7
                                             DS:0000  CD 20 FF 9F 00 EA F0 FE
                                             DS:0008  AD DE 1B 05 C5 06 00 00
0100 7412           JZ     0114              DS:0010  18 01 10 01 18 01 92 01
0102 8B46F2         MOV    AX,[BP-0E]        DS:0018  01 01 01 00 02 FF FF FF
0105 D1E0           SHL    AX,1              DS:0020  FF FF FF FF FF FF FF FF
0107 9ACF27A201     CALL   01A2:27CF         DS:0028  FF FF FF FF EB 19 C0 11
010C 89C3           MOV    BX,AX             DS:0030  A2 01 14 00 18 00 F5 19
010E 89D0           MOV    AX,DX             DS:0038  FF FF FF FF 00 00 00 00
0110 89DA           MOV    DX,BX             DS:0040  05 00 00 00 00 00 00 00
0112 EB04           JMP    0118              DS:0048  00 00 00 00 00 00 00 00

2         0  1  2  3  4  5  6  7   8  9  A  B  C  D  E  F
DS:0000  CD 20 FF 9F 00 EA F0 FE  AD DE 1B 05 C5 06 00 00   = ƒ.ﬂ≡▪  ↓▌..┼...
DS:0010  18 01 10 01 18 01 92 01  01 01 01 00 02 FF FF FF   ......Æ.  .....
DS:0020  FF FF FF FF FF FF FF FF  FF FF FF FF EB 19 C0 11             δ.└.
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 3Retrieve 4Help ON  5BRK Menu 6      7 up  8 dn  9 le 10 ri
```


Registers
Stack & Flags
COMMAND Line
Memory accessible using "m1" command
Listing File of your program
Memory accessible using "m2" command

- To scroll into the listing file press "F1"
- To see specific memory location from M1 or M2 memory just type m1 or m2 followed by address of that specific memory location.
- To quit from AFD type the following "quit" in COMMAND Line of AFD.

ACTIVITY 2: RUNNING YOUR FIRST PROGRAM

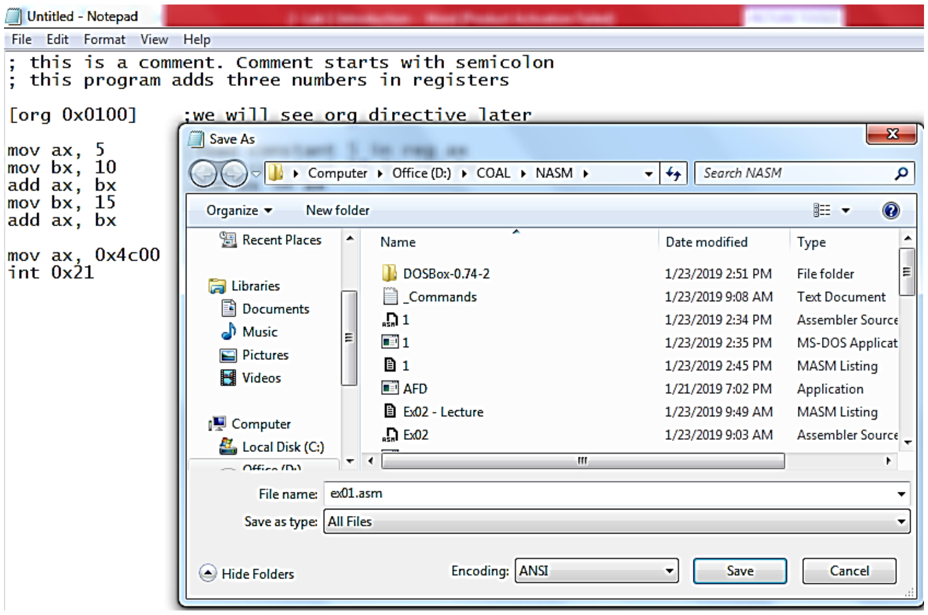
Follow these steps to run your first program:

1- Copy/paste following code in notepad

```
; this is a comment. Comment starts with semicolon
; this program adds three numbers in registers

[org 0x0100]    ;we will see org directive later
```

```
mov ax, 5       ; AX = 5
mov bx, 10      ; BX = 10
add ax, bx      ; AX = AX + BX
mov bx, 15      ; BX = 15
add ax, bx      ; AX = AX + BX

mov ax, 0x4c00          ;terminate the program
int 0x21
```

2- Save this file as “ex01.asm” in your folder e.g. “D:\COAL”:



```
; this is a comment. Comment starts with semicolon
; this program adds three numbers in registers

[org 0x0100]     ;we will see org directive later

mov ax, 5
mov bx, 10
add ax, bx
mov bx, 15
add ax, bx

mov ax, 0x4c00
int 0x21
```

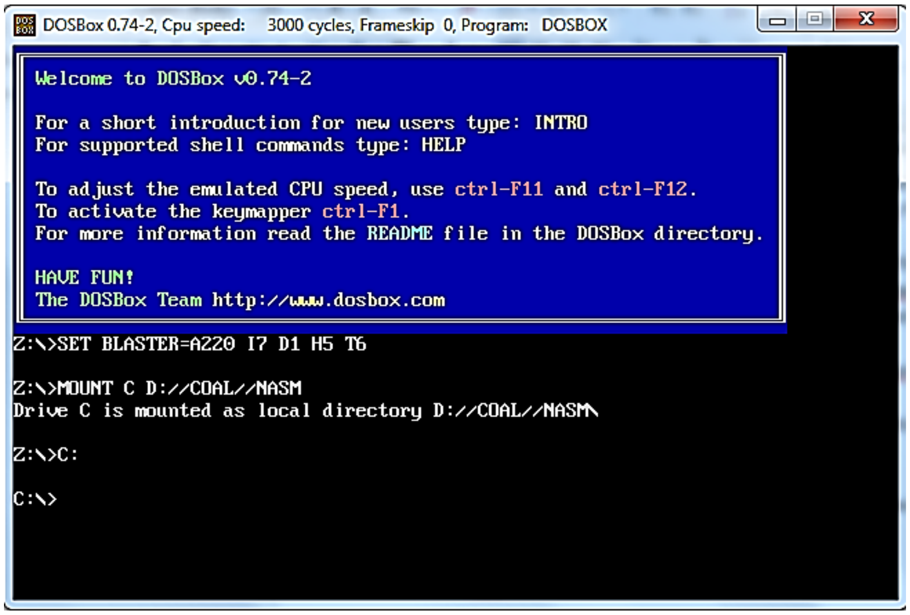
Name	Date modified	Type
DOSBox-0.74-2	1/23/2019 2:51 PM	File folder
_Commands	1/23/2019 9:08 AM	Text Document
1	1/23/2019 2:34 PM	Assembler Source
1	1/23/2019 2:35 PM	MS-DOS Applicat
1	1/23/2019 2:45 PM	MASM Listing
AFD	1/21/2019 7:02 PM	Application
Ex02 - Lecture	1/23/2019 9:49 AM	MASM Listing
Ex02	1/23/2019 9:03 AM	Assembler Source

File name: ex01.asm
Save as type: All Files
Encoding: ANSI

nasm ex01.asm -o ex01.com -l ex01.lst

3- Above command will assemble your code and create ex01.com and ex01.lst files. Open ex01.lst file in notepad.
   a. What is opcode of instruction “mov ax, someConstant”
   b. Verify the above opcode everywhere the instruction has been used.
   c. What does “B80500” mean?
   d. Verify the opcode of instruction “mov bx, someConstant” throughout the machine code.
   e. What is the offset of first instruction?
   f. Why are offsets of second and third instructions 3 and 6?
   g. What should be the size of ex01.com file?
   h. Right click ex01.com and verify its size.

4- Open DOSBox (by double clicking dosbox.exe), following window will appear:

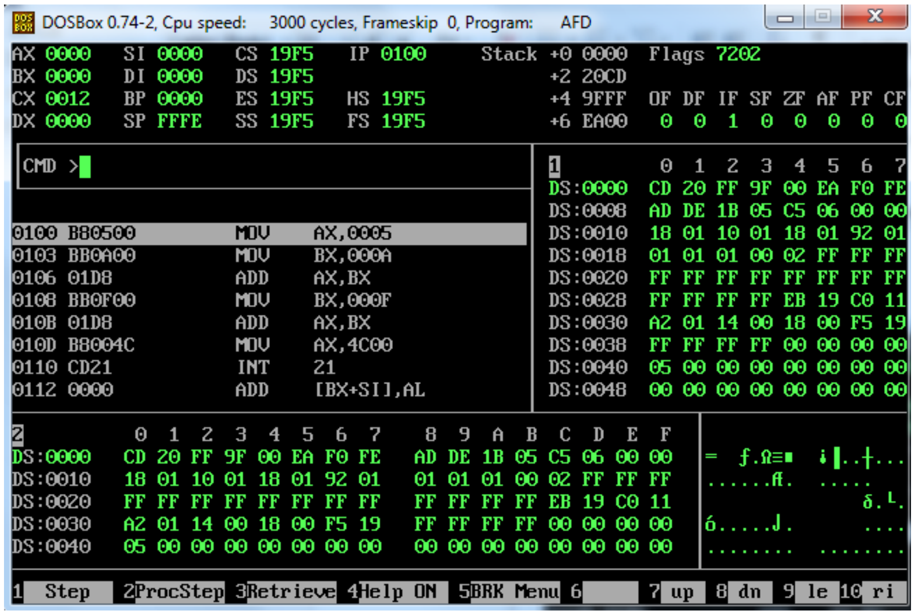


```
DOSBox 0.74-2, Cpu speed:    3000 cycles, Frameskip  0, Program:   DOSBOX

Welcome to DOSBox v0.74-2

For a short introduction for new users type: INTRO
For supported shell commands type: HELP

To adjust the emulated CPU speed, use ctrl-F11 and ctrl-F12.
To activate the keymapper ctrl-F1.
For more information read the README file in the DOSBox directory.

HAVE FUN!
The DOSBox Team http://www.dosbox.com

Z:\>SET BLASTER=A220 I7 D1 H5 T6

Z:\>MOUNT C D://COAL//NASM
Drive C is mounted as local directory D://COAL//NASM\

Z:\>C:

C:\>
```

5- Write following command and press enter.

Afd ex01.com

(Your AFD.exe should be in same directory where we have installed everything)



```
DOSBox 0.74-2, Cpu speed:    3000 cycles, Frameskip  0, Program:    AFD

AX 0000   SI 0000   CS 19F5   IP 0100     Stack +0 0000  Flags 7202
BX 0000   DI 0000   DS 19F5                     +2 20CD
CX 0012   BP 0000   ES 19F5   HS 19F5           +4 9FFF   OF DF IF SF ZF AF PF CF
DX 0000   SP FFFE   SS 19F5   FS 19F5           +6 EA00    0  0  1  0  0  0  0  0

 CMD >                                          1        0  1  2  3  4  5  6  7
                                                DS:0000  CD 20 FF 9F 00 EA F0 FE
                                                DS:0008  AD DE 1B 05 C5 06 00 00
0100 B80500         MOV     AX,0005             DS:0010  18 01 10 01 18 01 92 01
0103 BB0A00         MOV     BX,000A             DS:0018  01 01 01 00 02 FF FF FF
0106 01D8           ADD     AX,BX               DS:0020  FF FF FF FF FF FF FF FF
0108 BB0F00         MOV     BX,000F             DS:0028  FF FF FF FF EB 19 C0 11
010B 01D8           ADD     AX,BX               DS:0030  A2 01 14 00 18 00 F5 19
010D B8004C         MOV     AX,4C00             DS:0038  FF FF FF FF 00 00 00 00
0110 CD21           INT     21                  DS:0040  05 00 00 00 00 00 00 00
0112 0000           ADD     [BX+SI],AL          DS:0048  00 00 00 00 00 00 00 00

2          0  1  2  3  4  5  6  7    8  9  A  B  C  D  E  F
DS:0000   CD 20 FF 9F 00 EA F0 FE   AD DE 1B 05 C5 06 00 00   =  ƒ.Ω≡■  ╻▌..┼...
DS:0010   18 01 10 01 18 01 92 01   01 01 01 00 02 FF FF FF   ......Æ.  .....
DS:0020   FF FF FF FF FF FF FF FF   FF FF FF FF EB 19 C0 11             δ.└.
DS:0030   A2 01 14 00 18 00 F5 19   FF FF FF FF 00 00 00 00   ó.....⌡.      ....
DS:0040   05 00 00 00 00 00 00 00   00 00 00 00 00 00 00 00   ........  ........

1 Step  2ProcStep 3Retrieve 4Help ON 5BRK Menu 6       7 up  8 dn  9 le 10 ri
```

6- Above command will open the debugger and load your ex01.com file in it.

a. What is the value of IP register? And what will be its effect?

b. Note the initial values of data registers

c. Press F1 and watch the values of data registers

ACTIVITY 3 PRACTICE QUESTION

Modify this program to generate the sum of first five entries of table of 3, using registers, and watch its execution in the debugger.

Help: [Approach 1] Can you do this using two registers only? [Approach 2] Can you do this using one register only if we have **add ax, 3** available in our instruction set? Try both of these approaches and watch the first five entries of table of 3 in AX.

ACTIVITY 4: PRACTICE QUESTION

Write a program that rotates the value of three registers clockwise twice i.e. given these initial values: ax=10, bx=20, cx=30.

Help: First draw data registers on paper. Solve this problem on paper then write your code accordingly. After writing your code verify the execution on paper first then check the execution on AFD. You may use DX.

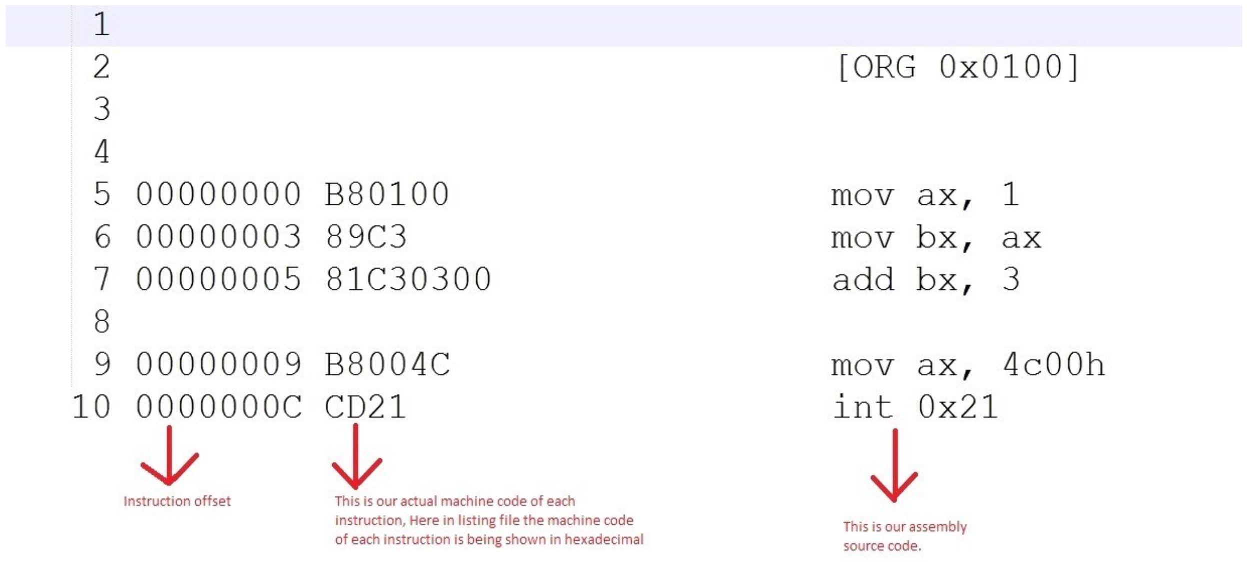
APPENDIX:

Listing File:

Listing file is created by nasm when you enter "-l list_file_name.lst" during assembling the program, such as, if you enter the following:

```
nasm code.asm –o output.com  –l list_file.lst
```

The above command will now generate a listing file named "list_file.lst" along with the com file. Listing File will look something like this:



```
 1
 2                                      [ORG 0x0100]
 3
 4
 5 00000000 B80100                      mov ax, 1
 6 00000003 89C3                        mov bx, ax
 7 00000005 81C30300                    add bx, 3
 8
 9 00000009 B8004C                      mov ax, 4c00h
10 0000000C CD21                        int 0x21
```

Instruction offset
This is our actual machine code of each instruction, Here in listing file the machine code of each instruction is being shown in hexadecimal
This is our assembly source code.

Difference between Mnemonic and Opcode:

MNEMONIC: Human Readable words. The assembly keywords, such as, mov, add, sub, etc are MNEMONICS for programmers because they are easily understood by them. We use these MENMONICS to write programs because we can easily remember mnemonics. Mnemonics cannot be executed by the CPU, so mnemonics are always converted into some opcode which can be executed by the CPU.

OPCODE: It is a number interpreted by the CPU that represents the operation to perform. For example in the above listing file, the opcode for moving an immediate operand into AX register is B8. Can you identify the opcode for adding an immediate value into BX from the above listing file?

Purpose of [ORG 0x0100]:

It simply tells the nasm that the instructions of our program should placed at the start 256th byte of code segment. (The first 256 bytes are to be skipped). Note that 0x0100 is a hexadecimal number whose decimal value is 256. The reason we skip the first 256 bytes is because these bytes have some important piece of code that we do not want to overwrite with our own. This will be further clarified in some later lab session.

REFERENCES

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