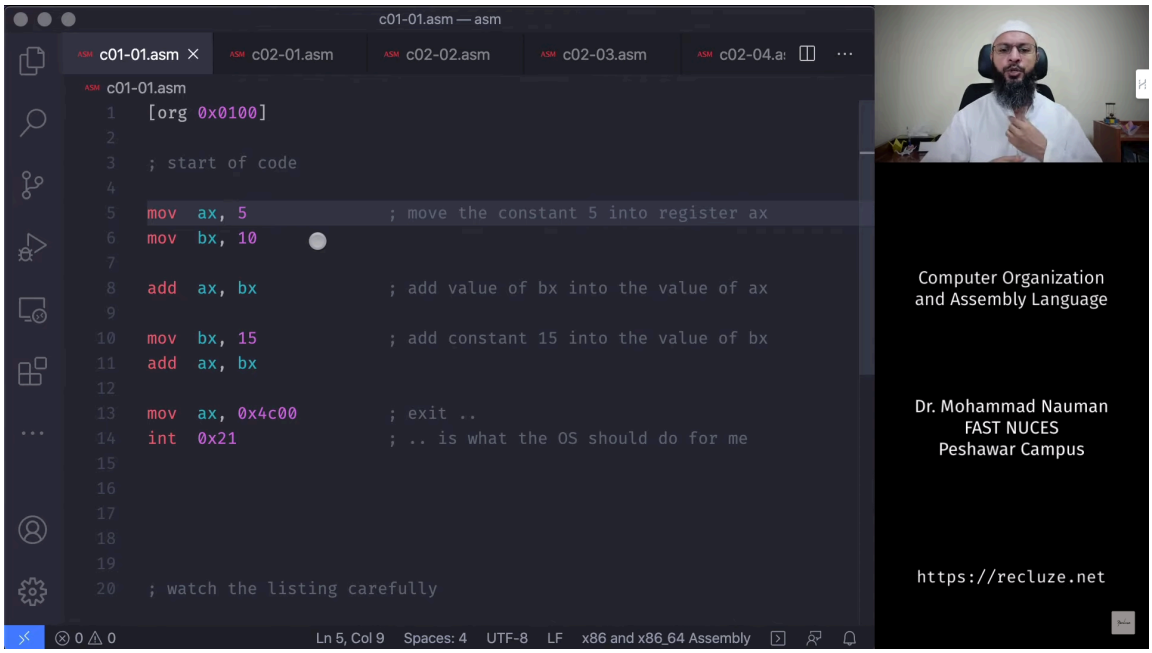
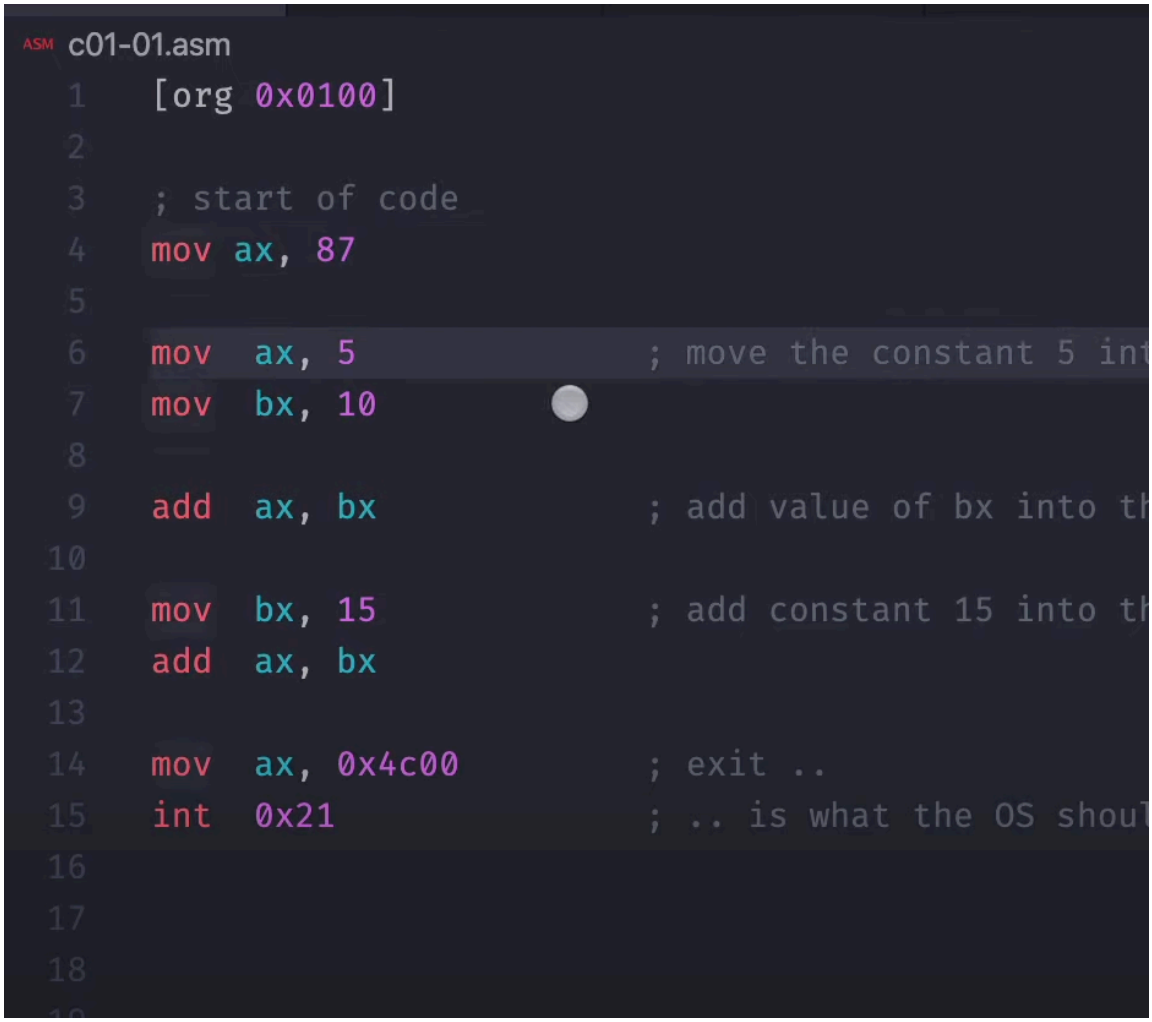
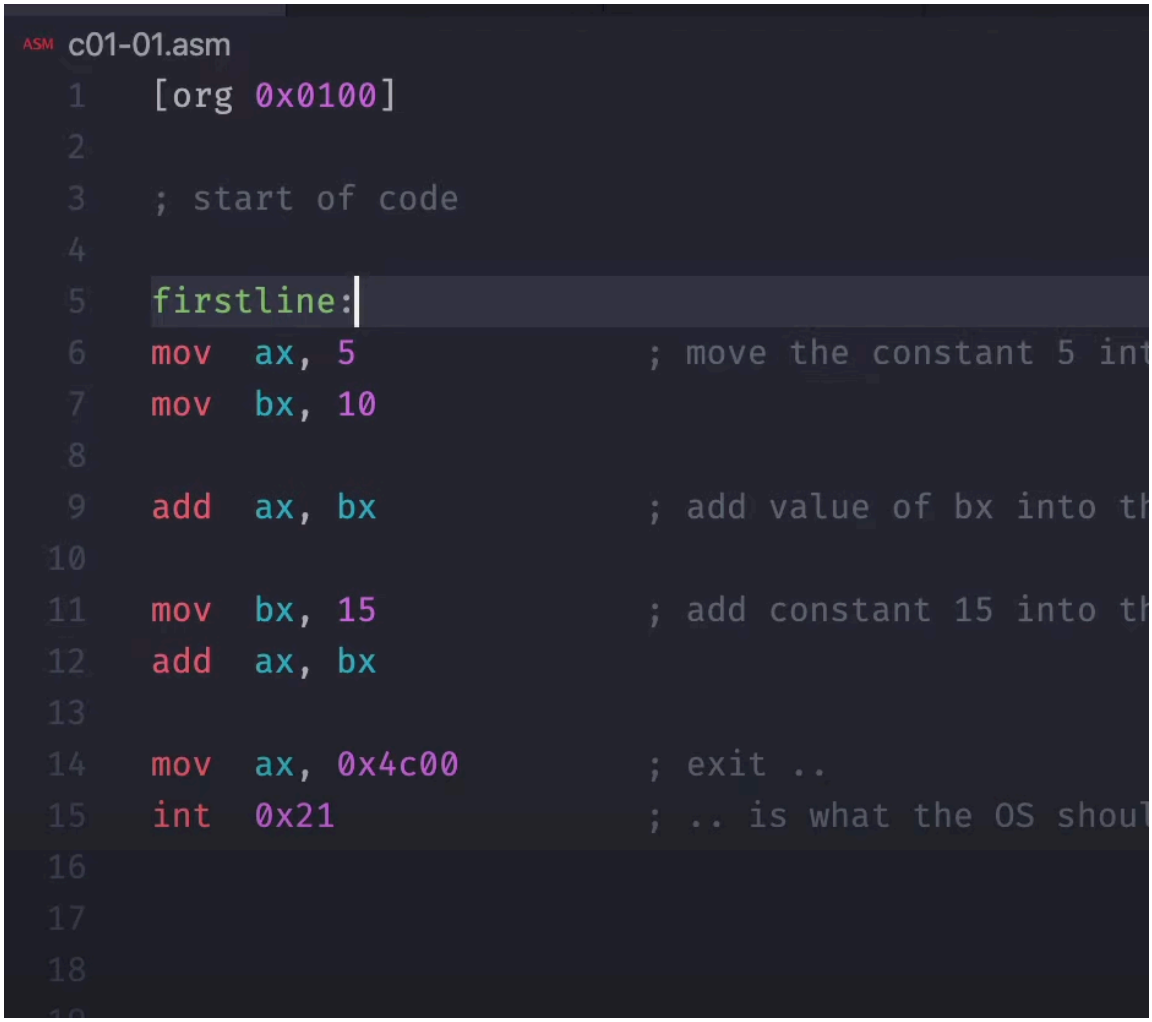
COAL LECTURE 4



- All the old lecture revision about what all the OPP code does and what these Instruction results in
- What we are trying to do in this lecture is that we are gonna load data from RAM (MEMORY) instead of hard coding it

- 

    - Because of this change , by writing the (mov ax , 87) the address of line number 6 changes as the assembler starts assembling instruction from top to bottom
- Now instead of memorizing the address in our brain which is kinda very difficult we will give it a LABEL a kind of BOOKMARK

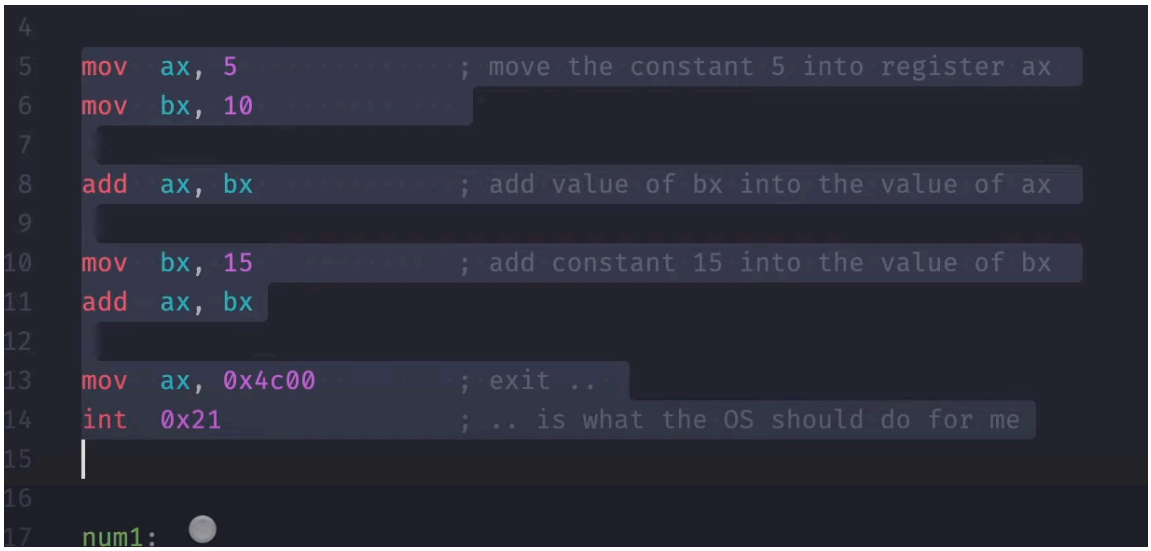
- 

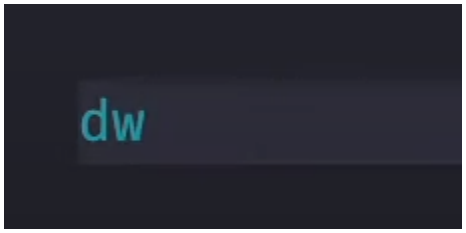
    - As you can see the FIRSTLINE : , this is not part of the code but a label that the first line starts from here

- 

    - Or you can see it this way
    - Now the address of this instruciton is strored in the LABEL " FIRSTLINE "
    - 

        - This is nothing but a address " B80500 "

- 

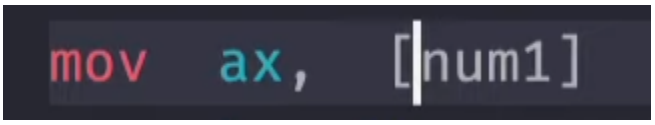
    - What are these address ?
        - These are all the addresses of RAM
- 

    - DW : Define Word
    - This allocates a 16-bit memory to be used by the code when we assign something to it

```
4
5   mov  ax, 5                ; move the constant
6   mov  bx, 10
7
8   add  ax, bx               ; add value of bx int
9
10  mov  bx, 15               ; add constant 15 int
11  add  ax, bx
12
13  mov  ax, 0x4c00           ; exit ..
14  int  0x21                 ; .. is what the OS
15
16
17  dw   5
18
19
```

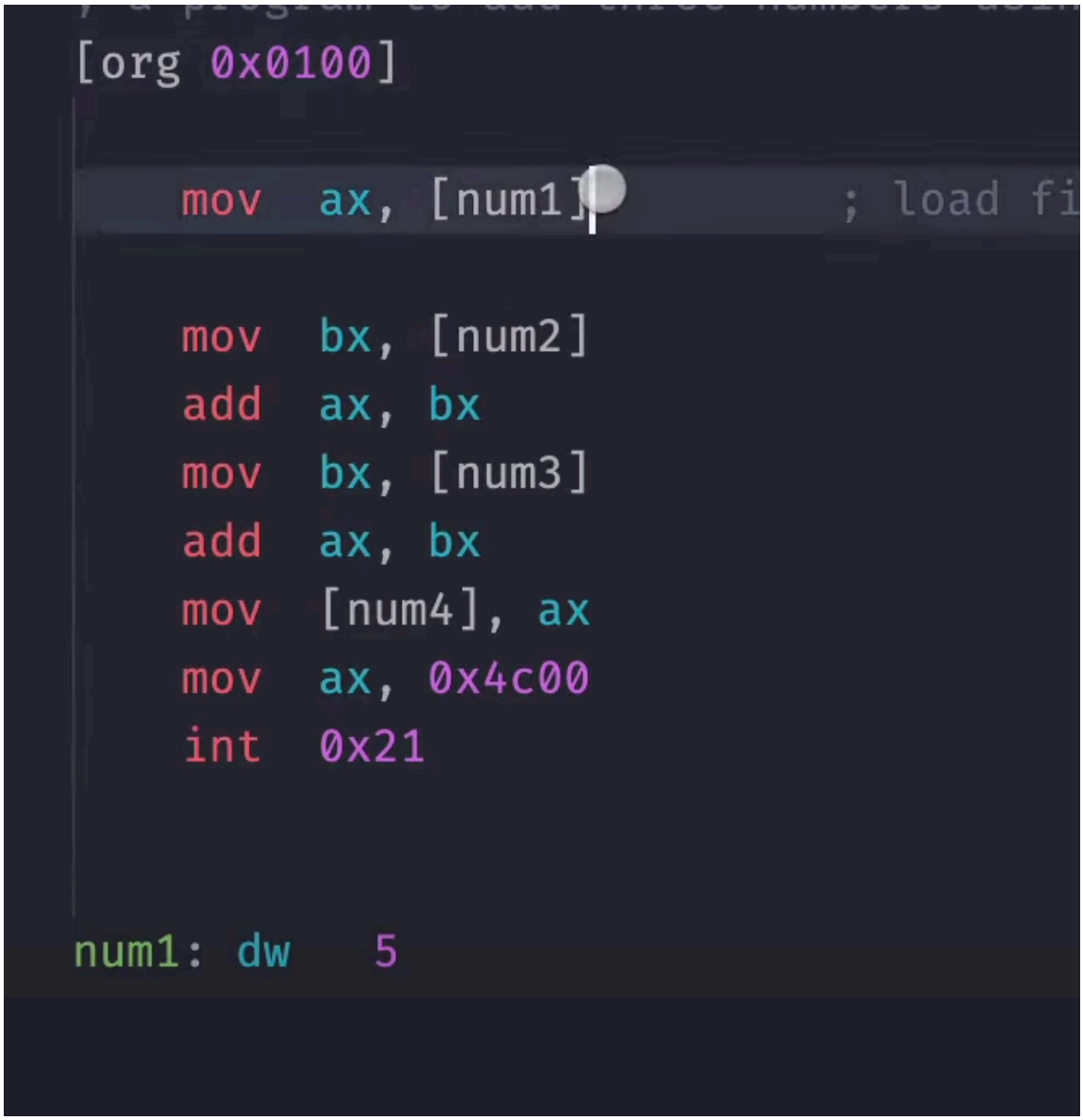
- Now in RAM as it starts from 0x0100 the instruction on line 17 will save a 16-bit storage whose address will be 0x0113 as it is 16-bit taking 4 bytes of memory DW : defined word (16-bit) memory
  - 1 byte = 8 bits
  - 1 nibble = 4 bits
  - 2 nibbles = 1 byte
  - 0x0100 : this is two byte as 0100 are 4 nibbles and 2 bytes

```
mov   ax,   [num1]              ; move the const
mov   bx, 10

add   ax, bx                    ; add value of bx int

mov   bx, 15                    ; add constant 15 int
add   ax, bx

mov   ax, 0x4c00                ; exit ..
int   0x21                      ; .. is what the OS

num1: dw    5
```

- Now as discussed before remembering these addresses is a bit difficult task
- So we save it in a LABEL called num1
- As num1 acts as a pointer we write it in squared brackets [ ].....[num1]
- square brackets with a label inside it means , take the value stored in the address num1 and move it into AX
- Now it means take a 16 bit value from num1 and move it into AX
- The definition of how many bits to move is defined by what register or anything in that place we are using
- 

  - This ax will define how many bits to catch and move from num1 into AX

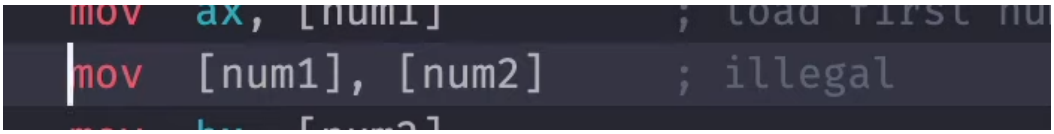
- And this was defined by INTEL they said the value to be inserted into the register would be of the size of the register

- 
```
[org 0x0100]

    mov  ax, [num1]          ; load fi

    mov  bx, [num2]
    add  ax, bx
    mov  bx, [num3]
    add  ax, bx
    mov  [num4], ax
    mov  ax, 0x4c00
    int  0x21


num1: dw   5
```
  - Num1 has the value 5
  - We move value 5 from num1 into the AX register
  - Thanks to little indian we will get the value 0500 in memory

```
[org 0x0100]

    mov  ax, [num1]        ; load first number

    mov  bx, [num2]
    add  ax, bx
    mov  bx, [num3]
    add  ax, bx
    mov  [num4], ax
    mov  ax, 0x4c00
    int  0x21


num1: dw   5
num2: dw   10
num3: dw   15
num4: dw   0
```

-
    - Take value from num1 address and move it into ax
    - Take value form num2 address and move it into bx
    - Take value from BX and add it into AX
    - Take value from num3 address and move it into AX
    - Now ADD AX AND BX
    - MOVE VALUE FROM AX INTO NUM4
    - Move program terminator instruction into AX

- A question might arise in mind if we can make labels then why create the AX BX register mess
    - ANSWER :
        - As we know we can either write from memory or read from memory

        - We have only 1 address bus which keeps address of one thing
        - So if read something from RAM and want to move it into RAM we cannot do that because we have only 1 address bus
        - After reading something RAM , our CPU is not that intelligent to store the data read in some other address which is why we use registers…
        - Which is why we can NEVER apply ANY instruction like MOV , ADD from MEMORY to MEMORY because we have only one ADDRESS bus and not two
        - But we can move from register to register because
        - it is inside the CPU
- Whenever we are trying to move data or add as well as any other instruction that we are gonna explore you cannot have both operands as MEMORY
    - If one is memory other must be register
    - If one is register other must be memory
    - 

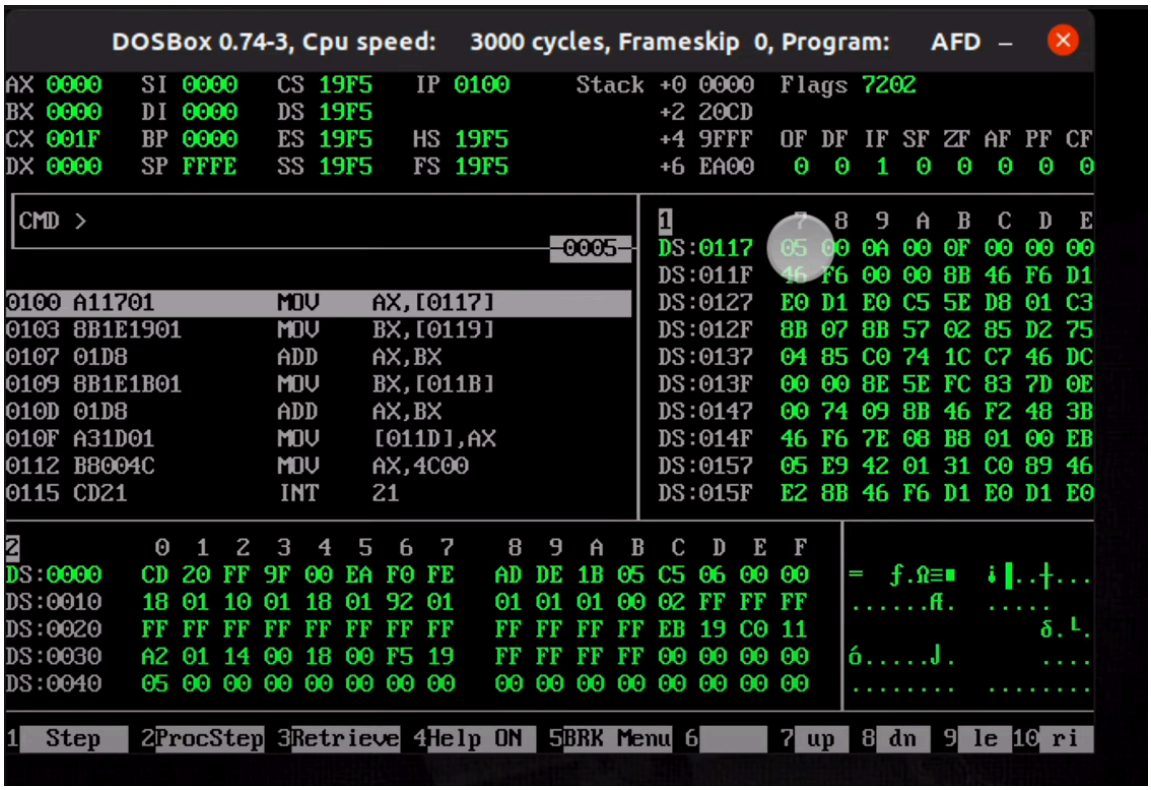
    - ILLEGAL

```
; a program to add three numbers using memory variables
[org 0x0100]

    mov  ax, [num1]          ; load first number in ax
    ; mov  [num1], [num2]     ; illegal
    mov  bx, [num2]
    add  ax, bx
    mov  bx, [num3]
    add  ax, bx
    mov  [num4], ax
    mov  ax, 0x4c00
    int  0x21


num1: dw   5
num2: dw   10
num3: dw   15
num4: dw   0
```

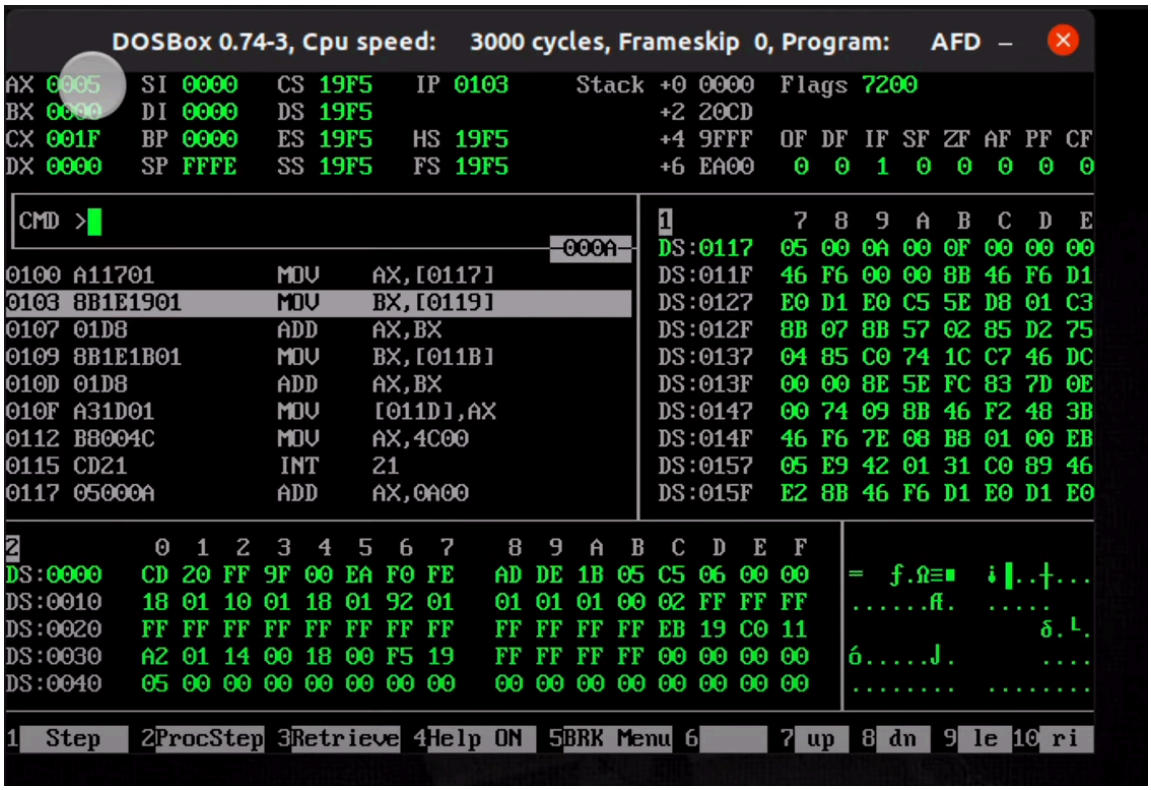
- Question : As we have defined the LABEL / VARIABLE below the code how will the assembler find it out
- Answer : Before Execution when program is loaded into MEMORY with the help of a loader all the variables if any in the program are assigned addresses of their own separately , so when we say (mov ax, [num1])
- It basically have the address , it just loads the data from that address to it

```
1                                   ; a program to add thre
2                                   [org 0x0100]
3
4  00000000 A1[1700]                    mov  ax, [num1]
5                                       ; mov  [num1], [num
6  00000003 8B1E[1900]                  mov  bx, [num2]
7  00000007 01D8                        add  ax, bx
8  00000009 8B1E[1B00]                  mov  bx, [num3]
9  0000000D 01D8                        add  ax, bx
10 0000000F A3[1D00]                    mov  [num4], ax
11 00000012 B8004C                      mov  ax, 0x4c00
12 00000015 CD21                        int  0x21
13
14
15 00000017 0500                    num1: dw   5
16 00000019 0A00                    num2: dw   10
17 0000001B 0F00                    num3: dw   15
18 0000001D 0000                    num4: dw   0
19
```

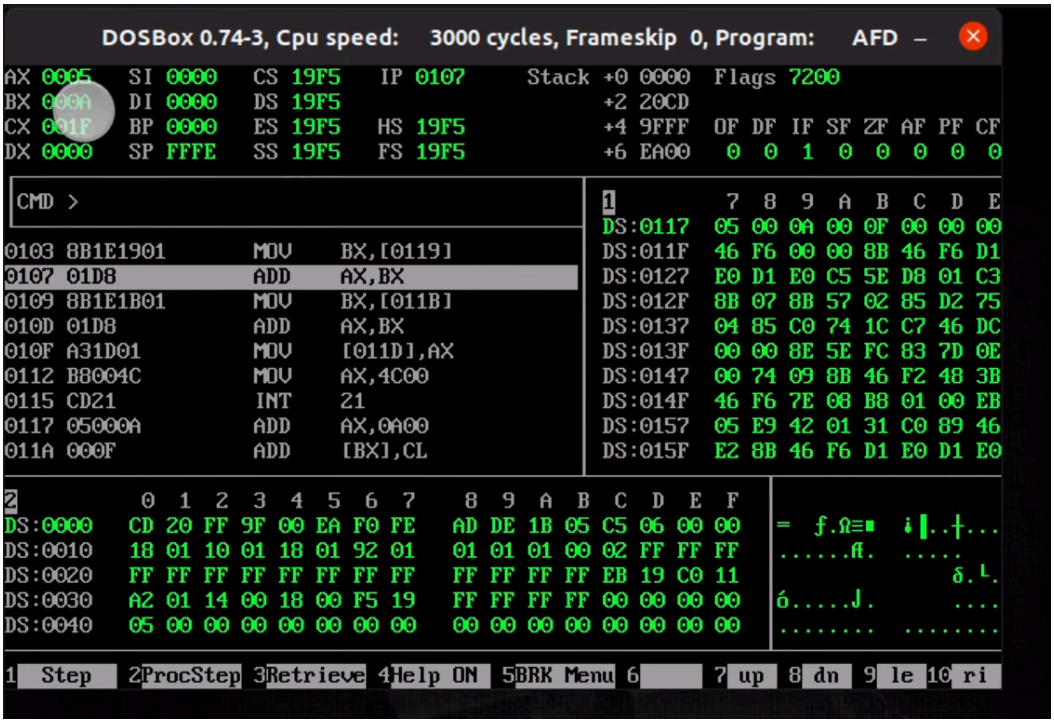
- As you can see the machine code it translates all the labels into address because it can only understand addresses
- 
```
4 00000000 A1[1700]                    mov  ax, [num1]
5                                      ; mov  [num1], [num
```
- As you can see the opp code of MOVE AX has been changed
- Because now we are not taking value from some immediate operand we are taking it from address
- A1 means , it is telling the machine to take value from the address 1700
- Because of little indian it is 1700 , it in actual is 0017

- 

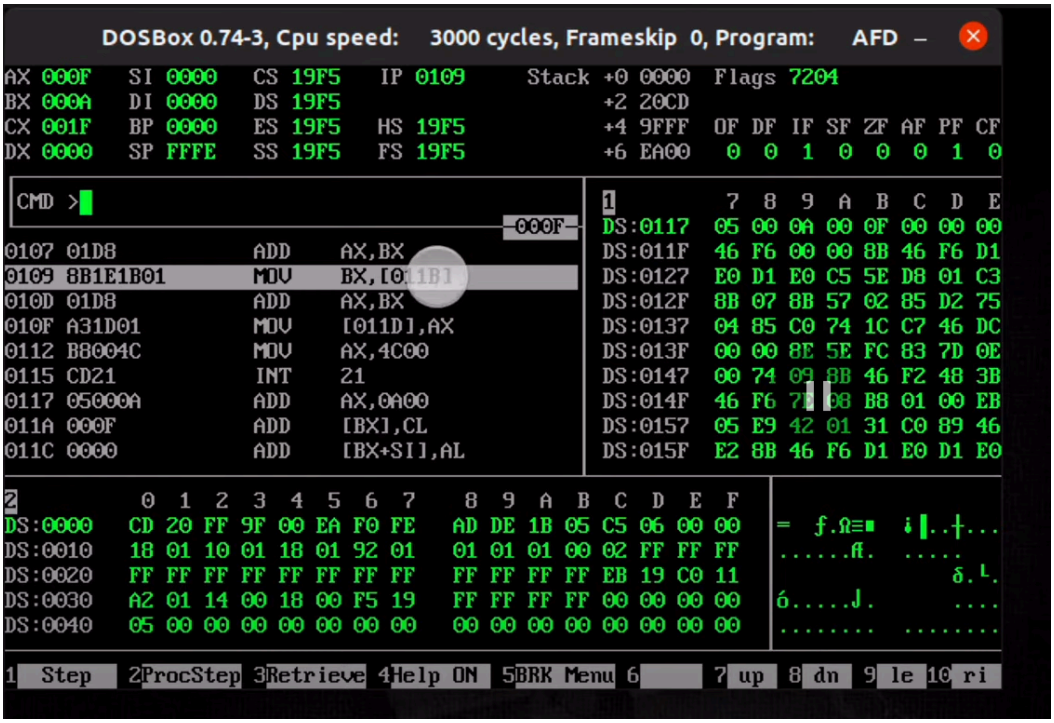
  - As you can recall it was 0017 or 1700
  - But as we loaded it because of ORG it changed into 1701 but because of our debugger it flipped so it becomes 0117

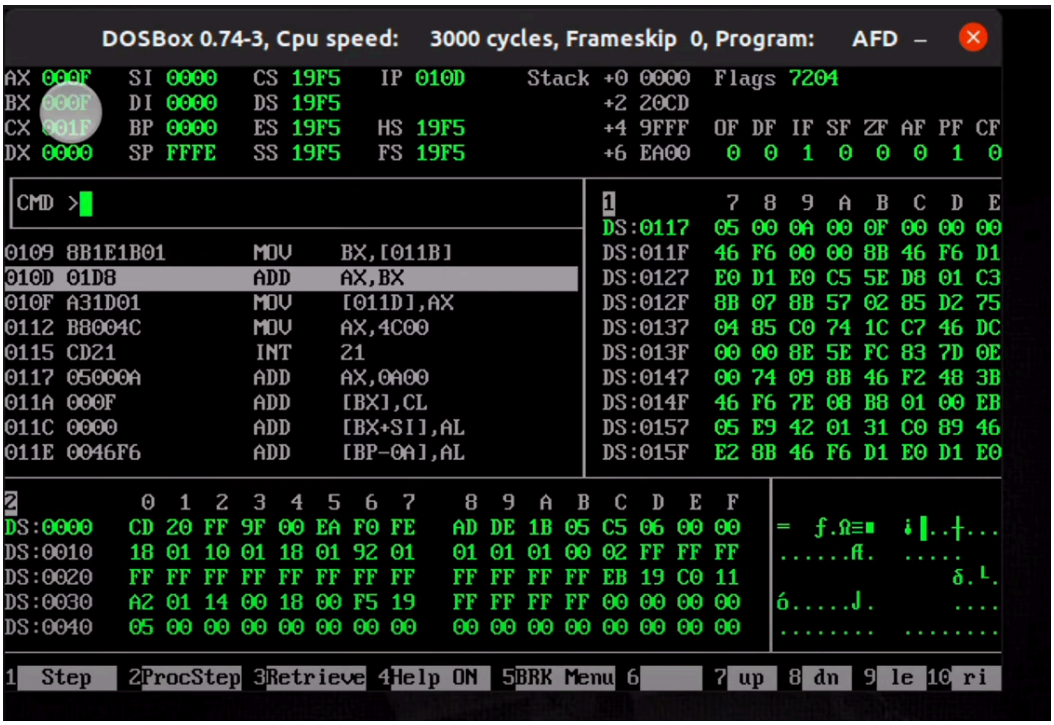


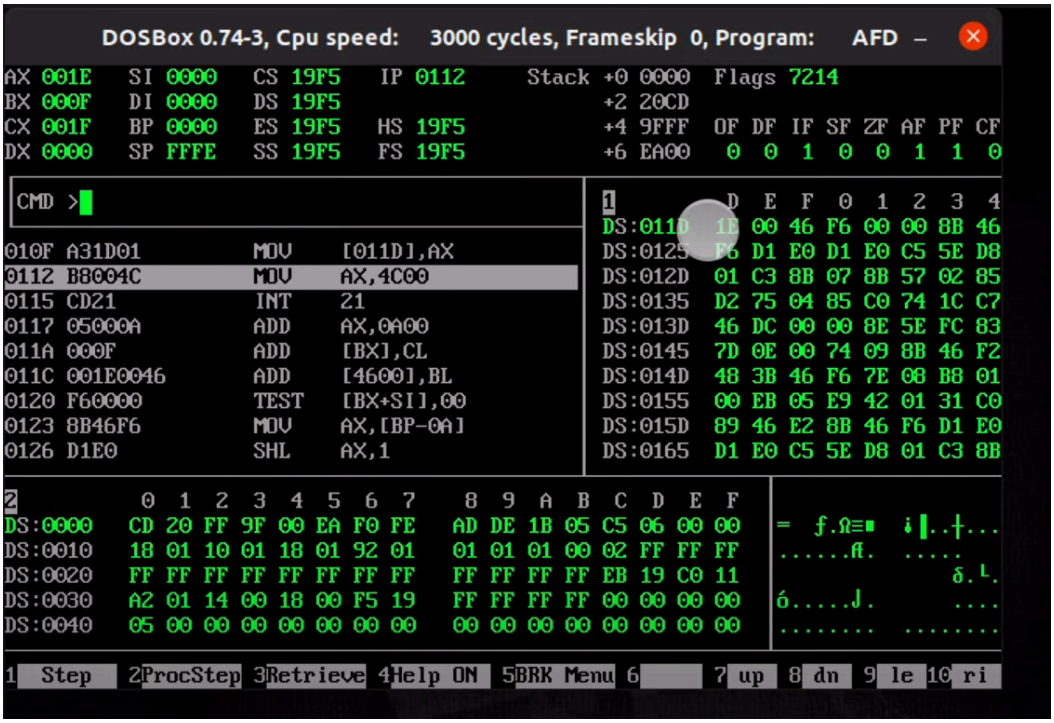
- ○ After executing 0100 , we move value from 0117 to AX : 0005



- ○
- ○ It goes on , as you can see it just moves and adds as per the instruciton

- 
DOSBox 0.74-3, Cpu speed: 3000 cycles, Frameskip 0, Program: AFD
AX 000F SI 0000 CS 19F5 IP 0109 Stack +0 0000 Flags 7204
BX 000A DI 0000 DS 19F5 +2 20CD
CX 001F 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 1 0
CMD >
000F
0107 01D8 ADD AX,BX
0109 8B1E1B01 MOV BX,[011B]
010D 01D8 ADD AX,BX
010F A31D01 MOV [011D],AX
0112 B8004C MOV AX,4C00
0115 CD21 INT 21
0117 05000A ADD AX,0A00
011A 000F ADD [BX],CL
011C 0000 ADD [BX+SI],AL
1 7 8 9 A B C D E
DS:0117 05 00 0A 00 0F 00 00 00
DS:011F 46 F6 00 00 8B 46 F6 D1
DS:0127 E0 D1 E0 C5 5E D8 01 C3
DS:012F 8B 07 8B 57 02 85 D2 75
DS:0137 04 85 C0 74 1C C7 46 DC
DS:013F 00 00 8E 5E FC 83 7D 0E
DS:0147 00 74 09 8B 46 F2 48 3B
DS:014F 46 F6 7E 08 B8 01 00 EB
DS:0157 05 E9 42 01 31 C0 89 46
DS:015F E2 8B 46 F6 D1 E0 D1 E0
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
DS:0010 18 01 10 01 18 01 92 01 01 01 01 00 02 FF FF FF
DS:0020 FF FF FF FF FF FF FF FF FF FF FF FF EB 19 C0 11
DS:0030 A2 01 14 00 18 00 F5 19 FF FF FF FF 00 00 00 00
DS:0040 05 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
1 Step 2 ProcStep 3 Retrieve 4 Help ON 5 BRK Menu 6 7 up 8 dn 9 le 10 ri

- 

- 

  - After taking value from the AX register and moving it on the address 011D it is inverted becasue of little indian
  - As it is taking value from a 16-bit register which is why in memory it will occupy 16-bit memory

- ASM c02-02.asm

```asm
; a program to add three numbers accessed using a single l
[org 0x0100]

    mov  ax, [num1]
    mov  bx, [num1 + 2]     ; notice how we can do arithme
    add  ax, bx             ; also, why +2 and not +1?
    mov  bx, [num1 + 4]
    add  ax, bx
    mov  [num1 + 6], ax     ; store sum at num1+6
    mov  ax, 0x4c00
    int  0x21

num1:   dw  5
        dw  10
        dw  15
        dw  0
```

  - As you can see we have written all the numbers under one label
  - And we are doing simple arithmetic , of addition in the square brackets
  - Now assmebler do not know what is num1 + 2
  - But as we know dw 5 takes 2 bytes
  - Dw 10 takes 2 bytes
  - By adding two in squared brackets it adds two bytes to the current address
  - Just like we used to do with pointers in C and C++

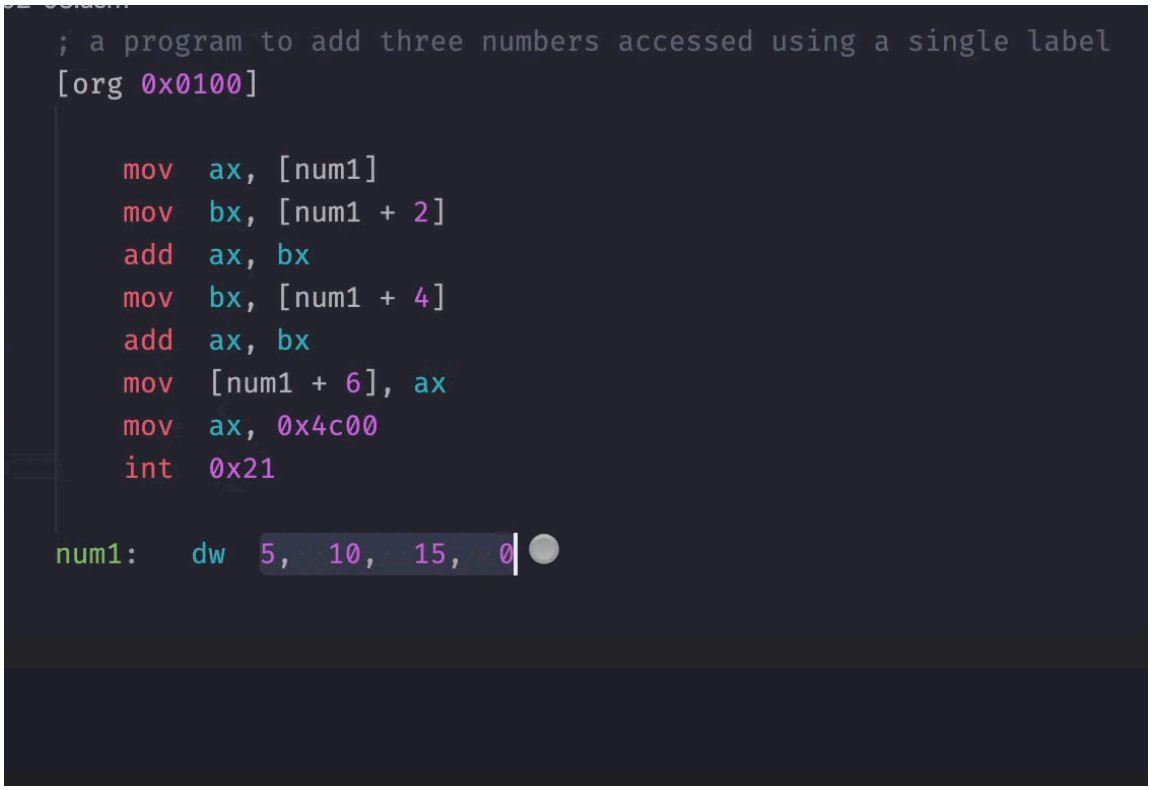
```
02-02.LST
 1                                  ; a program to add three
 2                                  [org 0x0100]
 3
 4 00000000 A1[1700]                    mov  ax, [num1]
 5 00000003 8B1E[1900]                  mov  bx, [num1 + 2]
 6 00000007 01D8                        add  ax, bx
 7 00000009 8B1E[1B00]                  mov  bx, [num1 + 4]
 8 0000000D 01D8                        add  ax, bx
 9 0000000F A3[1D00]                    mov  [num1 + 6], ax
10 00000012 B8004C                      mov  ax, 0x4c00
11 00000015 CD21                        int  0x21
12
13 00000017 0500                   num1:   dw  5
14 00000019 0A00                           dw  10
15 0000001B 0F00                           dw  15
16 0000001D 0000                           dw  0
```

- This is the new code whose machine code is exactly the same

```
 1                                  ; a program to add three
 2                                  [org 0x0100]
 3
 4 00000000 A1[1700]                    mov  ax, [num1]
 5                                      ; mov  [num1], [num2]
 6 00000003 8B1E[1900]                  mov  bx, [num2]
 7 00000007 01D8                        add  ax, bx
 8 00000009 8B1E[1B00]                  mov  bx, [num3]
 9 0000000D 01D8                        add  ax, bx
10 0000000F A3[1D00]                    mov  [num4], ax
11 00000012 B8004C                      mov  ax, 0x4c00
12 00000015 CD21                        int  0x21
13
14
15 00000017 0500                   num1: dw   5
16 00000019 0A00                   num2: dw   10
17 0000001B 0F00                   num3: dw   15
18 0000001D 0000                   num4: dw   0
19
```

- This is the old file

- AS YOU CAN SEE ABOVE BOTH THE MACHINE CODE ARE EXACTLY THE SAME

- 
```
; a program to add three numbers accessed using a single label
[org 0x0100]

    mov  ax, [num1]
    mov  bx, [num1 + 2]
    add  ax, bx
    mov  bx, [num1 + 4]
    add  ax, bx
    mov  [num1 + 6], ax
    mov  ax, 0x4c00
    int  0x21

num1:   dw  5,  10,  15,  0
```
    - Now assembler lets us define all the words all together like C++

- Some important CONCEPTS

```
; a program to add three numbers directly in memory
[org 0x0100]

    mov  ax, [num1]
    mov  [num1 + 6], ax     ; add this value to result

    mov  ax, [num1 + 2]
    add  [num1 + 6], ax

    mov  ax, [num1 + 4]
    add  [num1+6], ax

    mov  ax, 0x4c00
    int  0x21


num1:   dw  5, 10, 15, 0
```

-
-
```
mov  ax, [num1]
```
- Moves value from num1 which is the first value 0005 into AX
```
mov  [num1 + 6], ax     ; add this value to result
```
- Takes value from AX and moves it into num1 + 6 address zero becomes 5

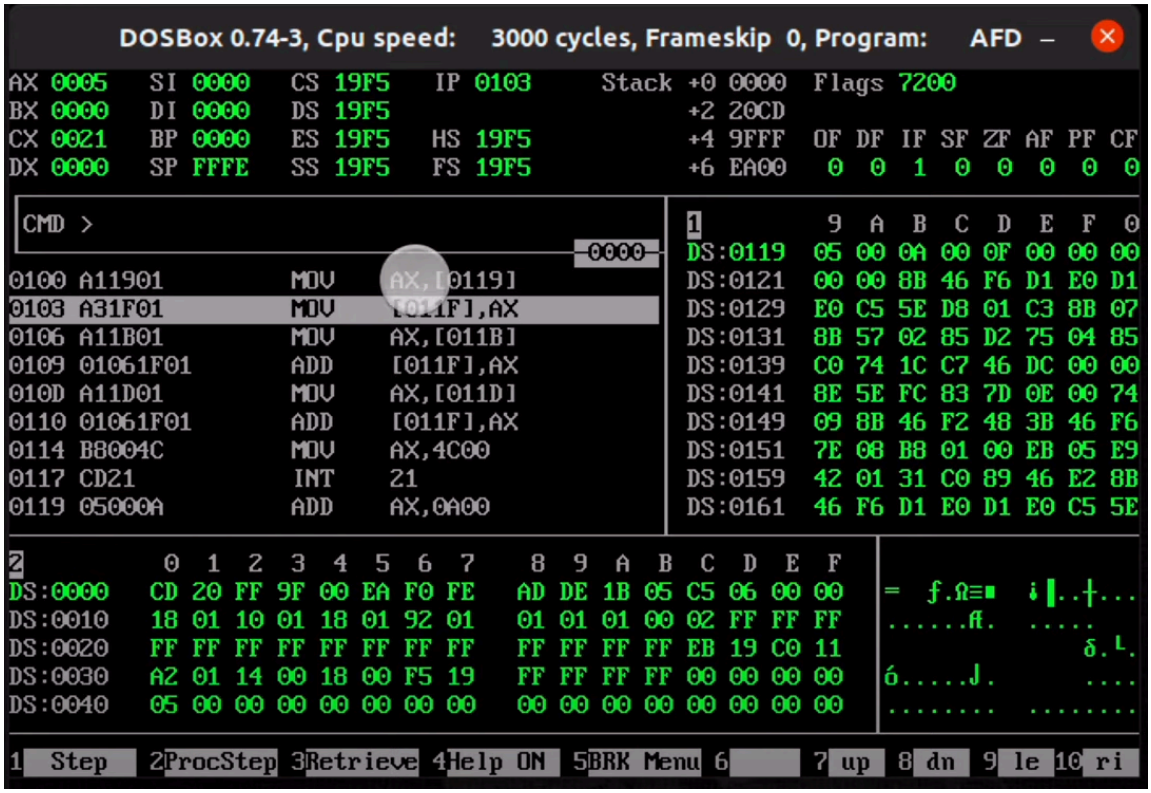
```
mov  ax, [num1 + 2]
```
- Same concept takes value from num1 + 2 which is 10 into AX
```
add  [num1 + 6], ax
```
- Takes value from ax and moves it into NUM 1 + 6 address , so it becomes 15
```
mov  ax, [num1 + 4]
```

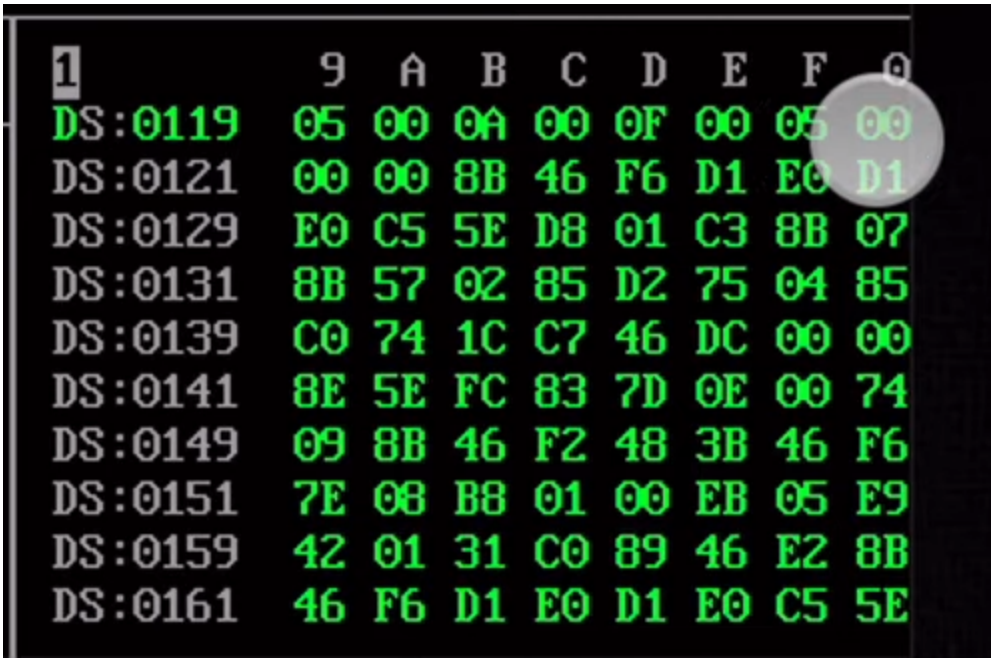
- It takes the value 15 and moves it into AX

```
add  [num1+6], ax
```

- Simply adds value of AX into num1 + 6 address which becomes 30

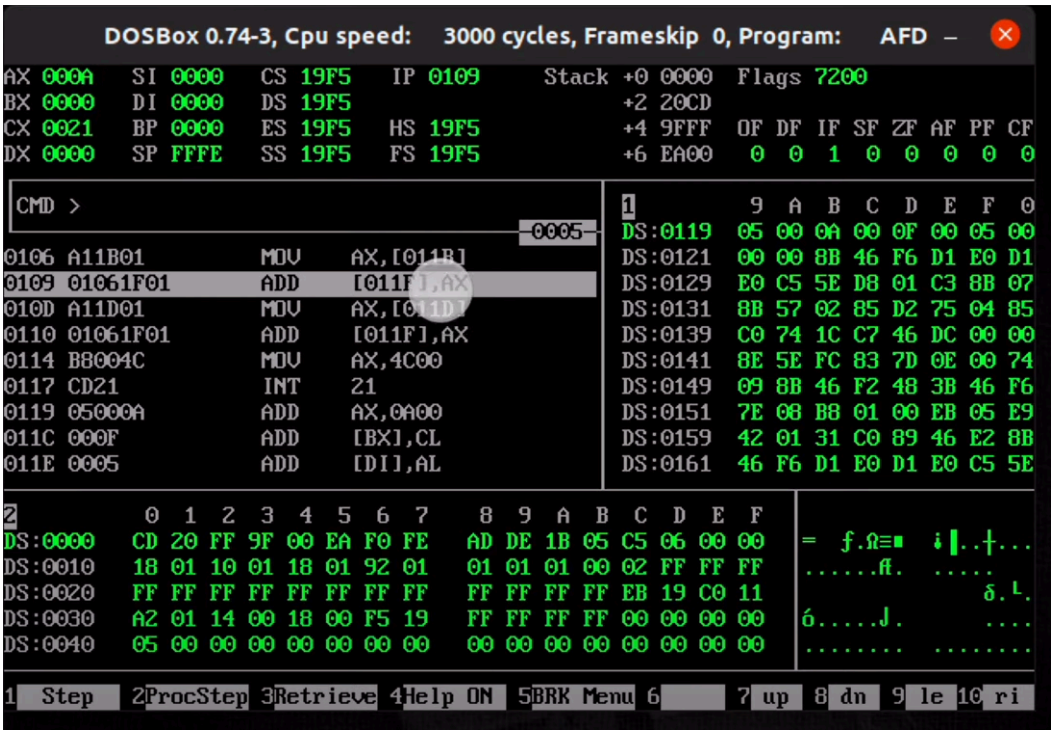
- The rest of the code is just 4C00

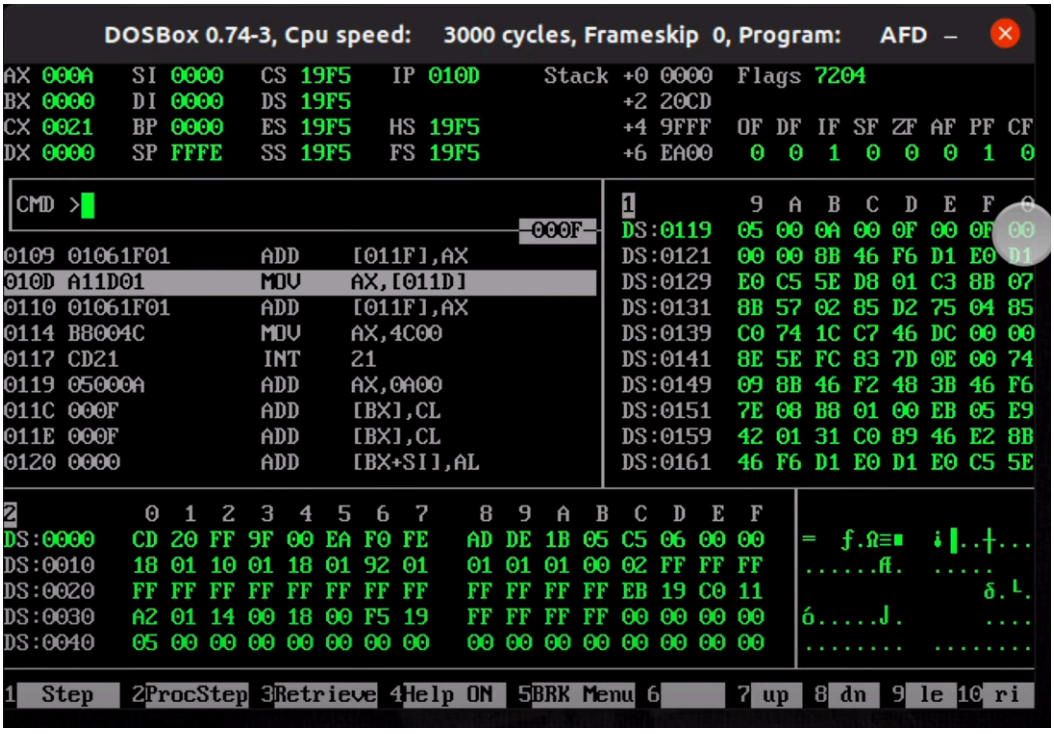
- 

- 

  - 

  - On 9 and A we have 0005
  - On B and C we have 000A
  - On D and E we have 000F
  - On F and 0 we have 0005

- 

  - We loaded value from 011B into AX which is 000A
- 

  - As we add AX and 011F we get 000F which is 15
- And the rest of the code

- SOME IMPORTANT TALKS

```
[org 0x0100]

    mov  ax, [num1]
    mov  [result], ax    ; add this value to result

    mov  ax, [num1 + 2]
    add  [result], ax

    mov  ax, [num1 + 4]
    add  [result], ax

    mov  ax, 0x4c00
    int  0x21


num1:   dw  5, 10, 15
result:  0
```

  - We should have done this for cleaner code better code
  - Now variables make it easy
  - In assembly language we aim to write precise and exact code as we are talking to the machine

NUMBER 1 :

  - READABILITY HONI CHAHIYE

NUMBER 2 :

  - If you are defining and using a global variable there is a 99% chance there is a flaw in your code which is why you are using global variable
  - DO NOT USE GLOBAL VARIABLES

```
[org 0x0100]

    mov  ax, [num1]
    mov  [result], ax     ; add this v

    mov  ax, [num1 + 2]
    add  [result], ax

    mov  ax, [num1 + 4]
    add  [result], ax

    mov  ax, 0x4c00
    int  0x21


num1:   dw  5, 10, 15
result: 0
```

- WHEN YOU ARE DOING ASSEMBLY LANGUAGE YOU SHOULD NOT BE DEFINING VARIABLES LIKE THIS
- This is just to make you understand

```
; a program to add three numbers using byte variables
[org 0x0100]

    mov  ax, [num1]

    mov  bx, [num1+1]
    add  ax, bx

    mov  bx, [num1+2]
    add  ax, bx

    mov  [num1+3], ax

    mov  ax, 0x4c00
    int  0x21

num1: db  5, 10, 15, 0

; something's wrong with this code.
```

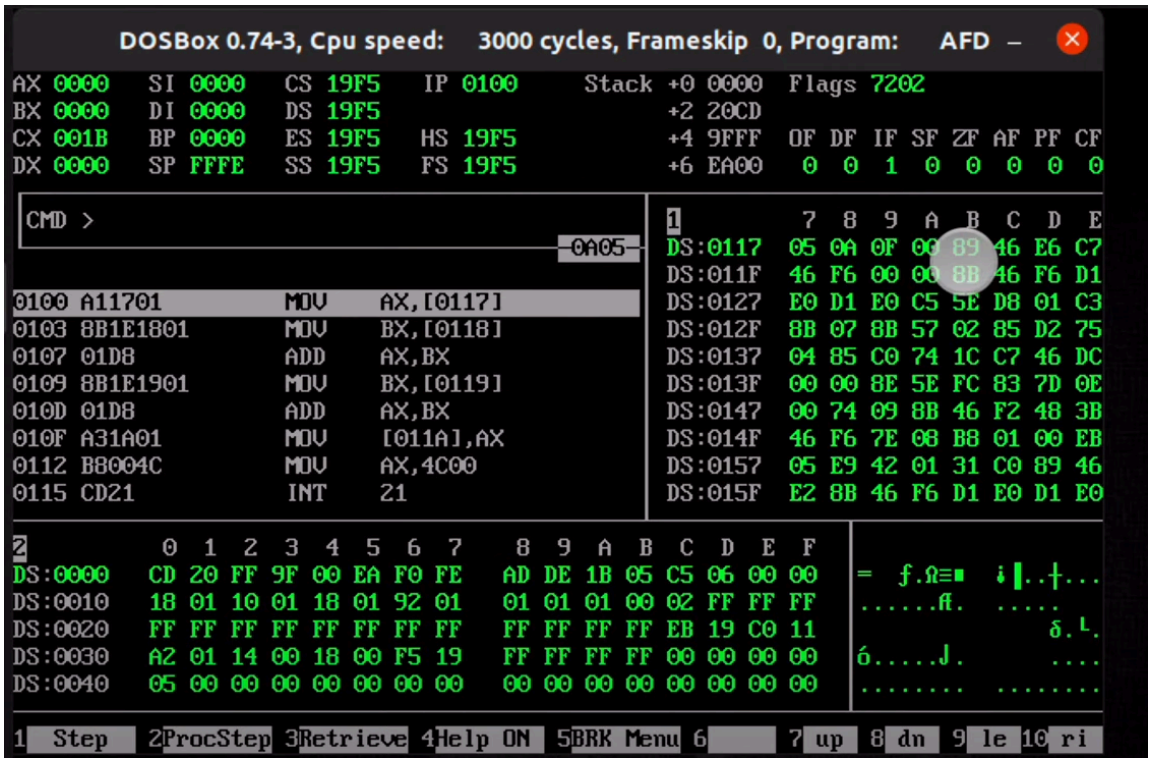
- What will be the value of AX when line number 4 is executed ? any guesses ?
- Well as you can see

```
num1: db  5, 10, 15, 0
```

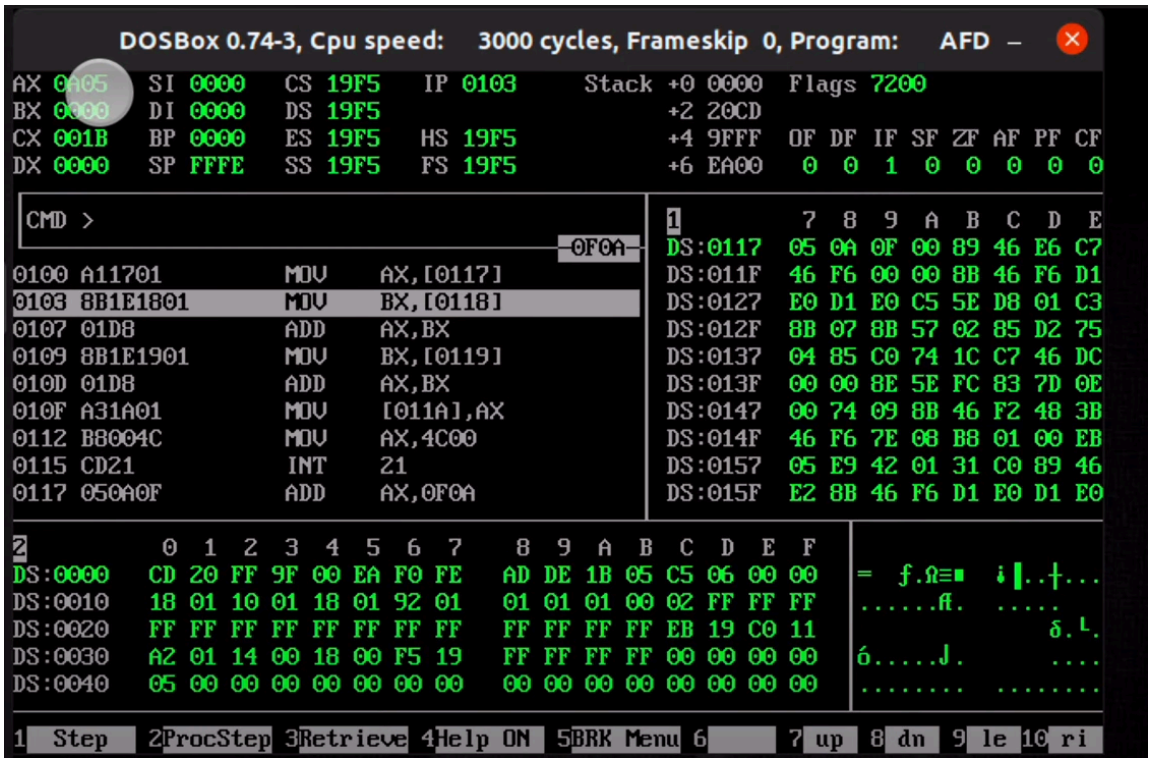
  - We have defined it as DEFINE BYTE and not DEFINE WORD
  - Which is why it allocates only 1 byte which is 05 and not 0005

```
; a program to add three numbers using byte variables
[org 0x0100]

    mov  ax, [num1]

    mov  bx, [num1+1]
    add  ax, bx

    mov  bx, [num1+2]
    add  ax, bx

    mov  [num1+3], ax

    mov  ax, 0x4c00
    int  0x21

num1: db  5, 10, 15, 0

; something's wrong with this code.
```

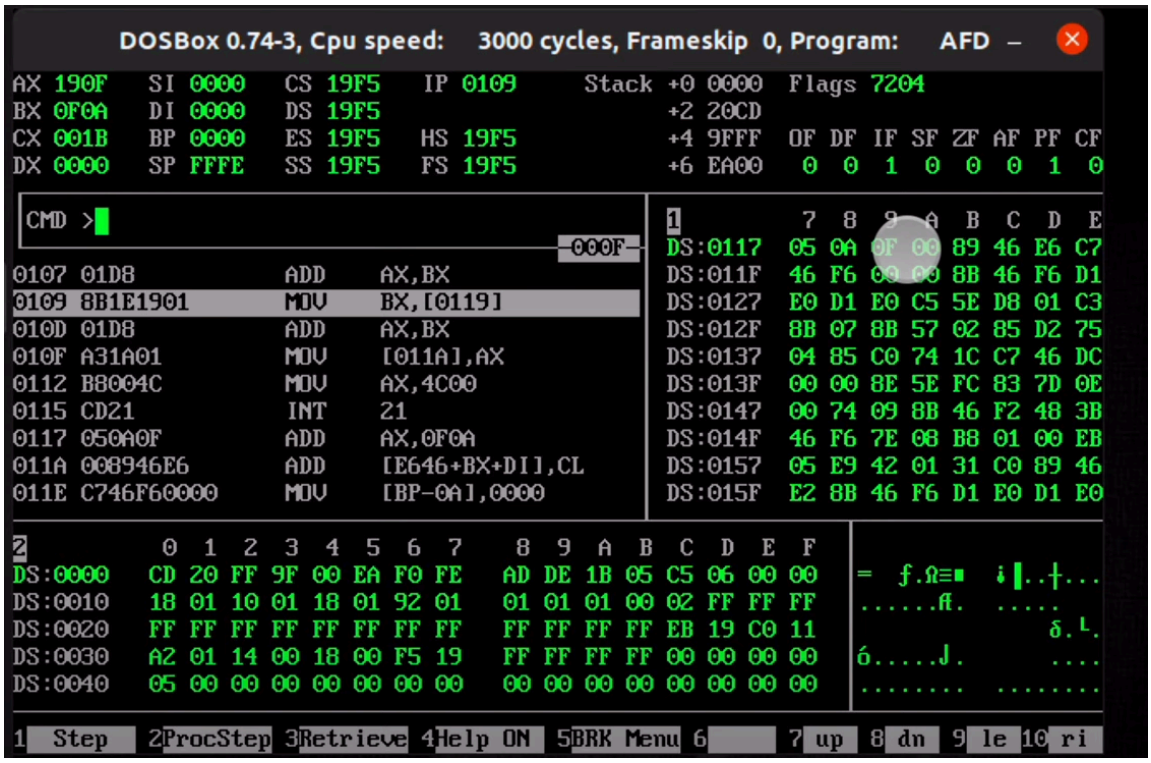
- Now in this program if we wanna move num1 into AX , it will load 16-bit into it and not 4-bit because AX is defined as 16-bit



-
  - As you can see only 1 bytes of data is distributed after the address 0117
  - 05 on 0117
  - 0A on 0118
  - OF on 0119
  - 00 on 011A

- 

    - Now as you can see it loads 0A05 into the AX register this is becasue AX is a 16-bit register and it will read 4 bytes of data meaning 16-bit data from memory

- 

  - Now it will load garbage into the data why?
  - 

    - Because this should have been DW and not DB
- Which is why if you define global variable you have to keep in mind that if you make a specific size of variable you will have to remember it when moving things into it