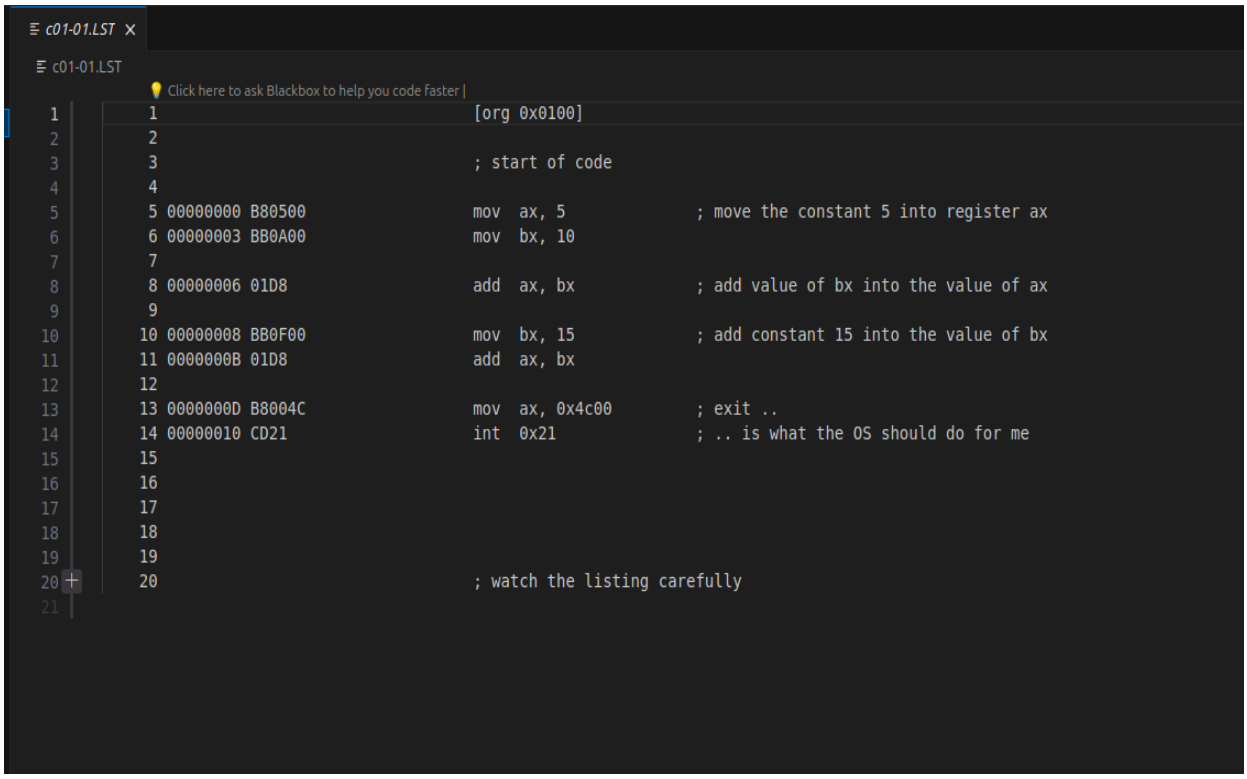
Lab # 3

Name : M.Shafeen

Roll No : 22P-9278

File c02-01 :

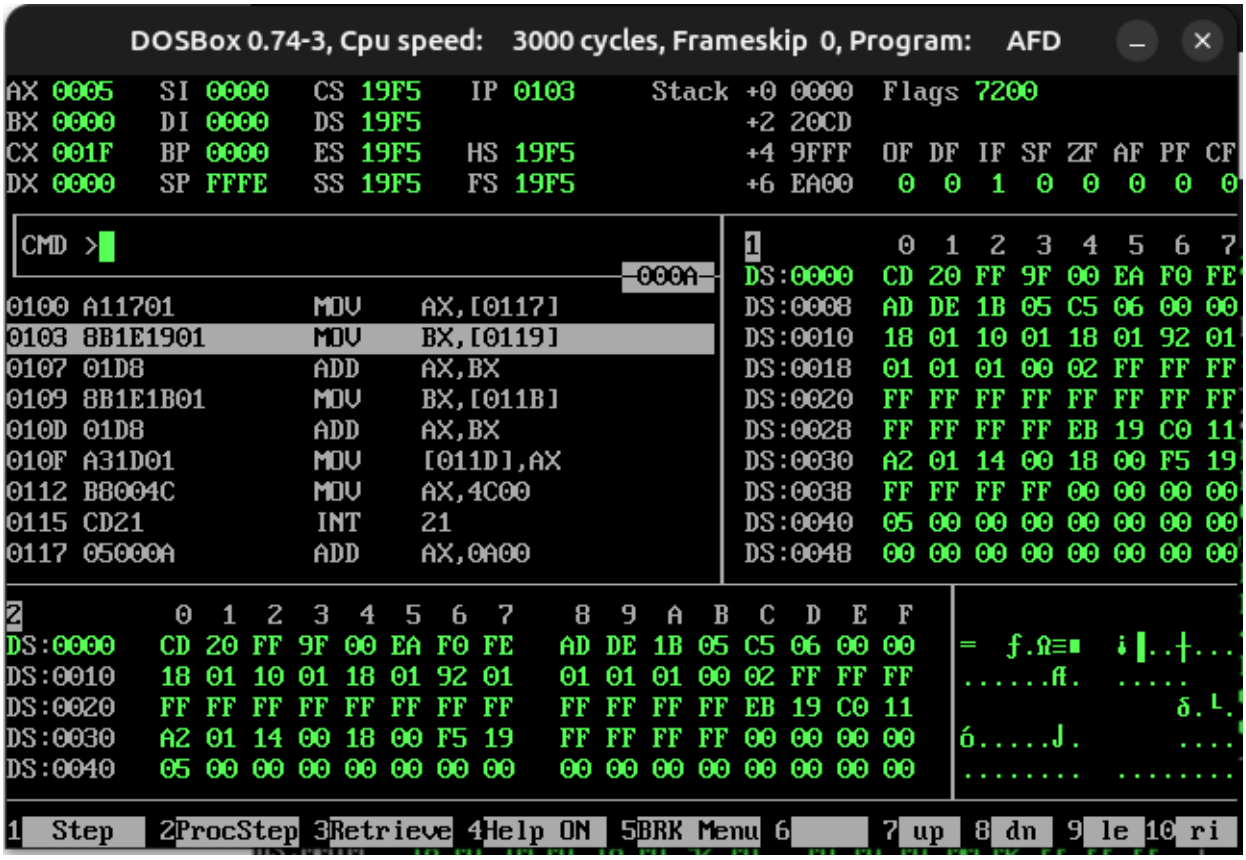
Step : 1

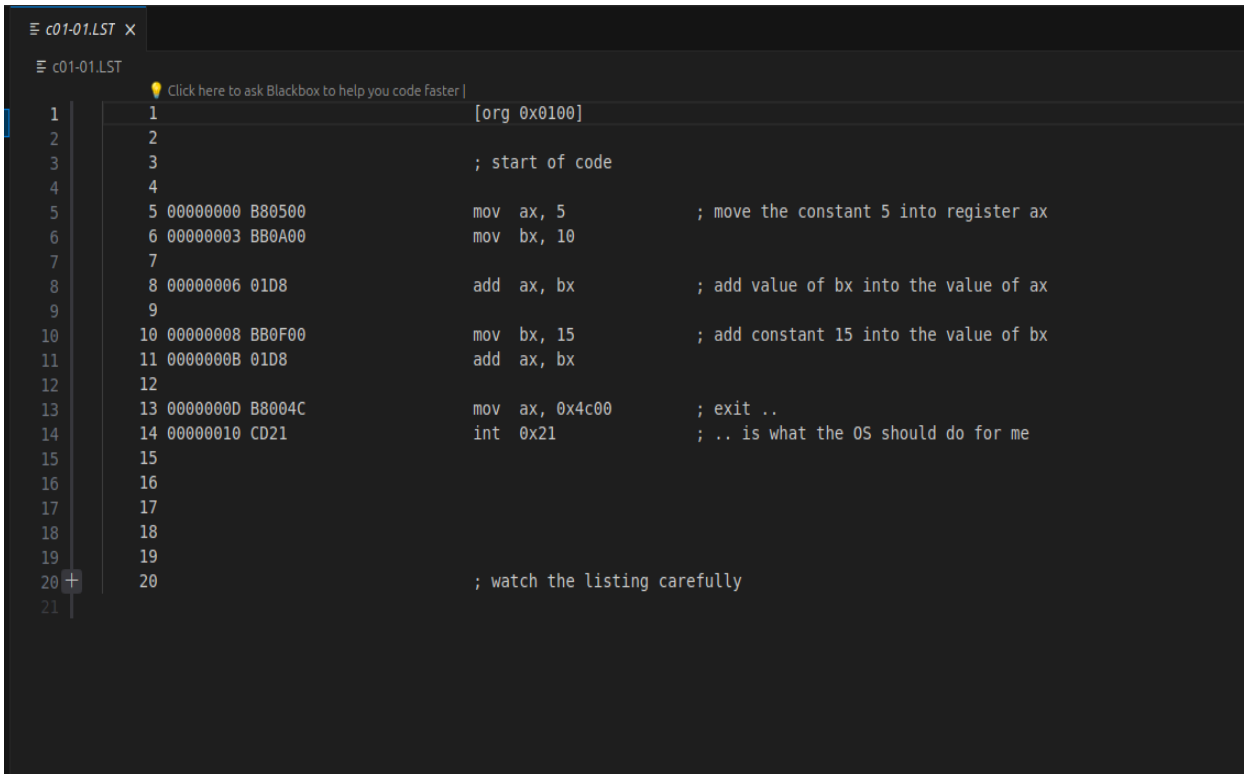


```
c01-01.LST

c01-01.LST

Click here to ask Blackbox to help you code faster |

1                                   [org 0x0100]
2
3                                   ; start of code
4
5 00000000 B80500                   mov  ax, 5              ; move the constant 5 into register ax
6 00000003 BB0A00                   mov  bx, 10
7
8 00000006 01D8                     add  ax, bx             ; add value of bx into the value of ax
9
10 00000008 BB0F00                  mov  bx, 15             ; add constant 15 into the value of bx
11 0000000B 01D8                    add  ax, bx
12
13 0000000D B8004C                  mov  ax, 0x4c00         ; exit ..
14 00000010 CD21                    int  0x21               ; .. is what the OS should do for me
15
16
17
18
19
20                                  ; watch the listing carefully
21
```

This above is the listing file of the **C02-01.asm** file and it is the machine code that tells us step by step how much memory it is consuming in our memory

Debugger 1 :


DOSBox 0.74-3, Cpu speed: 3000 cycles, Frameskip 0, Program: AFD
AX 0005 SI 0000 CS 19F5 IP 0103 Stack +0 0000 Flags 7200
BX 0000 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 0 0
CMD >
000A
0100 A11701 MOV AX,[0117]
0103 8B1E1901 MOV BX,[0119]
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
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
DS:0010 18 01 10 01 18 01 92 01
DS:0018 01 01 01 00 02 FF FF FF
DS:0020 FF FF FF FF FF FF FF FF
DS:0028 FF FF FF FF EB 19 C0 11
DS:0030 A2 01 14 00 18 00 F5 19
DS:0038 FF FF FF FF 00 00 00 00
DS:0040 05 00 00 00 00 00 00 00
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
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 2ProcStep 3Retrieve 4Help ON 5BRK Menu 6 7 up 8 dn 9 le 10 ri



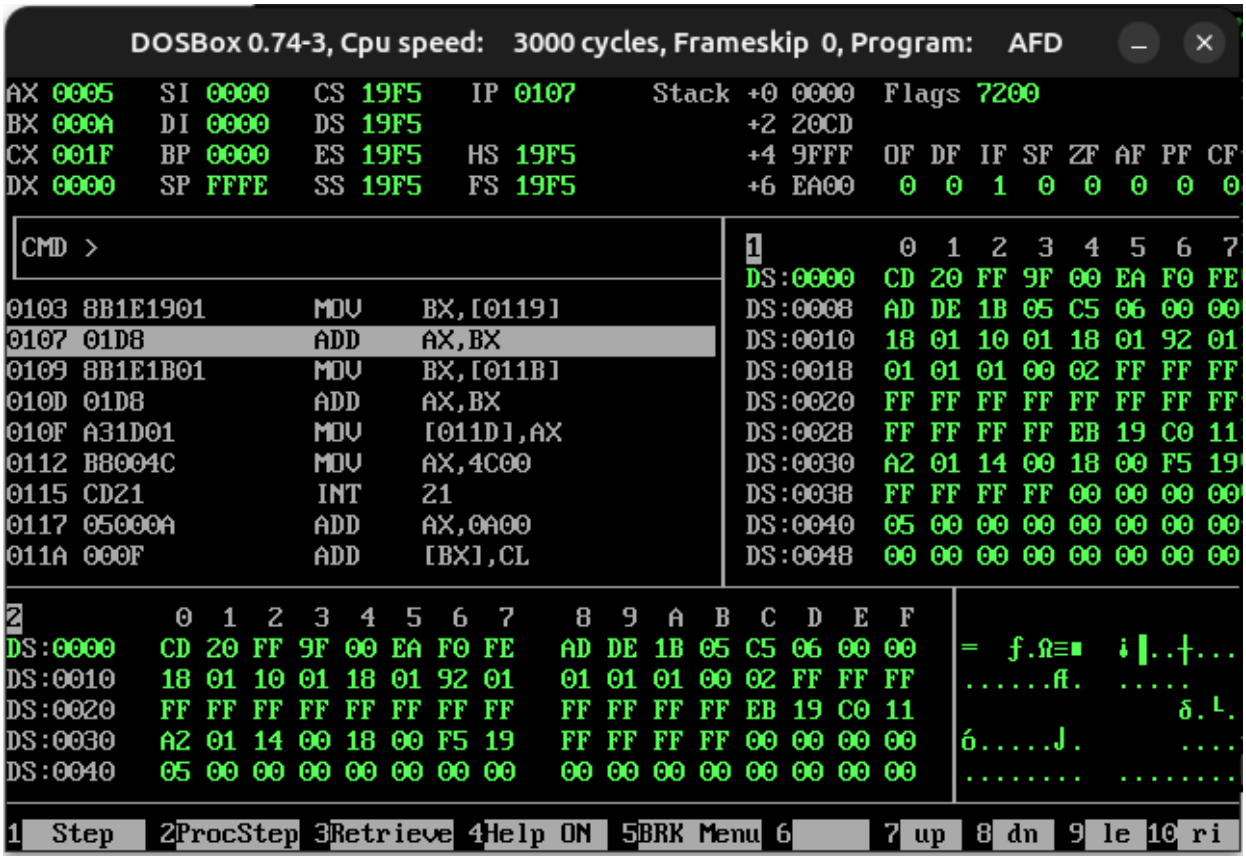
```
c01-01.LST

c01-01.LST

Click here to ask Blackbox to help you code faster |

1                                   [org 0x0100]
2
3                                   ; start of code
4
5 00000000 B80500                   mov  ax, 5              ; move the constant 5 into register ax
6 00000003 BB0A00                   mov  bx, 10
7
8 00000006 01D8                     add  ax, bx             ; add value of bx into the value of ax
9
10 00000008 BB0F00                  mov  bx, 15             ; add constant 15 into the value of bx
11 0000000B 01D8                    add  ax, bx
12
13 0000000D B8004C                  mov  ax, 0x4c00         ; exit ..
14 00000010 CD21                    int  0x21               ; .. is what the OS should do for me
15
16
17
18
19
20                                  ; watch the listing carefully
21
```

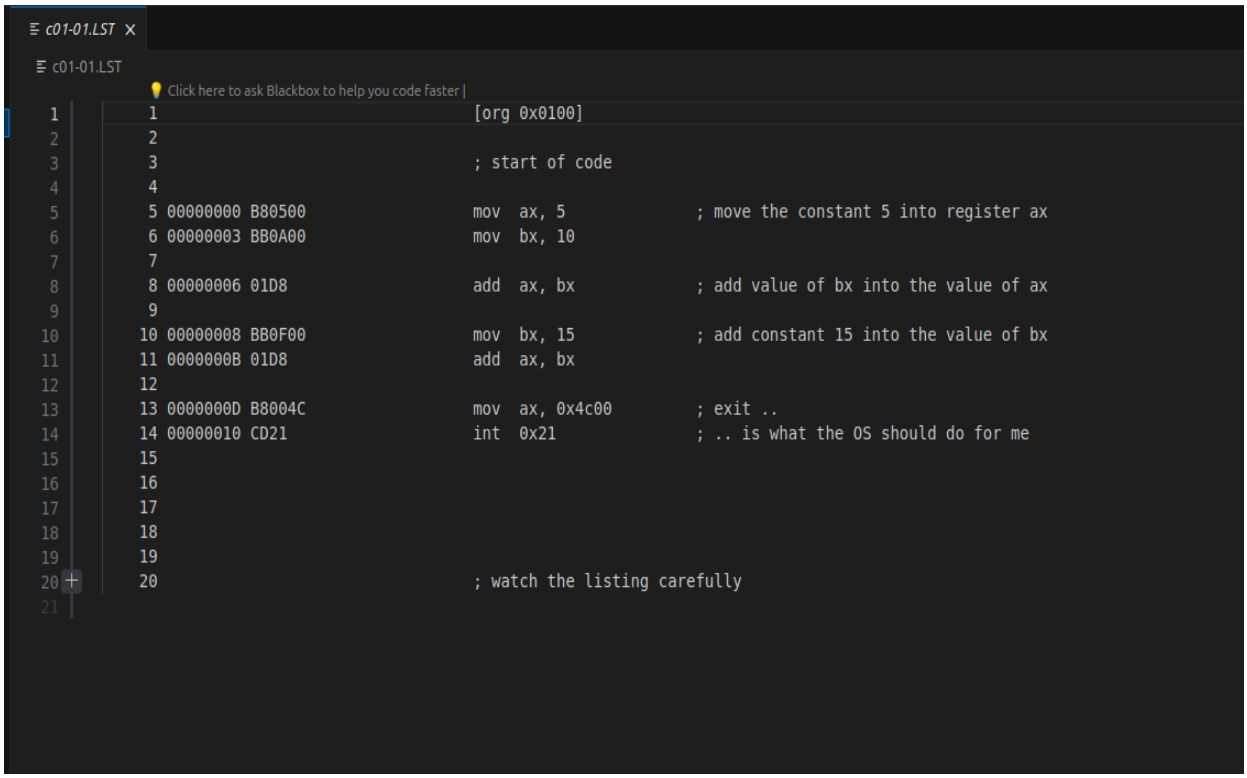
Explanation :

This instruction is taking a number (value : 5) stored in a variable called "**num1**" with the address **0117** and putting it into a special spot in the computer's brain called the "**ax**" register.

Step : 2

Debugger 2 :


DOSBox 0.74-3, Cpu speed: 3000 cycles, Frameskip 0, Program: AFD
AX 0005 SI 0000 CS 19F5 IP 0107 Stack +0 0000 Flags 7200
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 0 0
CMD >
0103 8B1E1901 MOV BX,[0119]
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
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
DS:0010 18 01 10 01 18 01 92 01
DS:0018 01 01 01 00 02 FF FF FF
DS:0020 FF FF FF FF FF FF FF FF
DS:0028 FF FF FF FF EB 19 C0 11
DS:0030 A2 01 14 00 18 00 F5 19
DS:0038 FF FF FF FF 00 00 00 00
DS:0040 05 00 00 00 00 00 00 00
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
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 2ProcStep 3Retrieve 4Help ON 5BRK Menu 6 7 up 8 dn 9 le 10 ri

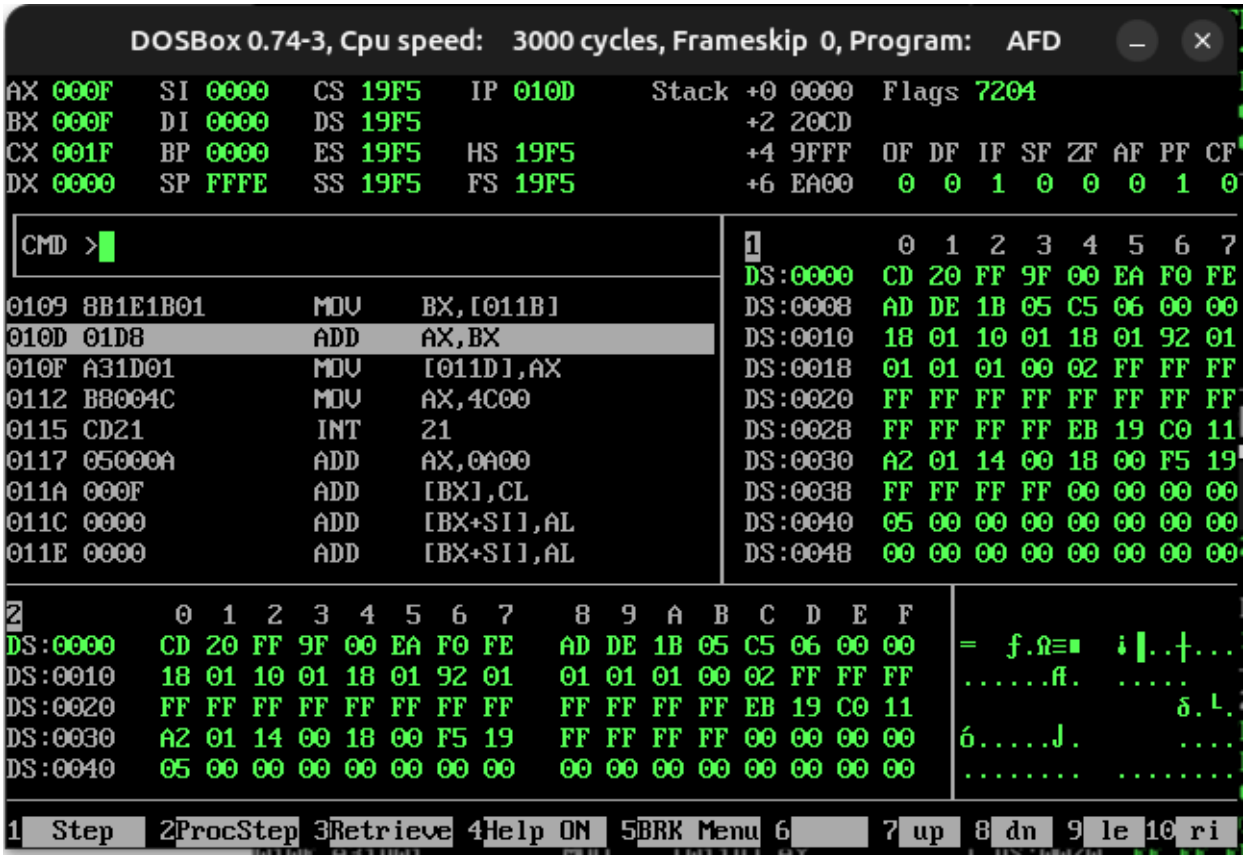


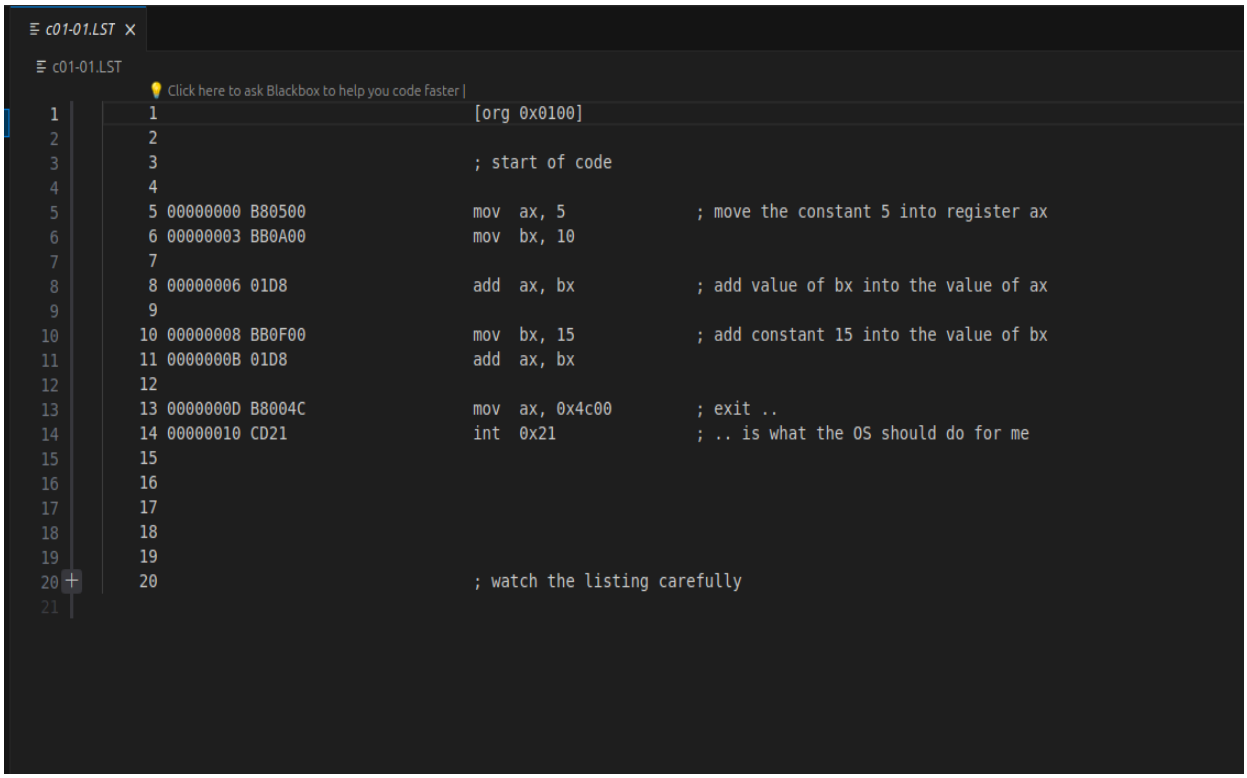
Explanation :

This instruction tells the computer to take the value (value : 10) stored in the "**num2**" with the address **0119** variable and put it into a special place called the "**bx**" register. Just like before, it's like moving a number from one mental drawer (memory) to another (register) so the computer can work with it.

Step : 3

Debugger 3 :



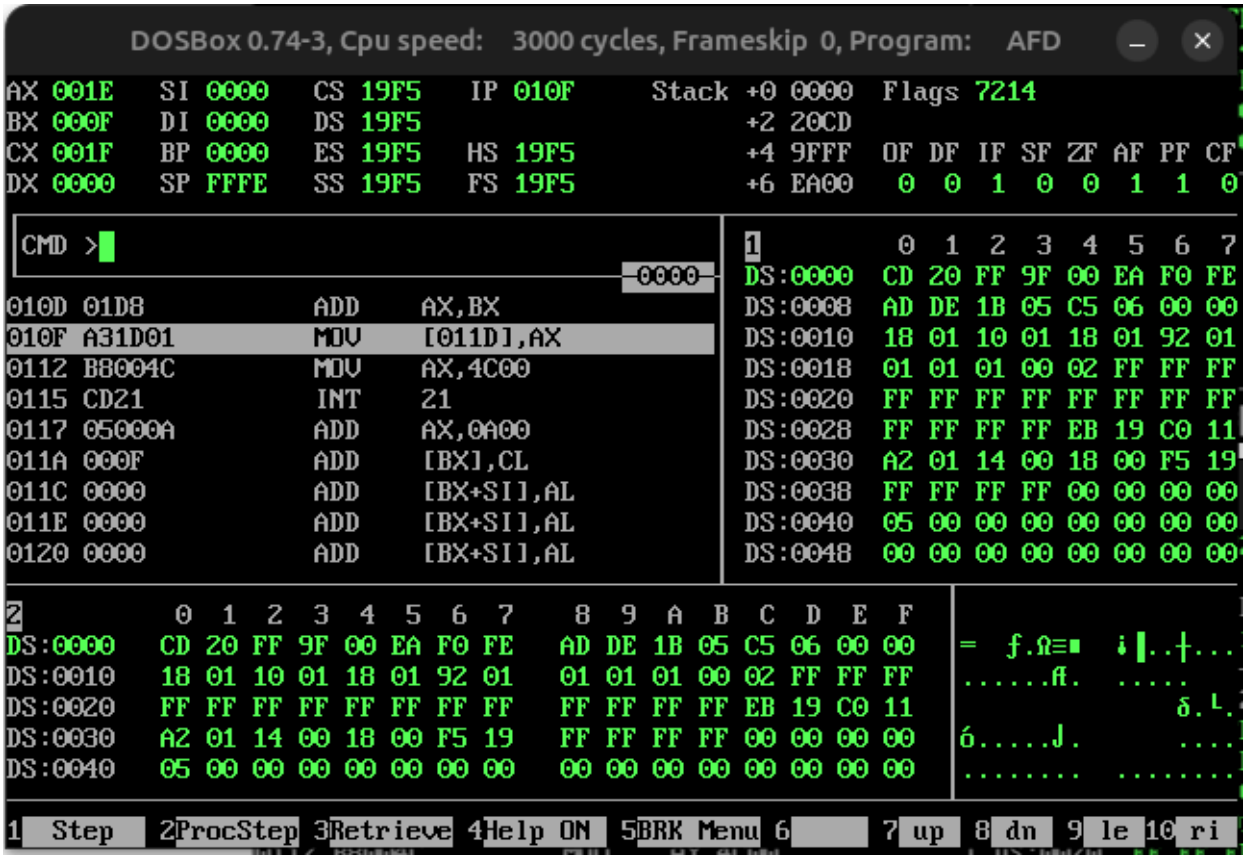


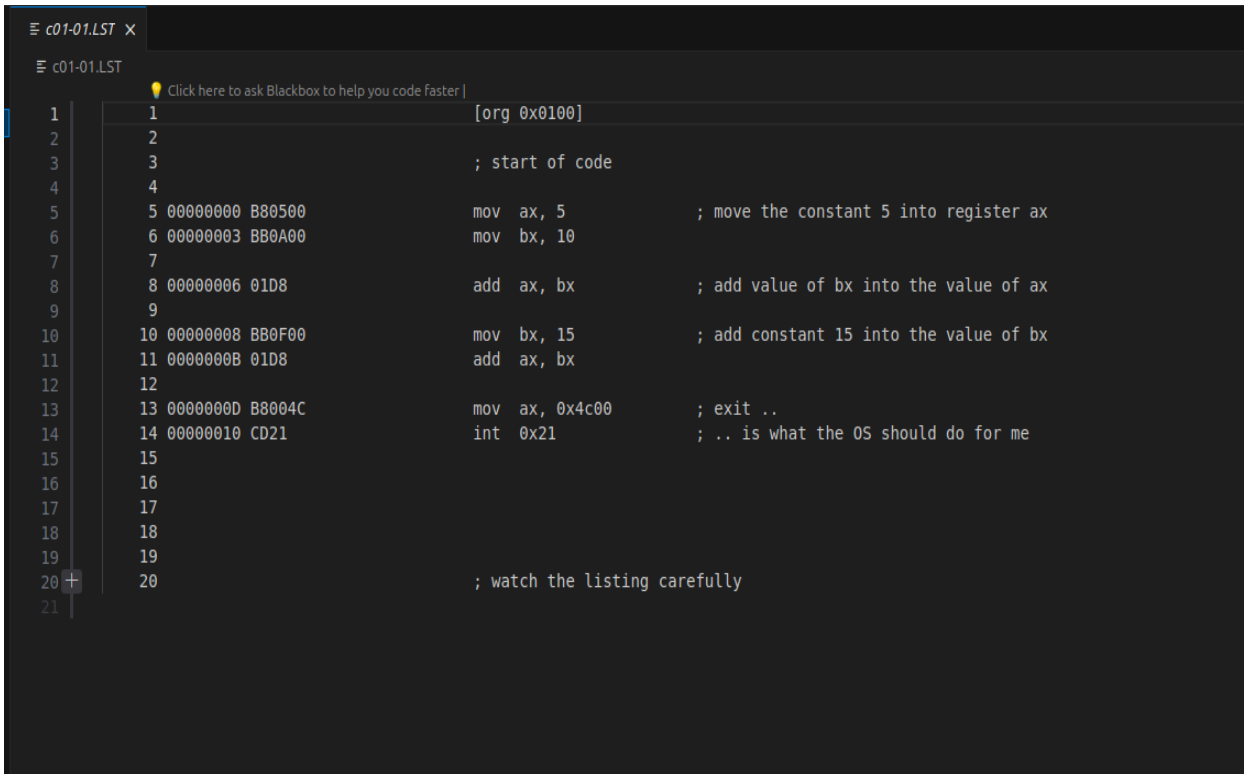
Explanation :

This instruction is fetching the value stored in the memory location labeled "**num3**" having address **011B** and putting it into the **BX** register

Step : 4

Debugger 4 :



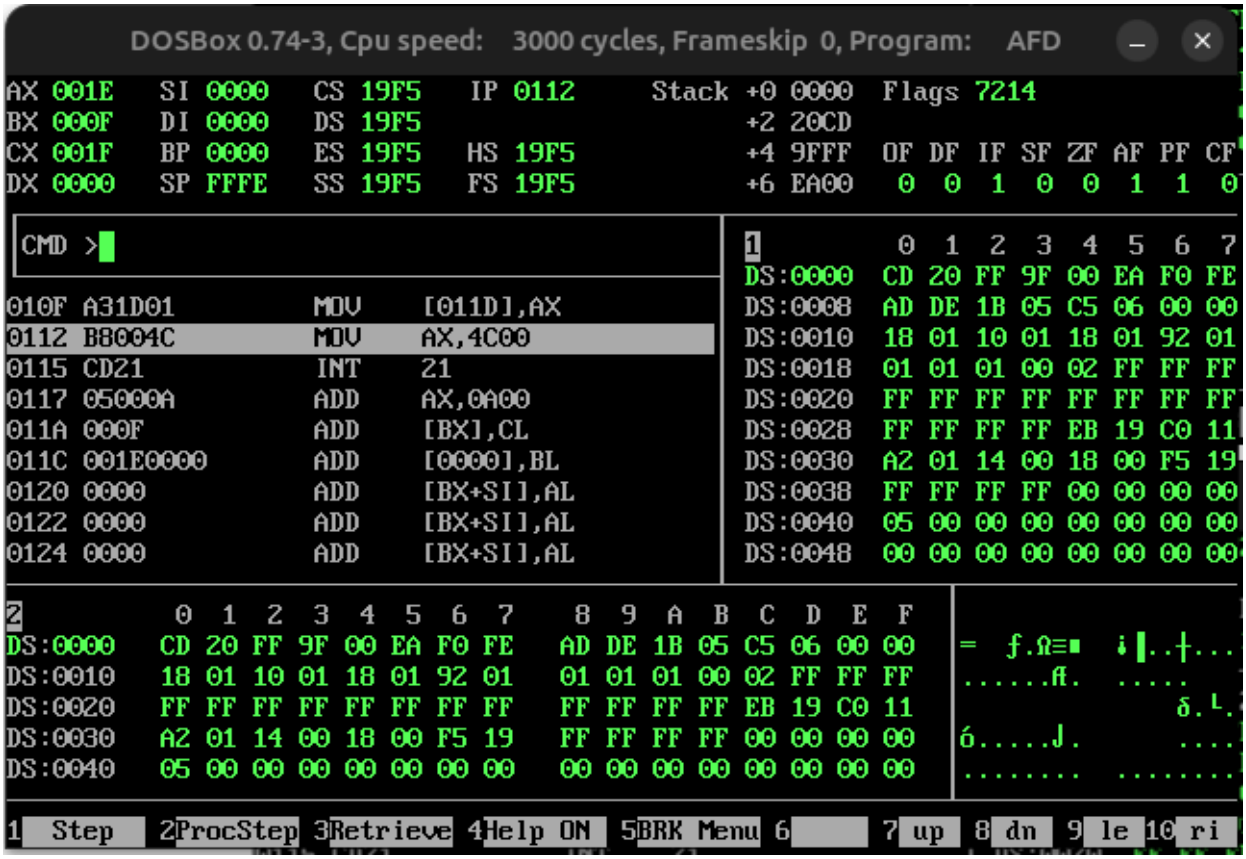


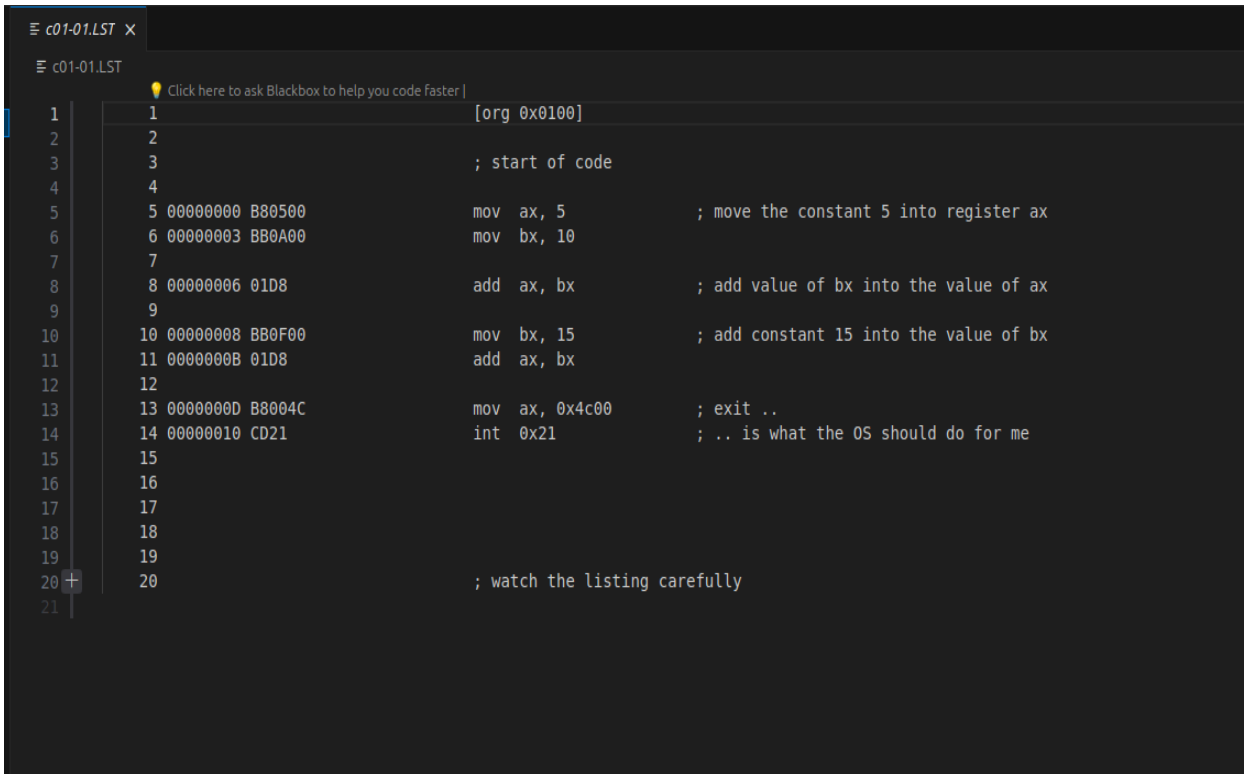
Explanation :

The instruction "**add ax, bx**" adds the value in the "**bx**" register to the value in the "**ax**" register, storing the result back in the "**ax**" register. In assembly language, this operation is represented by the opcode "**01D8**".

Step : 5

Debugger 5 :



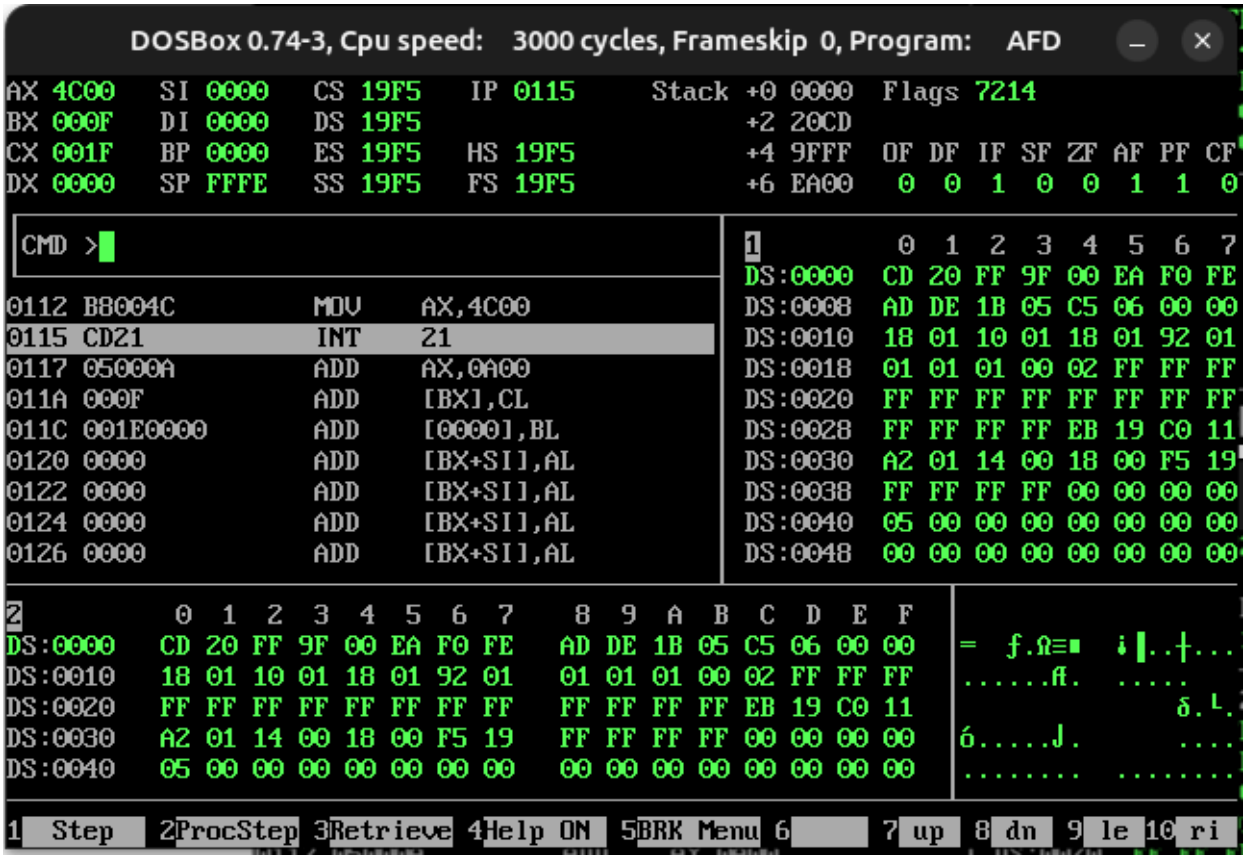


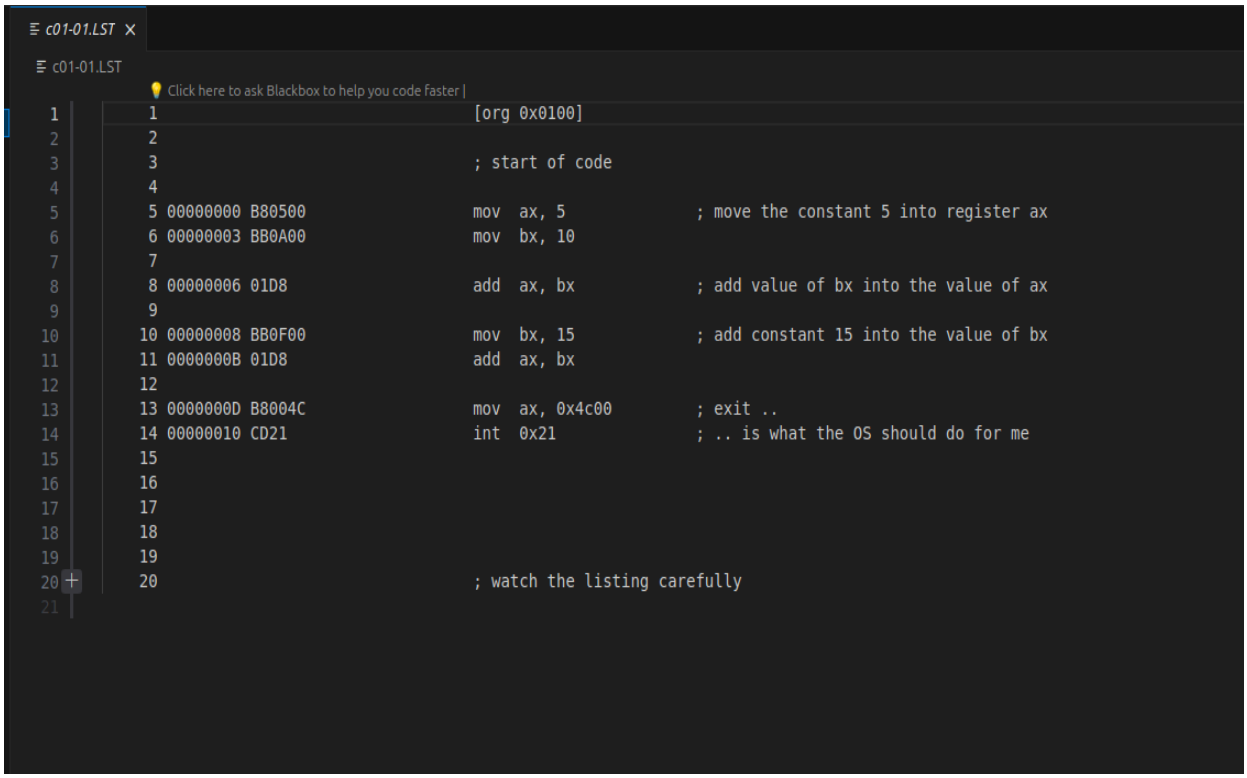
Explanation :

The instruction "**mov [num4], ax**" moves the value in the "**ax**" register into the memory location labeled "num4". In assembly language, this operation is represented by the opcode "**A3**" followed by the memory address where the value should be stored.

Step : 6

Debugger 6 :





Explanation :

The instruction "**mov ax, 0x4c00**" moves the hexadecimal value "**4c00**" into the "**ax**" register. In assembly language, this operation is represented by the opcode "**B8**" followed by the value to be moved.

File c02-02 :

c02-01.LST

```
1                                   ; a program to add three numbers using memory variables
2                                   [org 0x0100]
3
4  00000000 A1[1700]                    mov  ax, [num1]         ; load first number in ax
5                                        ; mov  [num1], [num2]     ; illegal
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
20
21                                  ; watch the listing carefully
```

c02-02.LST

```
1                                   ; a program to add three numbers accessed using a single label
2                                   [org 0x0100]
3
4  00000000 A1[1700]                    mov  ax, [num1]
5  00000003 8B1E[1900]                   mov  bx, [num1 + 2]     ; notice how we can do arithmetic here
6  00000007 01D8                         add  ax, bx             ; also, why +2 and not +1?
7  00000009 8B1E[1B00]                   mov  bx, [num1 + 4]
8  0000000D 01D8                         add  ax, bx
9  0000000F A3[1D00]                     mov  [num1 + 6], ax     ; store sum at num1+6
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
17
```

Difference :

The instruction "**mov bx, [num1 + 2]**" implies an arithmetic operation. It's fetching the value stored in the memory location labeled "**num1**", but it's also adding 2 to the address before

fetching the value. So, it's effectively accessing the memory location two bytes after "**num1**" and moving its value into the "**bx**" register.
Similarly the the other instructions on other lines as arrowed above works the same way

Here in file 1 each line defines a separate memory location labeled "**num1**" , "**num2** " , "**num3**" , " **num4** " , followed by values (5, 10, 15, 0) respectively .

The values **5**, **10**, **15**, and **0** are all defined under a single memory variable , labeled as "**num1**". And every addition of 2 to the memory addition points to the next value

As you can see there is no effect on the machine code, just the syntax is a bit different…

File c02-03 :

c02-02.LST × c02-03.LST

c02-02.LST

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```
1                                   ; a program to add three numbers accessed using a single label
2                                   [org 0x0100]
3
4 00000000 A1[1700]                     mov  ax, [num1]
5 00000003 8B1E[1900]                   mov  bx, [num1 + 2]     ; notice how we can do arithmetic here
6 00000007 01D8                         add  ax, bx             ; also, why +2 and not +1?
7 00000009 8B1E[1B00]                   mov  bx, [num1 + 4]
8 0000000D 01D8                         add  ax, bx
9 0000000F A3[1D00]                     mov  [num1 + 6], ax     ; store sum at num1+6
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
17
```

c02-02.LST c02-03.LST ×

c02-03.LST

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```
1                                   ; a program to add three numbers accessed using a single label
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 05000A000F000000        num1:   dw  5,  10,  15,  0
14
```

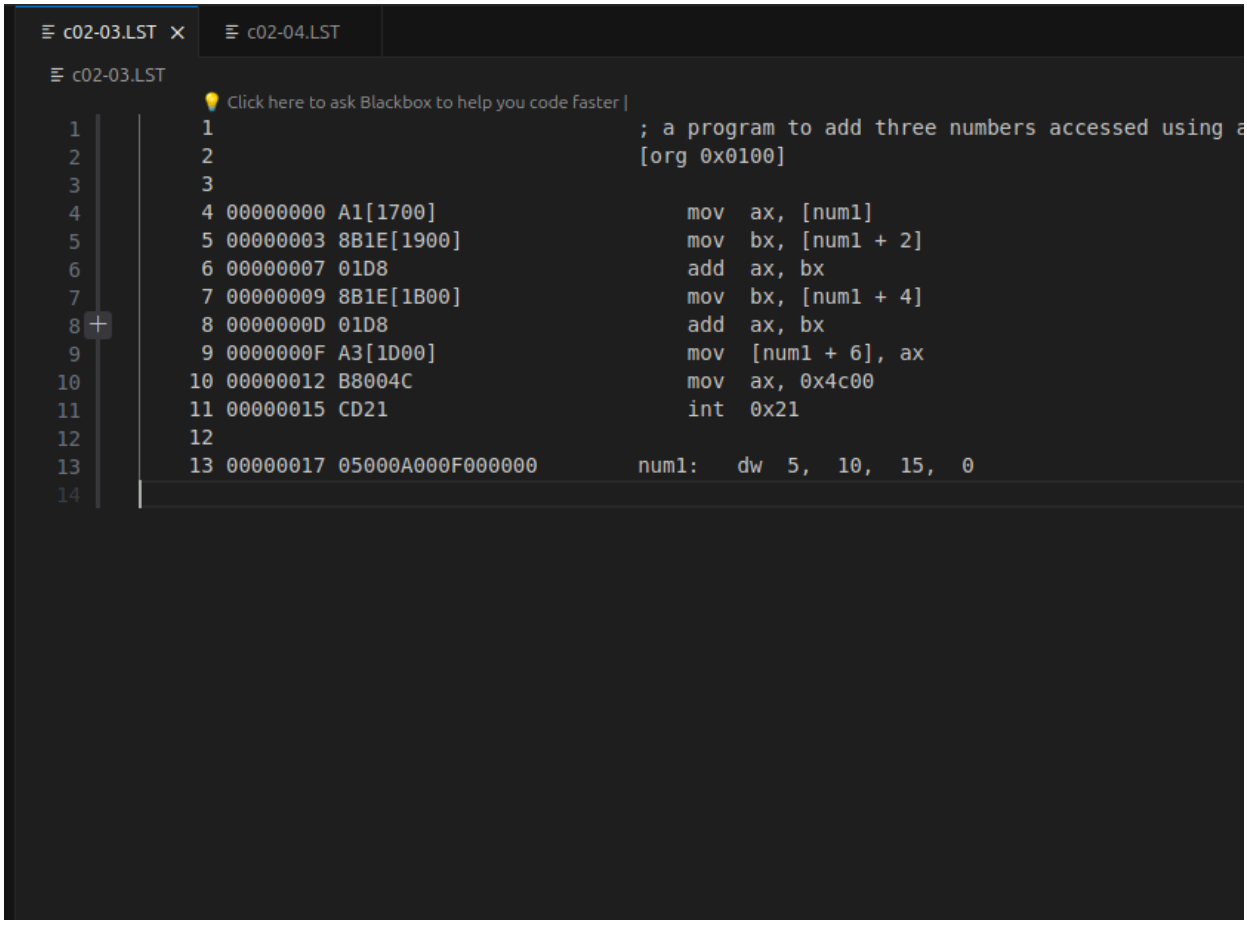
Difference :

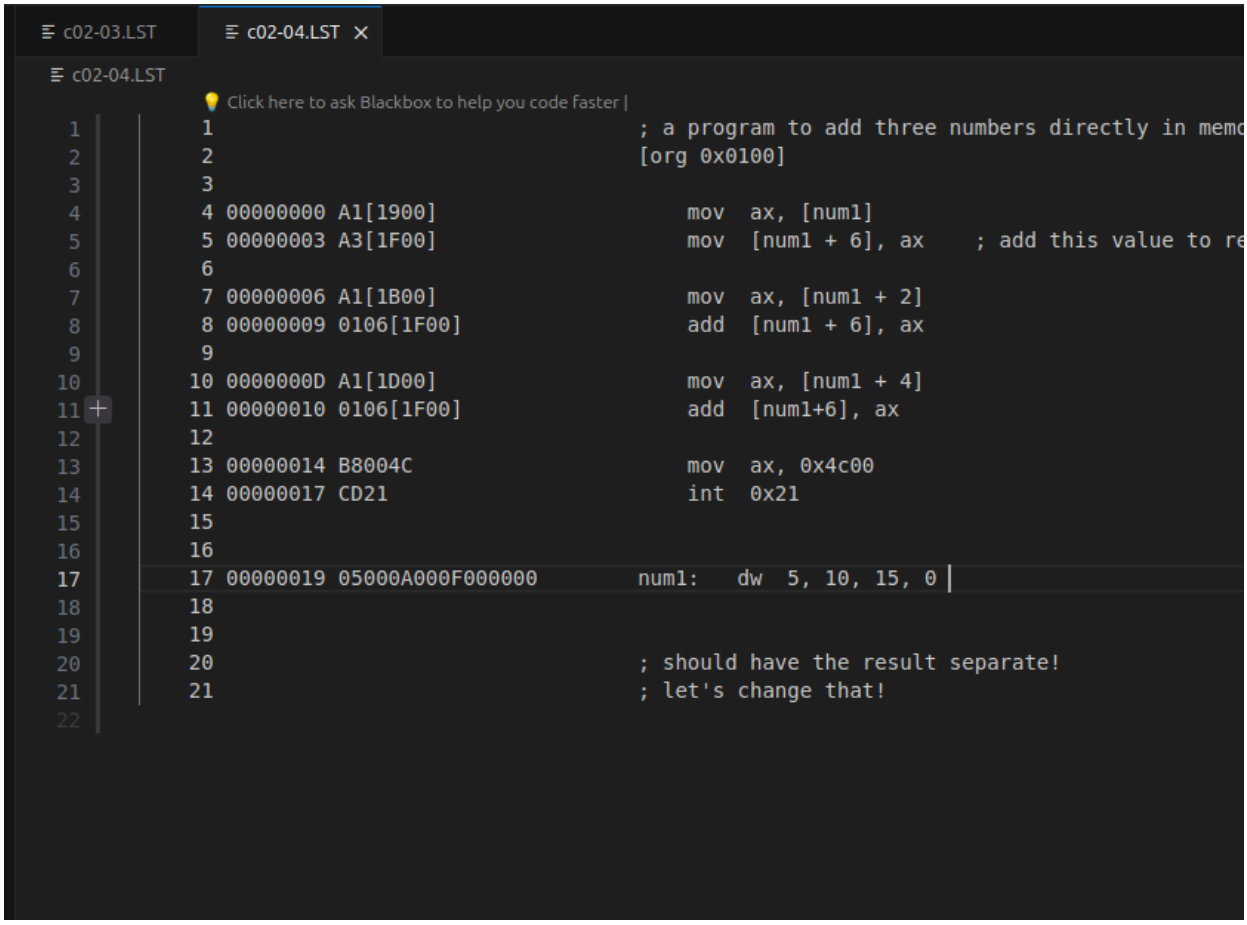
Here in **file 1** the variable/label num1 points to the **address** of the value **5** followed by **10**,**15** and **0** respectively whereas **0** is the result of all the arithmetic operations performed during the program.

The values **5**, **10**, **15**, and **0** are all defined under a single memory variable , labeled as "**num1**". And every addition of 2 to the memory addition points to the next value

As you can see there is no effect on the machine code, just the syntax is a bit different…

File c02-04 :


c02-03.LST
c02-04.LST
c02-03.LST
Click here to ask Blackbox to help you code faster |
1 ; a program to add three numbers accessed using a
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 05000A000F000000 num1: dw 5, 10, 15, 0
14



Difference :

- The main difference between the two files is how they handle the storage of the result:
  - **File 1** stores the result in the same memory area as the input numbers.
  - **File 2** stores the result separately from the input numbers.
- **File 1** modifies the original memory area containing the input numbers to hold the result, which may not be suitable if you want to preserve the original data.
- **File 2** keeps the input numbers intact and stores the result in a separate memory location, which is generally a cleaner approach.

File 1 :

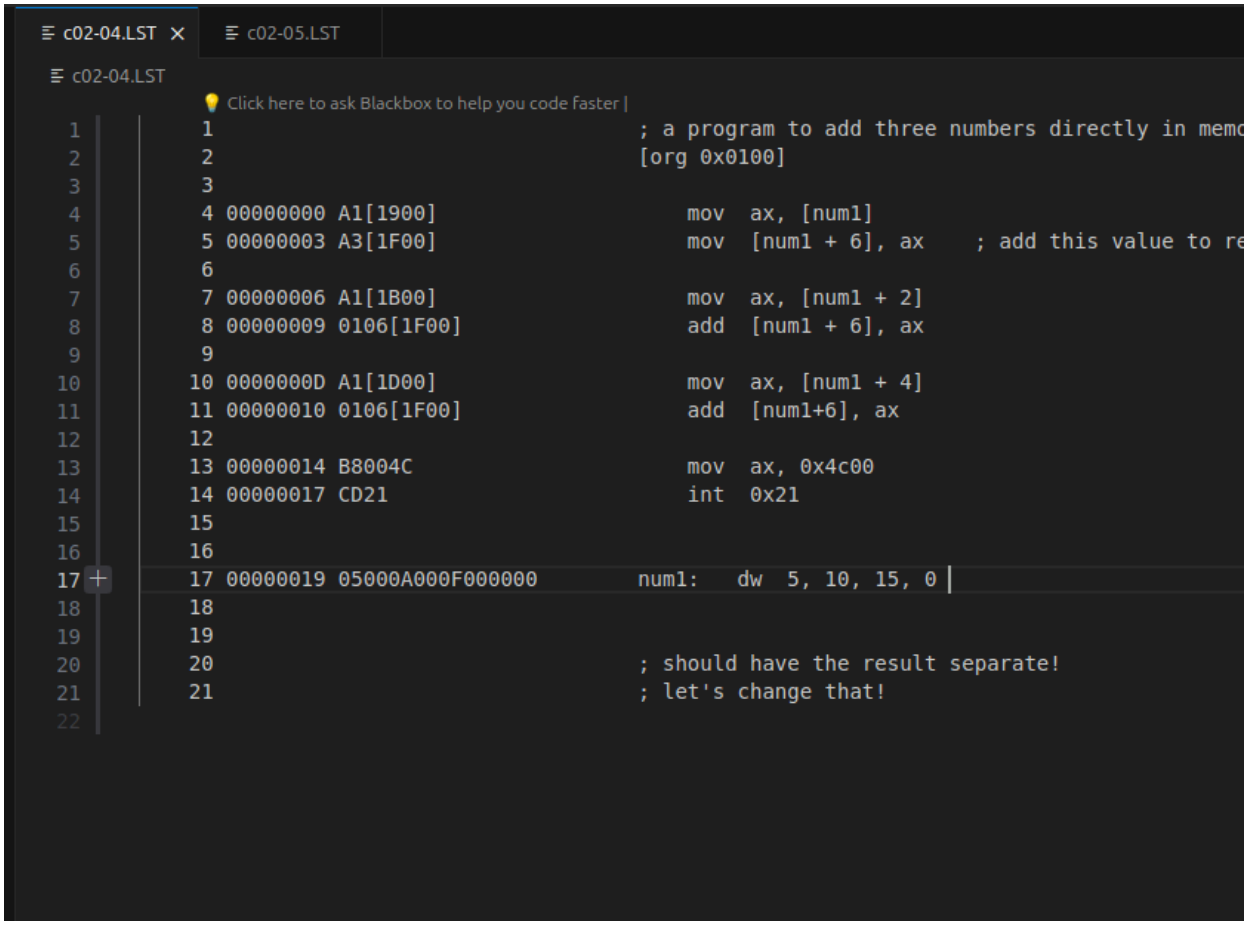
- **File 1 :** uses registers (**ax and bx**) to perform arithmetic operations.
- **File 1 :** uses the same memory location (**num1**) for both input numbers and the result.
- **File 1 :** is more register-centric, with explicit loading and storing of values from and to memory.

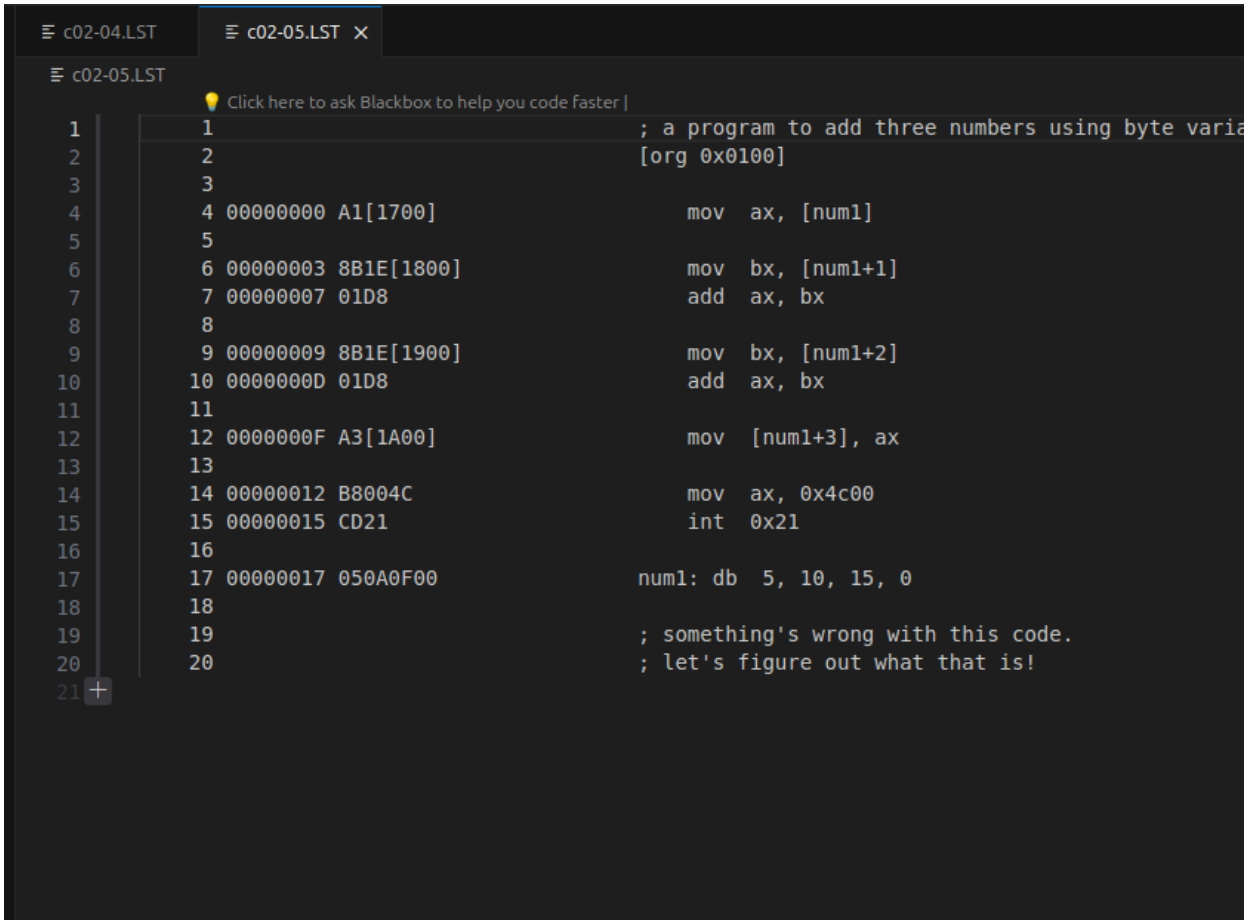
File 2 :

- **File 2 :** performs arithmetic operations directly in memory without using registers.

- **File 2 :** separates the input numbers (**num1**) from the result (**stored at num1 + 6**).
- **File 2 :** operates more directly in memory, with fewer register operations.

File c02-05 :


c02-04.LST
c02-05.LST
c02-04.LST
Click here to ask Blackbox to help you code faster |
1 ; a program to add three numbers directly in memo
2 [org 0x0100]
3
4 00000000 A1[1900] mov ax, [num1]
5 00000003 A3[1F00] mov [num1 + 6], ax ; add this value to re
6
7 00000006 A1[1B00] mov ax, [num1 + 2]
8 00000009 0106[1F00] add [num1 + 6], ax
9
10 0000000D A1[1D00] mov ax, [num1 + 4]
11 00000010 0106[1F00] add [num1+6], ax
12
13 00000014 B8004C mov ax, 0x4c00
14 00000017 CD21 int 0x21
15
16
17 00000019 05000A000F000000 num1: dw 5, 10, 15, 0
18
19
20 ; should have the result separate!
21 ; let's change that!
22



Difference :

File 1 :

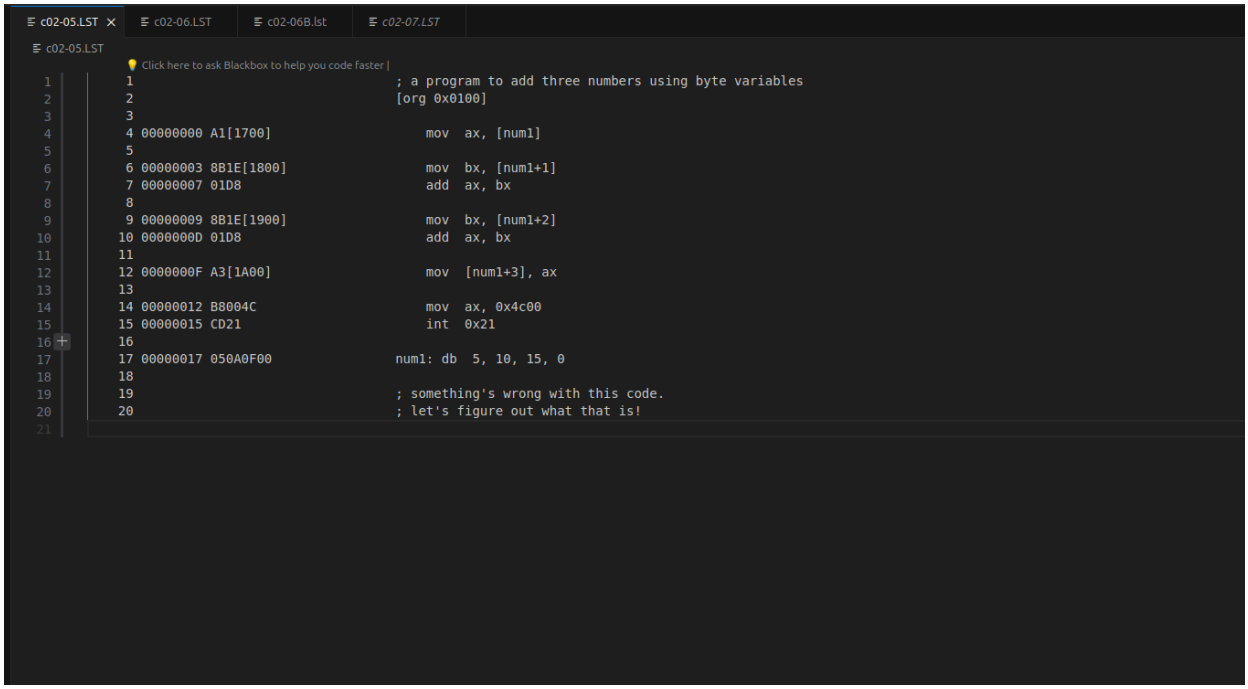
- **File 1 :** This program adds three numbers using memory directly.
- **File 1 :** It loads each number from the num1 array into the ax register, performs addition operations, and then stores the result back into memory.
- **File 1:** Uses words (**16 bits**) for each number in the num1 array (**dw directive**).
- **File 1:** Uses only the ax register to perform arithmetic operations.
- Performs addition directly between numbers loaded into **AX** register and the memory location holding the result.
- **File 1:** Treats each number as a **16-bit** word (**2 bytes**).
- **File 1:** Accesses memory in **16-bit** chunks (**word-by-word**).

FIle 2 :

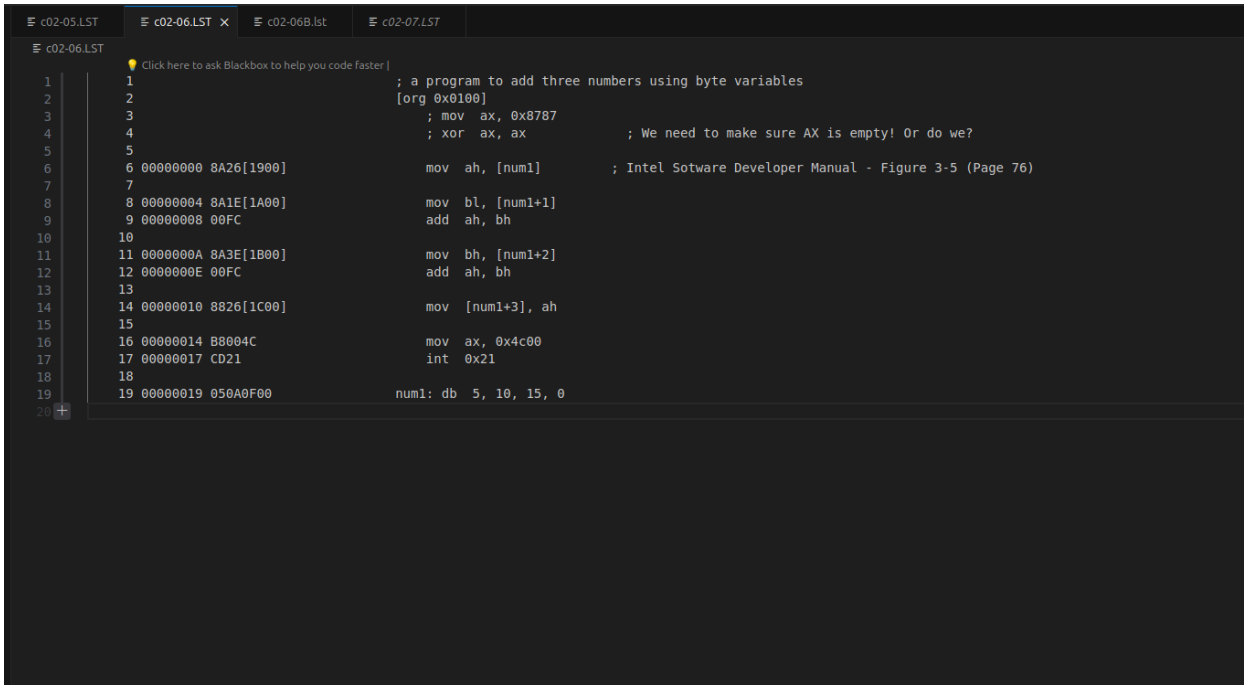
- **File 2:** Uses bytes (**8 bits**) for each number in the num1 array (**db directive**).
- **File 2:** Uses both ax and bx registers; ax to load numbers, bx to hold the intermediate sum during addition.

- **File 2:** Performs addition using bx register to accumulate the sum before storing the result back into memory.
- **File 2:** Treats each number as an **8-bit byte**.
- **File 2:** Accesses memory in 8-bit chunks (**byte-by-byte**).

File c02-06 :



```
c02-05.LST | c02-06.LST | c02-06B.lst | c02-07.LST
c02-05.LST
Click here to ask Blackbox to help you code faster |
1                                   ; a program to add three numbers using byte variables
2                                   [org 0x0100]
3
4 00000000 A1[1700]                     mov  ax, [num1]
5
6 00000003 8B1E[1800]                   mov  bx, [num1+1]
7 00000007 01D8                         add  ax, bx
8
9 00000009 8B1E[1900]                   mov  bx, [num1+2]
10 0000000D 01D8                        add  ax, bx
11
12 0000000F A3[1A00]                    mov  [num1+3], ax
13
14 00000012 B8004C                      mov  ax, 0x4c00
15 00000015 CD21                        int  0x21
16
17 00000017 050A0F00                num1: db  5, 10, 15, 0
18
19                                  ; something's wrong with this code.
20                                  ; let's figure out what that is!
21
```



```
c02-05.LST | c02-06.LST | c02-06B.lst | c02-07.LST
c02-06.LST
Click here to ask Blackbox to help you code faster |
1                                   ; a program to add three numbers using byte variables
2                                   [org 0x0100]
3                                       ; mov  ax, 0x8787
4                                       ; xor  ax, ax            ; We need to make sure AX is empty! Or do we?
5
6 00000000 8A26[1900]                   mov  ah, [num1]         ; Intel Sotware Developer Manual - Figure 3-5 (Page 76)
7
8 00000004 8A1E[1A00]                   mov  bl, [num1+1]
9 00000008 00FC                         add  ah, bh
10
11 0000000A 8A3E[1B00]                  mov  bh, [num1+2]
12 0000000E 00FC                        add  ah, bh
13
14 00000010 8826[1C00]                  mov  [num1+3], ah
15
16 00000014 B8004C                      mov  ax, 0x4c00
17 00000017 CD21                        int  0x21
18
19 00000019 050A0F00                num1: db  5, 10, 15, 0
20
```

Difference :

File 1 :

- File 1: Uses **ax** register to hold the accumulated **sum** and **bx** register to load each number from memory.
- File 1: Adds the numbers directly using the add instruction with the **ax** register.

File 2 :

- File 2: Uses **ah**, **bl**, and **bh** registers to hold each byte of the numbers and accumulate the sum in ah.
- File 2: Adds the numbers using the add instruction with ah register and temporary **bh** register for each byte.

Both programs access memory using byte-by-byte chunks (**db directive**).

File c02-06b :

c02-05.LST | c02-06.LST | c02-06B.lst | c02-07.LST

c02-06.LST

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```
1                                   ; a program to add three numbers using byte variables
2                                   [org 0x0100]
3                                       ; mov  ax, 0x8787
4                                       ; xor  ax, ax            ; We need to make sure AX is empty! Or do we?
5
6 00000000 8A26[1900]                   mov  ah, [num1]         ; Intel Sotware Developer Manual - Figure 3-5 (Page 76)
7
8 00000004 8A1E[1A00]                   mov  bl, [num1+1]
9 00000008 00FC                         add  ah, bh
10
11 0000000A 8A3E[1B00]                  mov  bh, [num1+2]
12 0000000E 00FC                        add  ah, bh
13
14 00000010 8826[1C00]                  mov  [num1+3], ah
15
16 00000014 B8004C                      mov  ax, 0x4c00
17 00000017 CD21                        int  0x21
18
19 00000019 050A0F00                num1: db  5, 10, 15, 0
20
```

c02-05.LST | c02-06.LST | c02-06B.lst | c02-07.LST

c02-06B.lst

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```
1                                   ; a program to add three numbers using byte variables
2                                   [org 0x0100]
3
4 00000000 B88787                       mov  ax, 0x8787
5 00000003 31C0                         xor  ax, ax          ; we need to make sure AX is empty!
6
7 00000005 A0[1C00]                     mov  al, [num1]
8
9 00000008 8A1E[1D00]                   mov  bl, [num1+1]
10 0000000C 00D8                        add  al, bl
11
12 0000000E 8A1E[1E00]                  mov  bl, [num1+2]
13 00000012 00D8                        add  al, bl
14
15 00000014 A2[1F00]                    mov  [num1+3], al
16
17
18
19                                      ; mov  ax, bl        ; ... assemble time error. Make sure you understand the error!
20
21 00000017 B8004C                      mov  ax, 0x4c00
22 0000001A CD21                        int  0x21
23
24 0000001C 050A0F00                num1: db  5, 10, 15, 0
25
```

Difference :

In x86 assembly language:

- **AH** and **AL** are the higher and lower halves, respectively, of the **AX** register, a **16-bit** general-purpose register.
- **BH** and **BL** are the higher and lower halves, respectively, of the **BX** register, another **16-bit** general-purpose register.

So, **AH** and **AL** represent the high and low bytes of the **AX** register, while **BH** and **BL** represent the high and low bytes of the **BX** register.

File 1:

Line 6:
- Loads the first number from the **num1** array into the **ah** register.

Line 8:
- Loads the second number from the **num1** array into the **bl** register.

Line 9:
- Incorrect operation. It tries to add the values in ah and bh registers, which are uninitialized and hold garbage values. It should be adding ah and bl.

Line 11:
- Loads the third number from the **num1** array into the **bh** register.

Line 12:
- Incorrect operation. It again tries to add the values in **ah** and **bh** registers, which are uninitialized and hold garbage values. It should be adding **ah** and **bh**.

Line 14:
- Stores the **result**, which is the sum in **ah**, into the memory location **num1 + 3**.

File 2:

Lines 4-5:
- Initializes ax with the value **0x8787** and then clears it to make sure it's empty.

Line 7:
- Loads the first number from the **num1** array into the **al** register.

Line 9:
- Loads the second number from the **num1** array into the **bl** register.

Line 10:
- Adds the values in **al** and **bl** registers.

Line 12:
- Loads the third number from the **num1** array into the **bl** register.

Line 13:
- Adds the values in **al** and **bl** registers.

Line 15:
- Stores the result, which is the sum in **al**, into the memory location **num1 + 3**.

File c02-07 :

c02-05.LST | c02-06.LST | c02-06B.lst | c02-07.LST

c02-06B.lst

Click here to ask Blackbox to help you code faster |

```
1                                   ; a program to add three numbers using byte variables
2                                   [org 0x0100]
3
4 00000000 B88787                       mov  ax, 0x8787
5 00000003 31C0                         xor  ax, ax          ; we need to make sure AX is empty!
6
7 00000005 A0[1C00]                     mov  al, [num1]
8
9 00000008 8A1E[1D00]                   mov  bl, [num1+1]
10 0000000C 00D8                        add  al, bl
11
12 0000000E 8A1E[1E00]                  mov  bl, [num1+2]
13 00000012 00D8                        add  al, bl
14
15 00000014 A2[1F00]                    mov  [num1+3], al
16
17
18
19                                      ; mov  ax, bl        ; ... assemble time error. Make sure you understand the error!
20
21 00000017 B8004C                      mov  ax, 0x4c00
22 0000001A CD21                        int  0x21
23
24 0000001C 050A0F00                num1: db  5, 10, 15, 0
25
```

c02-05.LST | c02-06.LST | c02-06B.lst | c02-07.LST

c02-07.LST

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```
1                                   ; a program to add three numbers using byte variables
2                                   [org 0x0100]
3 00000000 31C0                         xor  ax, ax                ; check effect on ZF
4
5 00000002 BB[1F00]                     mov  bx, num1
6
7 00000005 0307                         add  ax, [bx]
8 00000007 81C30200                     add  bx, 2
9
10 0000000B 0307                        add  ax, [bx]
11 0000000D 81C30200                    add  bx, 2
12
13 00000011 0307                        add  ax, [bx]
14 00000013 81C30200                    add  bx, 2
15
16
17 00000017 A3[2500]                    mov  [result], ax
18
19 0000001A B8004C                      mov  ax, 0x4c00
20 0000001D CD21                        int  0x21
21
22
23                                      ; to turn this into an iteration, we need a couple of things:
24                                      ; - branching instruction
25                                      ; - checking constraints -- e.g. c > 0       ; Intel Sotware Developer Manual - Figure 3-8 (Page 80)
26
27
28 0000001F 05000A000F00            num1: dw  5, 10, 15
29 00000025 0000                    result: dw 0
30
```

Difference :

File 1:

- **AX**: Initialized with **0x8787**, then cleared to ensure it's empty.
- **AL** and **BL**: Used to sequentially add byte values from memory.

File 2:

- **AX**: Cleared using xor operation for subsequent addition operations.
- **BX**: Used as a pointer to access byte values in memory sequentially.
- **Result**: Stores the final sum computed in **AX**.