Lab 6

Program Flow Control

Objectives

After completing this lab,

- Students will be able to transfer control to any label or address unconditionally.
- Students will be able to transfer control to any label or address based on some conditions.
- Students will be able to implement customized loops instead of using built-in loops.
- Students will be able to use opposite conditional jumps to reduce number of jump instructions inside loop.
- Students will be able to make a long conditional jump using short conditional jump instructions.

Control in a program can be unconditionally or conditionally transferred to any location based on status flags. There are instructions for transferring control.

Unconditional Jump

The basic syntax of JMP instruction:
JMP label

The "JMP" instruction transfers control to the address or label followed by it. This instruction can move control within or outside of the current code segment. In the following table, example 1 shows the jump inside the current code segment, called a "near jump," and example 2 shows the jump outside the current code segment, called a "long jump." For a short jump, the address that comes after the "JMP" instruction will be an offset. For a long jump, the address will be a logical address made up of a segment address and an offset.

Example-1: Transferring control to label within same code segment.	Example-2: Transferring control to address outside current code segment.

.model small
.data
 	
.code
 	
Mov ax,@data
Mov ds,ax
 	
Jmp Label1
 	
Mov AX, BX
Mov CX, DX
 	
Lable1:
Mov AX,1
Mov BX,2
 	
.exit
	.model small
	.data
	
	.code
	
	Mov ax,@data
	Mov ds,ax
	
	Jmp 0x07C0:0x0000
	
	Mov AX, BX
	Mov CX, DX
	
	.exit

Conditional Jumps

Unlike JMP instruction that does an unconditional jump, there are instructions that do a conditional jump (jump only when some conditions are in act). These instructions are divided in three groups, first group just test single flag, second compares numbers as signed, and third compares numbers as unsigned. All these three groups use status flags to jump.

We know that the status flags are modified because of ALU instructions. Therefore, to compare two numbers, we usually perform a subtraction operation on these two numbers. We are not concerned with the result of the subtract operation but with the status flags that are updated. Therefore, instead of the "SUB" instruction, the "CMP" instruction is used, which discards the result and keeps the status of flags.

The basic syntax of CMP instruction:
CMP Destination Operand, Source Operand

Jump instructions that test single flag

The following table shows the conditional jump instructions that jump based on the value of a single flag. In the instruction column, some rows contain more than one instruction that does the same thing. They are even assembled into the same machine code. **JE** will be assembled as **JZ, JC will be** assembled as **JB,** and so on. These names are used to make programs easier to understand, code, and remember.

Instruction	Description	Condition	Opposite Instruction
JZ JE	Jump if Zero Jump if Equal	ZF = 1	JNZ JNE
JC JB JNAE	Jump if Carry Jump if Below Jump if Not Above Equal	CF = 1	JNC JNB JAE
JS	Jump if Sign.	SF = 1	JNS
JO	Jump if Overflow.	OF = 1	JNO
JPE/ JP	Jump if Parity Even.	PF = 1	JPO
JNZ JNE	Jump if Not Zero Jump if Not Equal	ZF = 0	JZ JE
JNC JNB JAE	Jump if Not Carry Jump if Not Below Jump if Above Equal	CF = 0	JC JB JNAE
JNS	Jump if Not Sign.	SF = 0	JS
JNO	Jump if Not Overflow.	OF = 0	JO
JPO JNP	Jump if Parity Odd Jump if No Parity	PF = 0	JPE JP

Jump instructions for signed numbers.

To compare two signed numbers, the instructions shown in the following table are used right after the 'CMP' instruction.

Instruction	Description	Condition	Opposite Instruction
JE JZ	Jump if Equal (=). Jump if Zero.	ZF = 1	JNE JNZ
JNE JNZ	Jump if Not Equal (<>). Jump if Not Zero.	ZF = 0	JE JZ
JG JNLE	Jump if Greater (>). Jump if Not Less or Equal (not <=).	ZF = 0 and SF = OF	JNG JLE
JL JNGE	Jump if Less (<). Jump if Not Greater or Equal (not >=).	SF <> OF	JNL JGE
JGE JNL	Jump if Greater or Equal (>=). Jump if Not Less (not <).	SF = OF	JNGE JL
JLE JNG	Jump if Less or Equal (<=). Jump if Not Greater (not >).	ZF = 1 or SF <> OF	JNLE JG

Jump instructions for unsigned numbers

To compare two unsigned numbers, the instructions shown in the following table are used right after the 'CMP' instruction.

Instruction	Description	Condition	Opposite Instruction
JE JZ	Jump if Equal (=). Jump if Zero.	ZF = 1	JNE JNZ
JNE JNZ	Jump if Not Equal (<>). Jump if Not Zero.	ZF = 0	JE JZ
JA JNBE	Jump if Above (>). Jump if Not Below or Equal (not <=).	CF = 0 and ZF = 0	JNA JBE
JB JNAE JC	Jump if Below (<). Jump if Not Above or Equal (not >=). Jump if Carry.	CF = 1	JNB JAE JNC
JAE JNB JNC	Jump if Above or Equal (>=). Jump if Not Below (not <). Jump if Not Carry.	CF = 0	JNAE JB
JBE JNA	Jump if Below or Equal (<=). Jump if Not Above (not >).	CF = 1 or ZF = 1	JNBE JA

Limitation of Conditional Jump instructions

- All conditional jumps have one big limitation, unlike **JMP** instructions, they are short (one-byte jumps having a range from -128 to 127 bytes). However, we can easily avoid this limitation using a cute trick:
    - Get conditional jump instruction from the tables above and make it jump to ***label_X*.**
    - Under that **label_X**, Use **JMP** instructions to jump to the desired location.
- Emu8086 uses this trick implicitly for conditional jumps.

Program 1:
To swap values of AX and BX registers if AX < BX.

1a: Program with straight conditional jumps.	1b: Program with opposite conditional jump to reduce jumps.

.model small
 	
.data
 	
.code
 	
Mov ax,@data
Mov ds,ax
 	
Mov ax,5
Mov bx,10
 	
Cmp ax,bx
JS swap
Jmp exit_cmp
 	
Swap:
XCHG ax,bx
 	
exit_cmp:
 	
.exit
	.model small
	
	.data
	
	.code
	
	Mov ax,@data
	Mov ds,ax
	
	Mov ax,5
	Mov bx,10
	
	Cmp ax,bx
	JNS exit_cmp
	
	Swap:
	XCHG ax,bx
	
	exit_cmp:
	
	.exit

Program 2:
To iterate a loop while AX < BX using conditional jump for unsigned numbers.

1a: Program with straight conditional jumps.	1b: Program with opposite conditional jump to reduce jumps.

.model small
 	
.data
 	
.code
 	
Mov ax,@data
Mov ds,ax
 	
Mov ax,5
Mov bx,10
 	
compare:
cmp ax,bx
JB iterate
jmp exit_loop
 	
iterate:
inc ax
jmp compare
 	
exit_loop:
 	
.exit
	.model small
	
	.data
	
	.code
	
	Mov ax,@data
	Mov ds,ax
	
	Mov ax,5
	Mov bx,10
	
	compare:
	cmp ax,bx
	JAE exit_loop
	
	iterate:
	inc ax
	jmp compare
	
	exit_loop:
	
	.exit

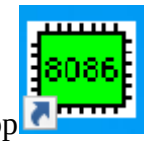
Program 3:
To iterate a loop while AX < BX using conditional jump for signed numbers.

1a: Program with straight conditional jumps.	1b: Program with opposite conditional jump to reduce jumps.

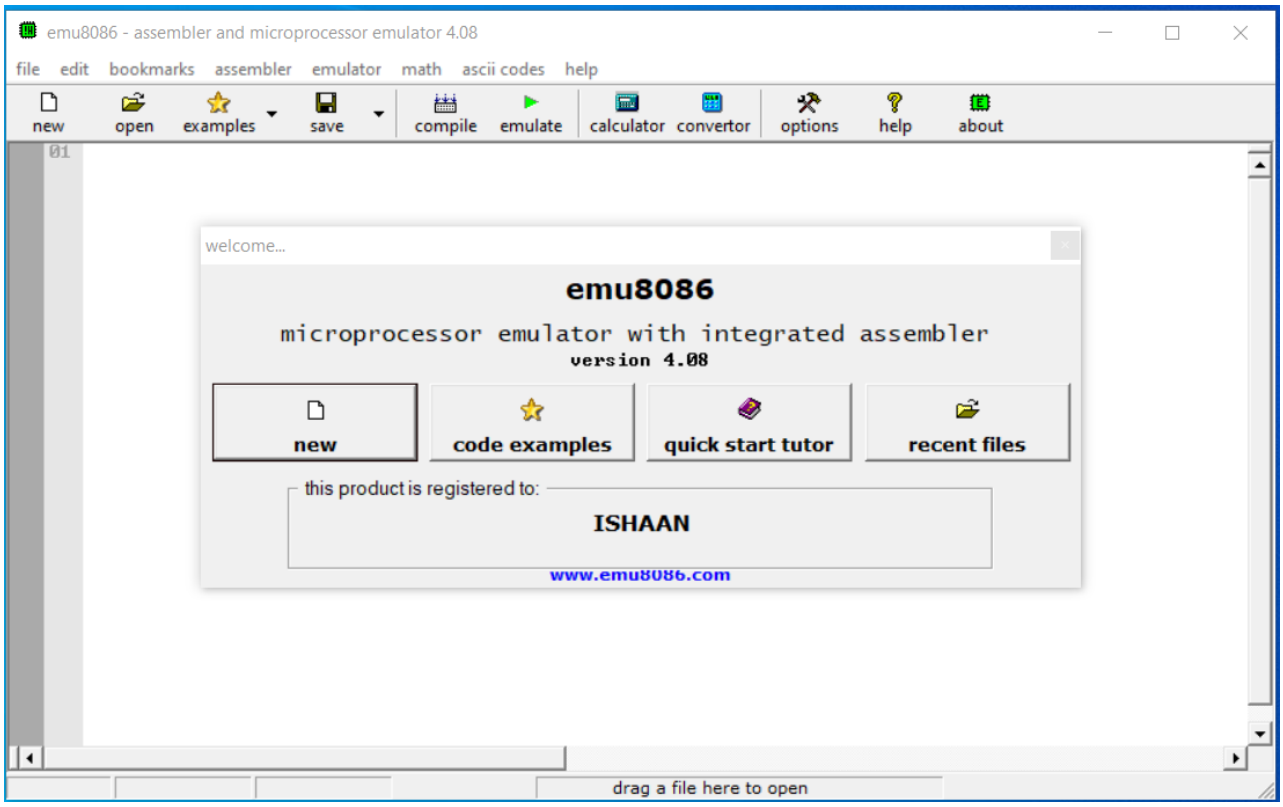
.model small
 	
.data
 	
.code
 	
Mov ax,@data
Mov ds,ax
 	
Mov ax,-5
Mov bx,0
 	
compare:
cmp ax,bx
JL iterate
jmp exit_loop
 	
iterate:
inc ax
jmp compare
 	
exit_loop:
 	
.exit
	.model small
	
	.data
	
	.code
	
	Mov ax,@data
	Mov ds,ax
	
	Mov ax,-5
	Mov bx,0
	
	compare:
	cmp ax,bx
	JGE exit_loop
	
	iterate:
	inc ax
	jmp compare
	
	exit_loop:
	
	.exit

Emu8086 Tutorial Step by Step

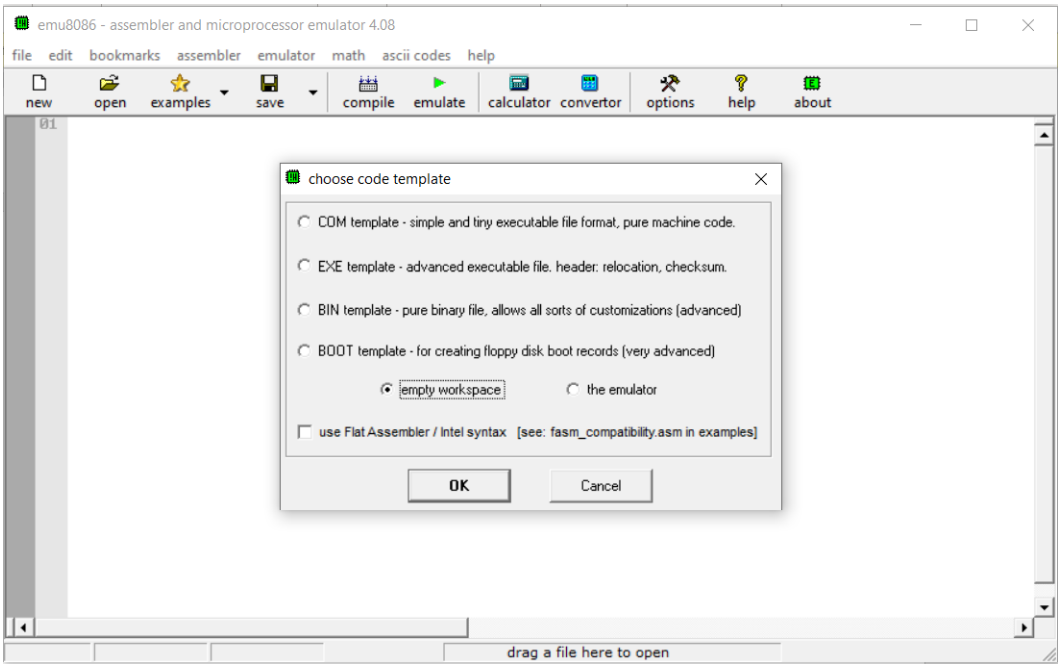
Step-1:

Double click on the icon on the desktop 

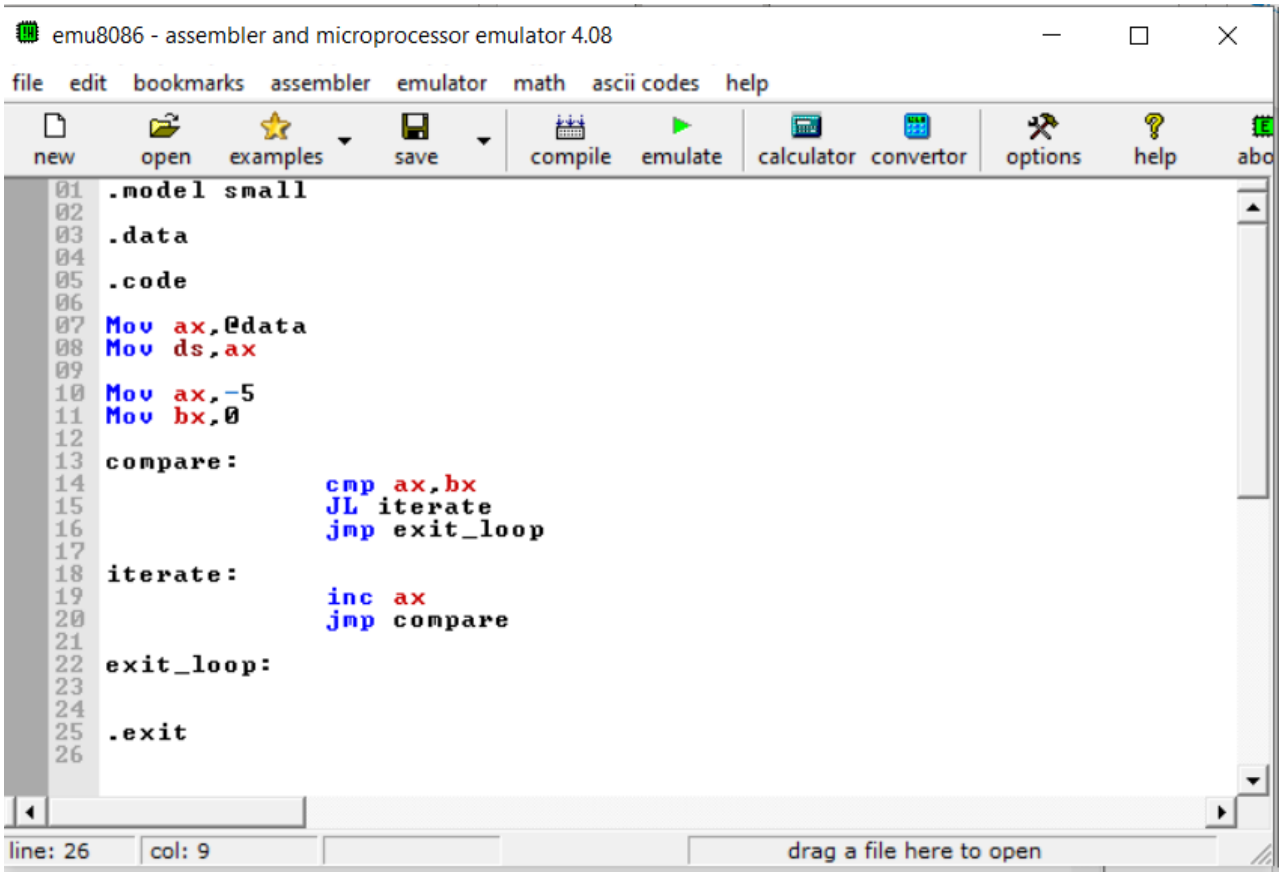
Step-2:
The following window will appear. Click on new.



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

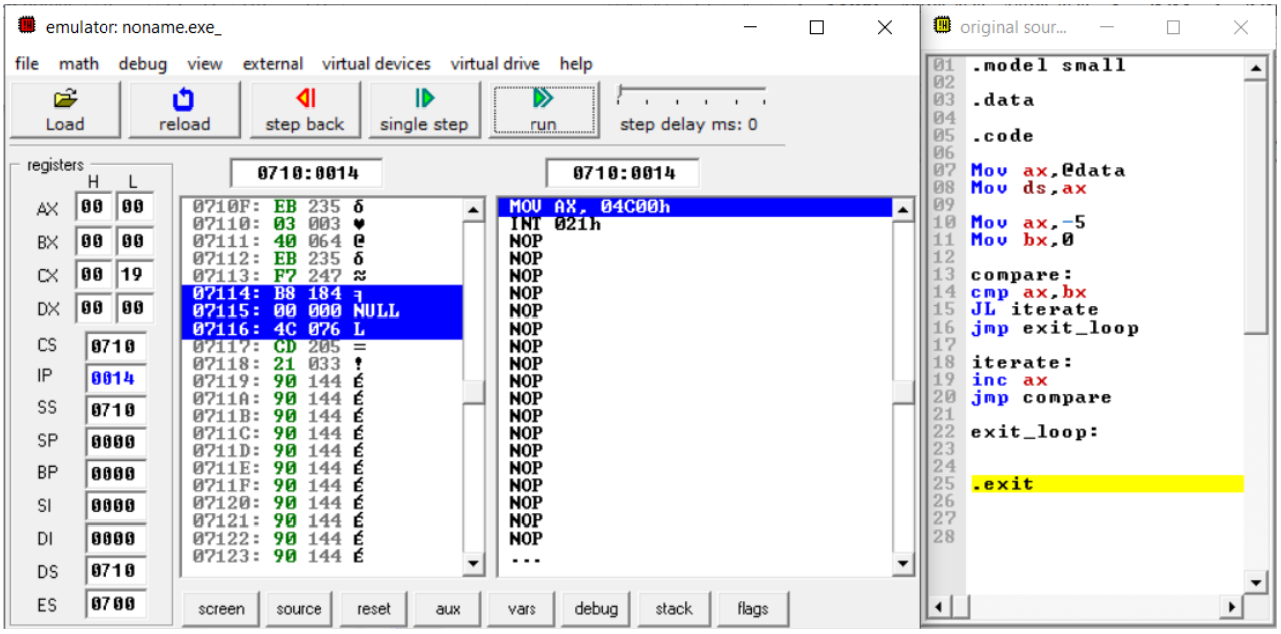


Step-4:
Type the code given in program-3a above and click on emulate.



Step-5:

Keep clicking on "Single Step" to execute program instructions one by one and observe the register values side by side and the number of times the loop is iterated. Stop clicking "Single Step" when the ".exit" is highlighted to observe the final value of the AX register.



Practice Exercise

Task-1

Write a program that declares and initializes an array of 20 elements and then calculates the number of occurrences of a specific number in the array.

Task-2

Write a program that declares and initializes a word-type array of 20 elements and sorts it using any sorting algorithm of your choice.