Introduction to IBM PC Assembly Language

Assembly Language Syntax

- **Assembler**
  - Assembly language programs are translated into machine language instructions by assembler
  - Assembly language code is not case sensitive
- **Statements**
  - Program consists of statements one per line
  - Two types: **instruction** and **assembler directive**
  - Statements have four fields
    - name operation operand(s) comment
    - Instruction- START: MOV CX,5 ;initialize counter
    - Assembler directive- MAIN PROC

Name Field

- Used for instruction labels, procedure names and variable names
- Assembler translates name into memory address
- Names can be **1 to 31 characters** long and may consist of letters, digits or special characters.
- If period is used, it must be first character.
- Embedded blanks are not allowed.
- May not begin with a digit.
- Not case sensitive

Operation Field

- Contains symbolic Operation code
- Assembler translates op code into machine language op code
- Examples: ADD, MOV, SUB
- In an **assembler directive**, the operation field represents **pseudo-op code**
- Pseudo-op code is **not** translated into machine code, it only tells assembler to do something.
- Example: **PROC** pseudo-op is used to create a procedure

Operand Field

- Specifies the data that are to be acted on by the operation
- An instruction may have **zero, one or more operands**.
- In two-operand instruction, **first operand is destination, second operand is source.**
- For an assembler directive, operand field represents more information about the directive
- Examples

```
NOP              ;no operand, does nothing
INC AX           ;one operand, adds 1 to the contents of AX
ADD WORD1, 2; two operands, adds value 2 to the contents
                    of memory location WORD1
```

Comment Field

- Say something about what the statement does
- Marked by semi colon in the beginning
- Assembler ignores anything after semicolon
- Optional
- Good practice

Program Data

- Processor operates only on binary data.
- In assembly language, one can express data in:
  - Binary
  - Decimal
  - Hexadecimal
  - Characters
- Numbers
  - **For Hexadecimal, the number must begin with a decimal digit.** E.g.: write 0ABCh, not only ABCH.
  - Cannot contain any non-digit character. E.g.: 1,234 not allowed
- Characters enclosed in single or double quotes.
  - ASCII codes can be used
  - No difference in “A” and 41h

Variables

- Each variable has a data type and is assigned a memory address by the program.
- Possible Values:
  - 8 Bit Number Range: Signed (-128 to 127), Unsigned (0-255)
  - 16 Bit Number Range: Signed (-32,678 to 32767), Unsigned (0-65,535)
  - **? To leave variable uninitialized**
- Mainly three types
  - Byte variables
  - Word variables
  - Arrays

Data Defining Pseudo-Ops

Pseudo-ops	Description	Bytes	Examples
DB	Define Byte	1	var1 DB 'A' Var2 DB ? array1 DB 10, 20,30,40
DW	Define Word	2	var2 DW 'AB' array2 DW 1000, 2000
DD	Define Double Word	4	Var3 DD -214743648
DQ	Define Quad Word	8	Var DQ ?
DT	Define Ten Bytes	10	Var DT ?

Named Constants

- Use symbolic name for a constant quantity
- Syntax:
  - name EQU constant
- Example:
  - **LF** EQU **0Ah**
- **No memory allocated**

A Few Basic Instructions

- MOV
- XCHG
- ADD
- SUB
- INC
- DEC
- NEG

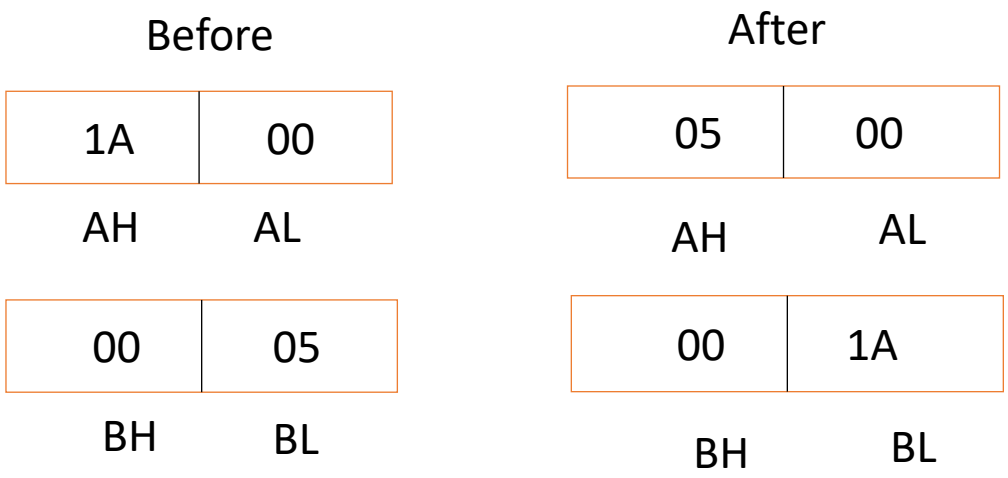
MOV

- Transfer data
  - Between registers
  - Between register and a memory location
  - Move a number directly to a register or a memory location
- Syntax
  - MOV destination, source
- Example
  - MOV AX, WORD1

	Before	After
AX	0006	0008
WORD1	0008	0008

XCHG

- Exchange the contents of
  - Two registers
  - Register and a memory location
- Syntax
  - XCHG destination, source
- Example
  - XCHG AH, BL



ADD

- To add contents of
  - Two registers
  - A register and a memory location
  - A number to a register
  - A number to a memory location
- Syntax
  - ADD destination, source
- Example
  - ADD WORD1, AX

	Before	After
AX	01BC	01BC
WORD1	0523	06DF

SUB

- To subtract the contents of:
  - Two registers
  - A register and a memory location
  - A number from a register
  - A number from a memory location
- Syntax
  - SUB destination, source
- Example
  - SUB AX, DX

	Before	After
AX	0000	FFFF
DX	0001	0001

Memory to Memory Instruction

- ADD BYTE1, BYTE2 is Illegal instruction
- Solution?

```
MOV AL, BYTE2
ADD BYTE1, AL
```

INC

- INC (increment) instruction is used to add 1 to the contents of
  - a register
  - memory location.
- Syntax:
  - INC destination
- Example:
  - INC WORD1

	Before	After
WORD1	0002	0003

DEC

- DEC (decrement) instruction is used to subtract 1 from the contents of
  - a register
  - memory location.
- Syntax:
  - DEC destination
- Example:
  - DEC BYTE1

NEG

- Used to negate the contents of destination.
- Replace the contents by its 2's complement.
- Syntax
  - NEG destination
- Example
  - NEG BX

	Before	After
BX	0002	FFFE

Translation of High-level Language to Assembly Language

- Consider instructions: MOV, ADD, SUB, INC, DEC, NEG
- A and B are two word variables
- Translate statements into assembly language:

Statement	Translation
B = A	MOV AX, A MOV B, AX

A = 5 - A	MOV AX, 5
	SUB AX, A
	MOV A, AX
	OR
	NEG A
	ADD A, 5

A = B – 2 x A	MOV AX, B
	SUB AX, A
	SUB AX, A
	MOV A, AX

Program Structure

- Machine Programs consists of
  - Stack
  - Code
  - Data
- Each part occupies a memory segment.
- Same organization is reflected in an assembly language program as Program Segments.
- Each program segment is translated into a memory segment by the assembler.

Memory Models

- Determines the size of data and code a program can have.
- Syntax:
  - .MODEL memory_model

Model	Description
SMALL	code in one segment, data in one segment
MEDIUM	code in more than one segment, data in one segment
COMPACT	code in one segment, data in more than one segment
LARGE	Both code and data in more than one segments. No array larger than 64KB
HUGE	Both code and data in more than one segments. Array may be larger than 64KB

Stack Segment

- A block of memory to store stack
- Syntax
  - .STACK size
  - Where size is optional and specifies the stack area size in bytes
  - If size is omitted, 1 KB set aside for stack area
- For example:
  - .STACK 100h

Data Segment

- All variable definitions
- Constant definitions are often made here
- Use .DATA directive
- For Example:

```
.DATA
  WORD1 DW 2
  BYTE1 DB 10h
```

Code Segment

- Contains a program's instructions
- Syntax

  .CODE name
- Where name is ***optional***
- **Do not write name when using SMALL as a memory model**
- Inside a code segment instructions are organized as procedures

The Format of a Code

```
.MODEL SMALL
.STACK 100h
.DATA
    ;data definition go here
.CODE
MAIN PROC
    ;instructions go here
MAIN ENDP
    ;other procedures go here
END MAIN
```

Input and Output Instructions

Function Number	Routine	Function	Code
1	Single key input	**Input**: AH=1 **Output**: AL=ASCII Code if character is pressed =0 if non-character key is pressed	MOV AH,1 ;*input key function* INT 21H ;*ASCII code in AL*
2	Single character output	**Input**: AH=2 DL=ASCII code of the display character or control character **Output:** AL=ASCII code of the display character or control character	MOV AH,2 ;*display character function* MOV DL,'? ' ;*character is ?* INT 21H ;*display character*
9	Character string output	**Input:** DX=offset address of string. The string must end with a $ character	MSG DB 'HELLO$'

LEA Instruction

- It means Load Effective Address
- To get the **offset address*** of the **character string** in DX we use LEA instruction
- Syntax

  LEA destination, source
- Destination is a general register and source is a memory location
- Example

  LEA DX, MSG

**the address of the string within the segment*