

Lab 5

Variables, Arrays & Loops

Objectives

After completing this lab,

- Students will be able to declare and initialize variables.
- Students will be able to declare and initialize a linear array.
- Students will be able to define constant.
- Students will be able to implement built-in loop instructions.
- Students will be able to apply base plus index addressing mode to access arrays.
- Students will be able to traverse arrays and perform various operations on them.

Variables

A variable is a memory location. It is easier for a programmer to remember a variable name like "Var1" than an address like 5A73:235B, especially when there are 10 or more variables. The Emu8086 supports bytes and words as the db and dw variables, respectively.

Syntax for a variable declaration:

name **DB** value

name **DW** value

DB - for Define Byte.

DW - for Define Word.

name - can be any letter or digit combination, though it should start with a letter. It's possible to declare unnamed variables by not specifying the name (this variable will have an address but no name).

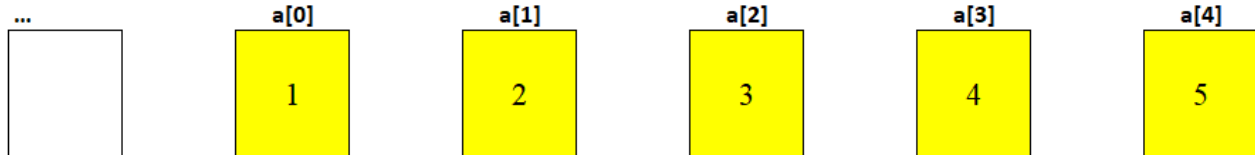
value - can be any numeric value in any supported numbering system (hexadecimal, binary, or decimal), or "?" symbol for variables that are not initialized.

Arrays

Arrays can be seen as chains of variables. It is a set of consecutive memory locations having the same data type.

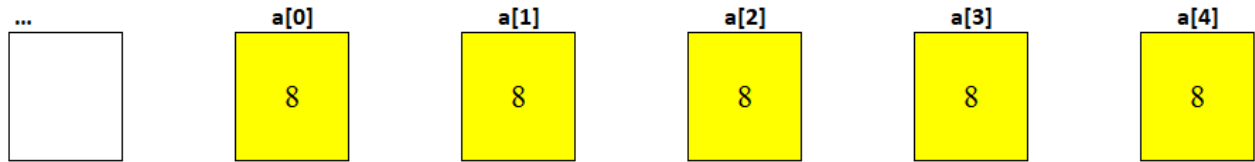
Declaring and initializing an array

a **db** 1,2,3,4,5



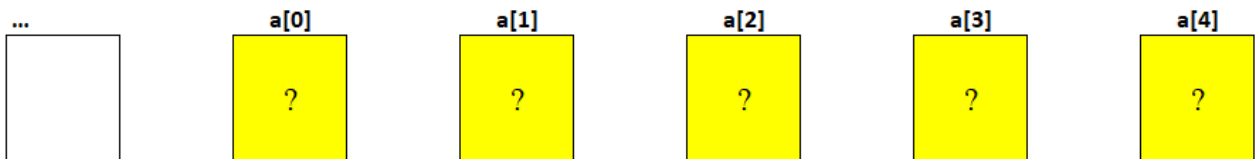
Declaring array of 5 elements and initializing it with 8.

a db 5 dup(8)



Declaring array of 5 elements without initializing it.

a db 5 dup(?)



Constant

Constants are just like variables, but they exist only until your program is assembled. After assembling, the definition of a constant is replaced with its value. Constant is defined as follows:

name EQU < any expression >

Example:

```
.data
k EQU 5
.code
MOV AX, k
```

The above example is functionally identical to code: MOV AX, 5

Base-plus-Index addressing mode

Arrays can be accessed using direct or register-indirect addressing modes. However, the base-plus-index addressing mode facilitates the programmer in accessing arrays better. In this addressing mode, as the name suggests, there is a base register that points to the base address of an array, while the index register points to the index of the array that is to be accessed. The offset part of the logical address is made by adding the contents of the base and index registers.

There are two base registers: BX and BP, and two index registers: SI and DI. One base register and one index register must be combined to form an offset. There cannot be two base registers or two index registers. If BX is used as the base register, segment addresses will be taken from DS by default. However, in the case of BP, the segment address will be taken from SS by default. However, segment registers can be overridden, as we have already seen in previous labs. The following table shows how physical addresses are calculated.

Instructions	Default Segment	Physical Address Calculation
MOV AX, [BX + SI]	DS	DS:[BX+SI]
MOV AX, [BP + SI]	SS	SS:[BP + DI]

Program 1: Program to move elements of array to AL,AH, CL,CH and DL registers.

```
.model small

.data

Array db 1,2,3,4,5

.code

Mov ax,@data
Mov ds,ax

Mov bx, offset Array
Mov si, 0

Mov al, [bx + si]
Inc si

Mov ah, [bx + si]
Inc si

Mov cl, [bx + si]
Inc si

Mov ch, [bx + si]
Inc si

Mov dl, [bx + si]

.exit
```

- The **offset** keyword is used to get the address of a variable or an array.
- **SI** is incremented by 1 in the case of a byte array. It will be incremented by 2 for the word array.

Labels

A label is an identifier that is optional and can be placed at the beginning of an instruction. When a program is assembled, the reference to the label is replaced by the offset address.

Example:

```
L1: Mov ax,bx  
  
    Mov bx, L1
```

Loops

Loops are used to execute a set of instructions multiple times until specific conditions are met. There are some built-in loop instructions. One of them is "Loop," which transfers the control to the label specified with it if the counter register (CX) is not zero.

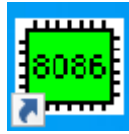
Instruction	Description
Loop label	If (CX == 0) Jump to label else Jump to next instruction

Program 2: Program to increment AX and decrement DX register 100 times

```
.model small  
  
.data  
  
.code  
Mov DX,0xffff  
Mov CX,100  
  
L1:  
  
Inc AX  
Dec DX  
  
Loop L1  
  
.exit
```

Emu8086 Tutorial Step by Step

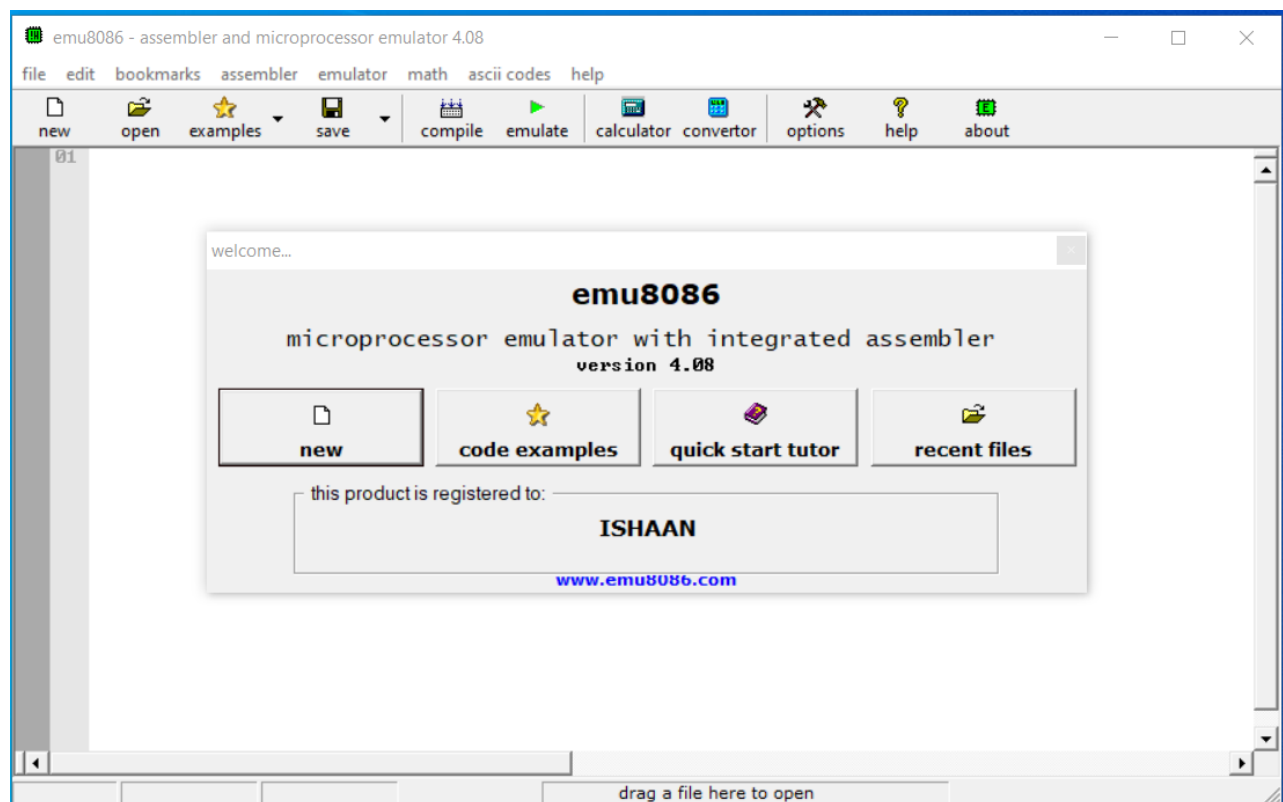
Step-1:



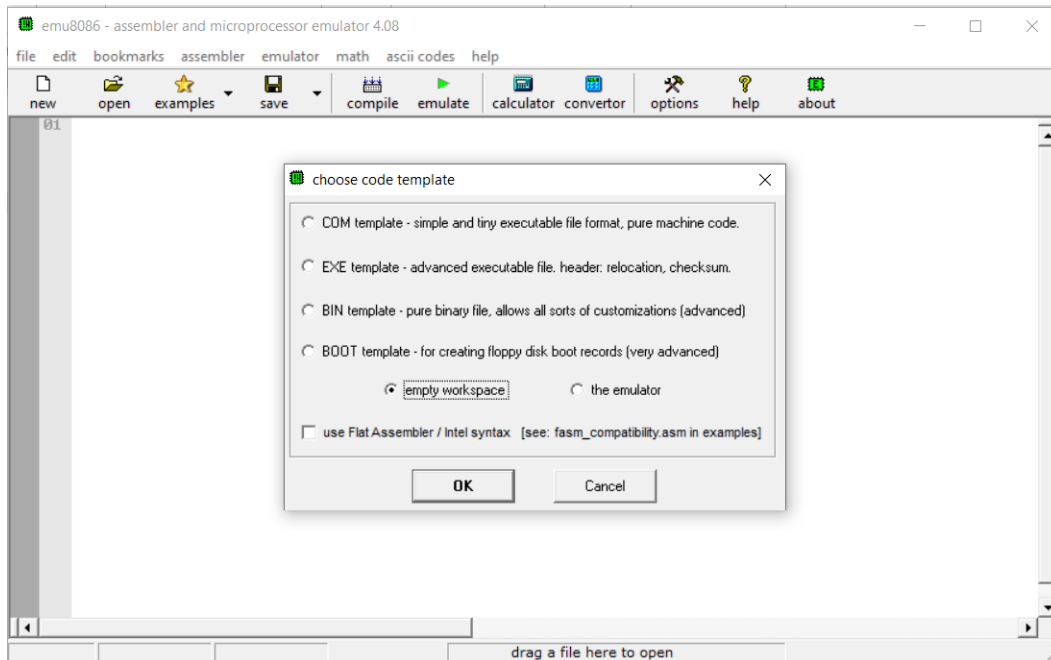
Double click on the icon on the desktop

Step-2:

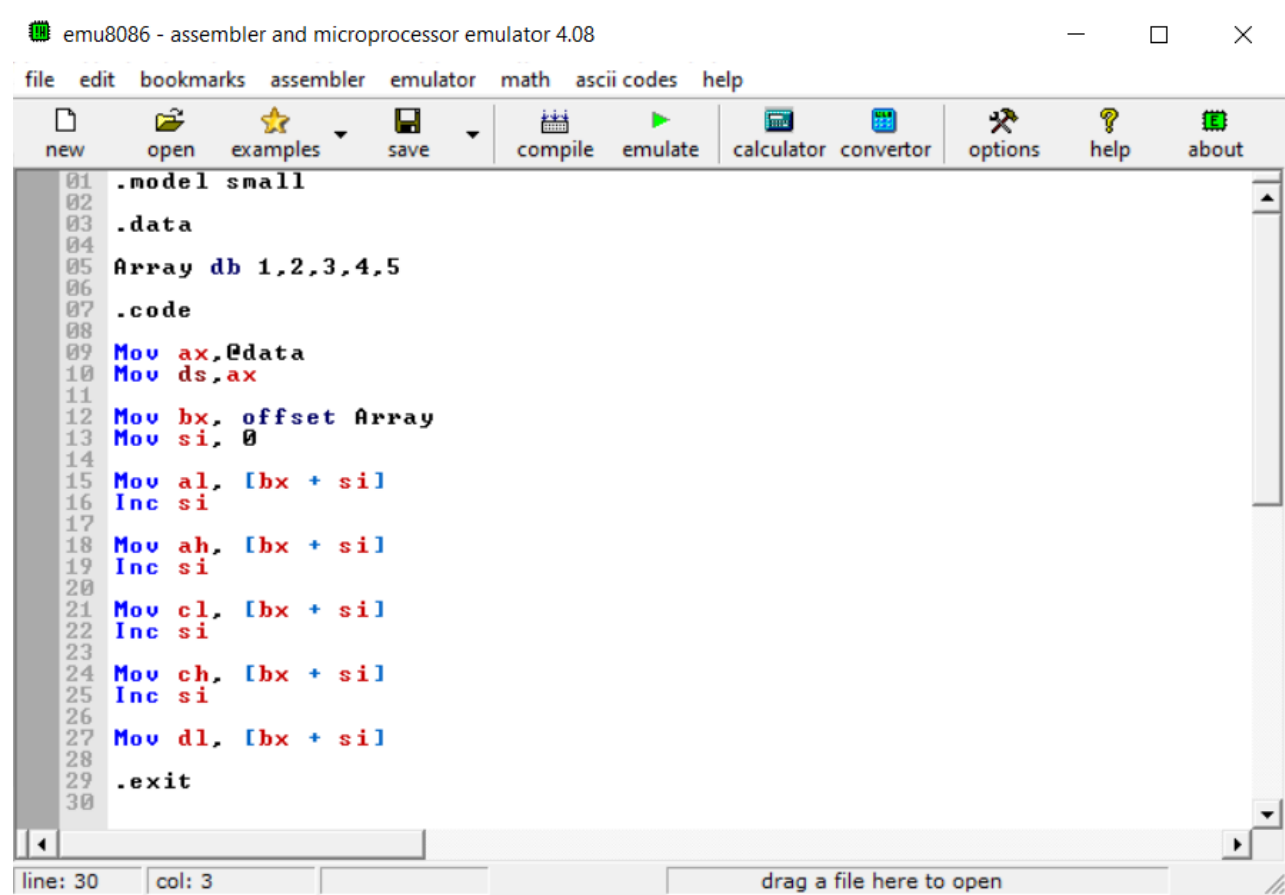
The following window will appear. Click on new.



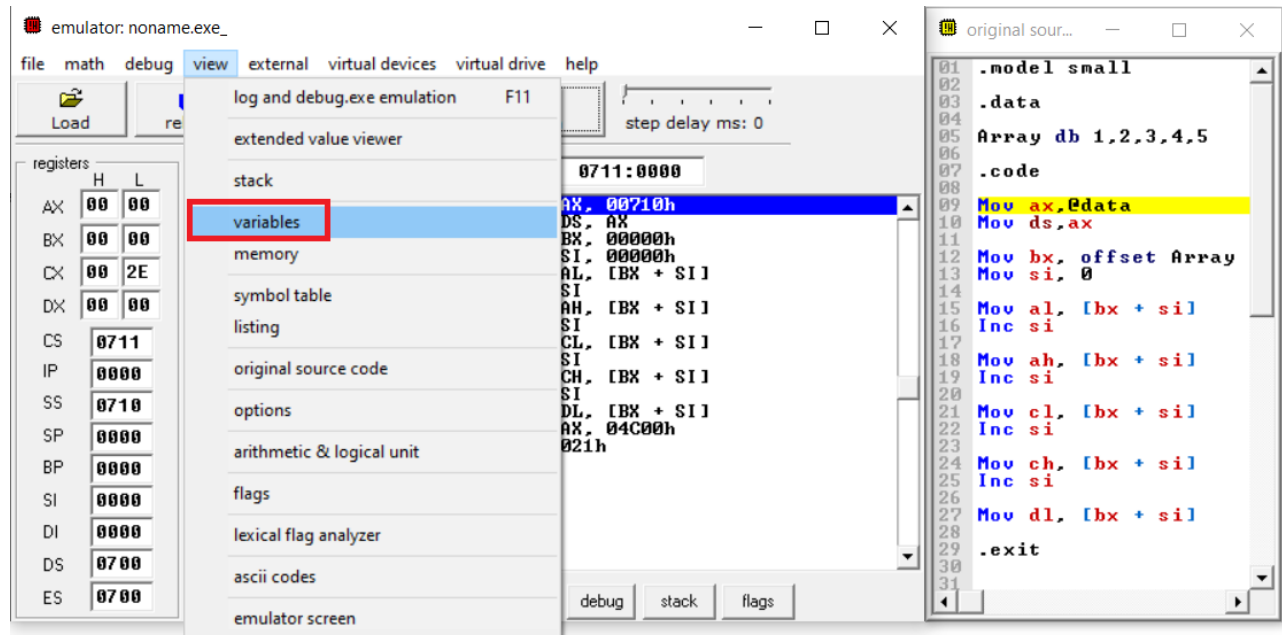
Step-3: Click on empty workspace and press OK.



Step-4: Type the code given in program 1 above and click on emulate.



Step-5: Click on “variables” from the view menu.



Step-6: Set size, number of elements and radix in the variable window.

The screenshot displays an x86 emulator interface with three main windows:

- Assembly Source Window (original sour...):** Shows assembly code for a program that initializes a data segment, defines an array of 5 bytes (1, 2, 3, 4, 5), and iterates through it using registers AX, BX, SI, and DI. The code includes instructions like `mov ax, @data`, `mov ds, ax`, `mov bx, offset Array`, and a loop that increments `si` and `di` while moving data from the array to `ax`.
- Registers Window:** Shows the state of various registers. The `CS` register is set to `0711`, and the `IP` register is `0000`. The `DS` register is `0700`. The `SI` register is `0000`. The `DI` register is `0000`. The `AX` register is `0000`. The `DX` register is `0000`. The `ES` register is `0700`.
- Variables Window:** This window is used to configure the display of the `Array` variable. It shows:
 - size:** `byte` (selected from a dropdown menu).
 - elements:** `5` (entered in a text box).
 - show as:** `signed` (selected from a dropdown menu).
 - radix:** `signed` (selected from a dropdown menu).

Annotations in the Variables Window:

- An orange arrow points to the `size` dropdown with the text "Select size of each element".
- A red arrow points to the `elements` text box with the text "Enter number of elements to display".
- A blue arrow points to the `show as` dropdown with the text "Select radix".

The `Array` variable is displayed as `1, 2, 3, 4, 5`.

Step-7: Keep clicking on “Single step” to execute program instructions one by one and observe the register values side by side.
 Stop clicking “Single step” when the “.exit” is highlighted to observe the register values.

The screenshot shows a debugger window titled "emulator: noname.exe_" with a menu bar (file, math, debug, view, external, virtual devices, virtual drive, help) and a toolbar (Load, reload, step back, single step, run, step delay ms: 0). The registers window on the left shows the following values:

Register	H	L
AX	02	01
BX	00	00
CX	04	03
DX	00	05
CS	0711	
IP	0019	
SS	0710	
SP	0000	
BP	0000	
SI	0004	
DI	0000	
DS	0710	
ES	0700	

The memory window shows the following values:

Address	Value
07126	46 070 F
07127	8A 138 E
07128	10 016
07129	B8 184
0712A	00 000 NULL
0712B	4C 076 L
0712C	CD 205 =
0712D	21 033
0712E	90 144 E
0712F	90 144 E
07130	90 144 E
07131	90 144 E
07132	90 144 E
07133	90 144 E
07134	90 144 E
07135	90 144 E
07136	90 144 E
07137	90 144 E
07138	90 144 E
07139	90 144 E
0713A	90 144 E

The instructions window shows the following code:

```

MOV AX, 00710h
MOV DS, AX
MOV BX, 00000h
MOV SI, 00000h
INC SI
MOV AH, [BX + SI]
INC SI
MOV CL, [BX + SI]
INC SI
MOV CH, [BX + SI]
INC SI
MOV DL, [BX + SI]
MOV AX, 04C00h
INT 021h
NOP
NOP
NOP
NOP
NOP
...

```

The 'original source' window shows the following assembly code:

```

.model small
.data
Array db 1,2,3,4,5
.code
09 Mov ax,@data
10 Mov ds,ax
11
12 Mov bx, offset Array
13 Mov si, 0
14
15 Mov al, [bx + si]
16 Inc si
17
18 Mov ah, [bx + si]
19 Inc si
20
21 Mov cl, [bx + si]
22 Inc si
23
24 Mov ch, [bx + si]
25 Inc si
26
27 Mov dl, [bx + si]
28
29 .exit
30
31

```

The 'variables' window shows the following array:

```

size: byte elements: 5
edit show as: signed
ARRAY 1, 2, 3, 4, 5

```

Practice Exercise

Task-1

Write a program that declares and initializes the array of 10 elements, then calculates the sum of them using a loop and places the result into the "SUM" variable.

Task-2

Write a program that declares and initializes two word-type arrays: A and B, each of which has 20 elements. The program then adds the corresponding elements of these two arrays and stores the result in the third array: C.