Introduction to 8086 Programming

Learning any imperative programming language involves mastering a number of common concepts:

Variables:	declaration/definition
Assignment:	assigning values to variables
Input/Output:	Displaying messages
	Displaying variable values
Control flow:	if-then
	Loops
Subprograms:	Definition and Usage

Programming in assembly language involves mastering the same concepts and a few other issues.

Variables

For the moment we will skip details of variable declaration and simply use the 8086 registers as the variables in our programs. Registers have predefined names and do not need to be declared.

We have seen that the 8086 has 14 registers. Initially, we will use four of them – the so called the general purpose registers:

```
    ax, bx, cx, dx
```

These four 16-bit registers can also be treated as eight 8-bit registers: **`ah, al, bh, bl, ch, cl, dh, dl`**

Assignment

In Java, assignment takes the form:

```
x = 42 ;
y = 24;
z = x + y;
```

In assembly language we carry out the same operaion but we use an instruction to denote the assignment operator ("=" in Java).

```
mov    x, 42
mov    y, 24
add    z, x
add    z, y
```

The **mov** instruction carries out assignment in 8086 assembly language.

It which allows us place a number in a register or in a memory location (a variable) i.e. it assigns a value to a register or variable.

Example: **Store the ASCII code for the letter A in register bx.**

A has ASCII code 65D (01000001B, 41H)

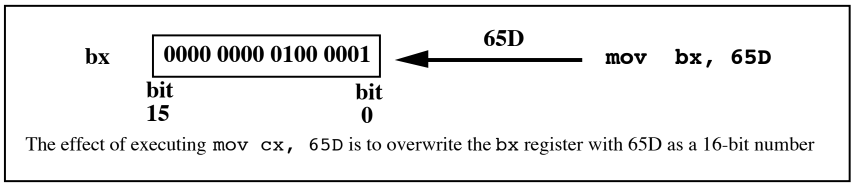
The following **mov** instruction carries out the task:

mov bx, 65d

We could also write it as:

```
      mov bx,  41h
or    mov bx,  01000001b
or    mov bx,  'A'
```

All of the above are equivalent. They each carry out exactly the same task, namely the binary number representing the ASCII code of A is copied into the bx register.


bx
0000 0000 0100 0001
65D
mov bx, 65D
bit 15
bit 0
The effect of executing mov cx, 65D is to overwrite the bx register with 65D as a 16-bit number

The value is copied into the right-hand side (low-order byte) of the register. The left-hand side will contain all 0's.

Thus we could also have written it as:

```
      mov bl,  65d
      mov bl,  'A'
```

Since register bl represents the low-order byte of register bx.

Note: The 8086 Assembler converts a **character constant** i.e. a character in single quotes (e.g. 'A') to its ASCII code automatically. This is a very useful feature and it means that you can specify many characters without having to look up their ASCII code. You simply enclose the character in single quotes. You will have to use the

ASCII code for control characters such as carriage return and line feed.

Notation

mov is one of the many 8086 instructions that we will be using. Most assembly language books use uppercase letters to refer to an instruction e.g. MOV.

However, the assembler will also recognise the instruction if it is written in lowercase or in mixed case e.g. Mov. (In fact, the assembler converts all instructions to uppercase).

It is **my personal** preference to use lower case when writing programs. You may write your programs using which ever notation you find convenient, but you should be consistent and stick to one particular style.

More about mov

The **mov** instruction also allows you to copy the contents of one register into another register.

Example:

```
mov     bx, 2
mov     cx, bx
```

The first instruction loads the value 2 into bx where it is stored as a binary number. [a number such as 2 is called an **integer** constant]

The Mov instruction takes two **operands,** representing the ***destination*** where data is to be placed and the ***source*** of that data.

General Form of Mov Instruction

mov ***destination, source***

where *destination* must be either a register or memory location and *source* may be a constant, another register or a memory location.

In 8086 assembly language, the source and destination **cannot both** be memory locations in the same instruction.

Note: The comma is essential. It is used to separate the two operands.

A missing comma is a common syntax error.

We will look at manipulating data in memory at a later stage.

More Examples

The following instructions result in registers ax, bx, and cx all having the value 4:

mov bx, 4 ; copy number 4 into register bx
mov ax, bx ; copy contents of bx into register ax
mov cx, ax ; copy contents of ax into register cx

Comments

Anything that follows semi-colon (**;**) is ignored by the assembler. It is called a **comment**. Comments are used to make your programs readable. You use them to explain what you are doing in English.

It is recommended that you use comments frequently in your programs, not only so that others can understand them, but also for yourself, when you look back at programs you have previously written.

Every programming language has a facility for defining comments.

More 8086 Instructions

add, inc, dec and sub instructions

The 8086 provides a variety of arithmetic instructions. For the moment, we only consider a few of them. To carry out arithmetic such as addition or substraction, you use the appropriate instruction.

In assembly language you can only carry out a single arithmetic operation at a time. This means that if you wish to evaluate an expression such as :

$$z = x + y + w - v$$

You will have to use 3 assembly language instructions – one for each arithmetic operation.

These instruction combine assignment with the arithmetic operation.

Example:

```
mov     ax, 5     ;     load 5 into ax

add     ax, 3     ;     add 3 to the contents of ax,
                  ;     ax now contains 8

inc     ax        ;     add 1 to ax
                  ;     ax now contains 9

dec     ax        ;     subtract 1 from ax
                  ;     ax now contains 8

sub     ax, 6     ;     subtract 4 from ax
                  ;     ax now contains 2
```

The **add** instruction adds the source operand to the destination operand, leaving the result in the destination operand.

The destination operand is always the first operand in 8086 assembly language.

(In M68000 assembly language, it is the other way round i.e. the source operand is always the first operand e.g. `move #10, x`)

The **inc** instruction takes one operand and adds 1 to it. It is provided because of the frequency of adding 1 to an operand in programming.

The **dec** instruction like **inc** takes one operand and subtracts 1 from it. This is also a frequent operation in programming.

The **sub** instruction subtracts the source operand from the destination operand leaving the result in the destination operand.

Some microprocessors do not provide instructions for multiplication or division (e.g. the M6800). With such microprocessors, multiplication and division have to be programmed using repeated additions and subtractions and shift operations (which will be discussed later).

The 8086 provides **mul** and **div** (and others) for multiplication and division.

Ambiguity

Suppose you wish to load the hexadecimal value A (decimal 10) written as **ah** in the register bl.

You might be tempted to write:

```
mov     bl, ah
```

But we have already seen that there is a register called **ah** (the high-order byte of ax) and so the above does not do what we intend. Instead it copies the contents of register ah into bl. In order to avoid ambiguity when writing hexadecimal numbers that begin with a letter we prefix them with 0. Thus we write:

```
mov     bl, 0ah  ; copy hex number ah into bx
```

It is common practice to write decimal numbers with the letter D appended so as to distinguish them from hexadecimal.

The 8086 assembler take all numbers to be decimal numbers unless there is a **B** (binary), **H** (hex) or **O** (octal) appended to them.

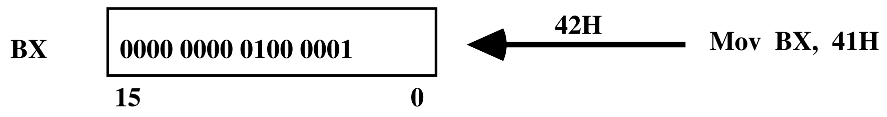
Note:

When data is moved to a register, all 16 bits (or 8 bits) are given a value. The assembler will automatically fill in 0's on the left-hand side.

Example:

mov bx, 42h ; copy 42 hex into bx

42H is 100 0001 in binary. This padded out with nine 0-bits on the left-hand side to fill all 16-bits of the register.



The effect of executing MOV BX, 41H is to overwrite the BX register with 41H in binary.

Exercises:

1) Write instructions to:
    Load character ? into register bx
    Load space character into register cx
    Load 26 (decimal) into register cx
    Copy contents of ax to bx and dx

2) What errors are present in the following :

```
mov     ax   3d
mov     23,  ax
mov     cx, ch
move    ax, 1h
add     2, cx
add     3, 6
inc     ax, 2
```

3) Write instructions to evaluate the arithmetic expression 5 + (6-2) leaving the result in ax using (a) 1 register, (b) 2 registers, (c) 3 registers

4) Write instructions to evaluate the expressions:

$a = b + c - d$

$z = x + y + w - v + u$

5) Rewrite the expression in 4) above but using the registers ah, al, bh, bl and so on to represent the variables: a, b, c, z, x, y, w, u, and v.