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Date: 27-08-2021
Ex. No. 6

Exercise 6 – Sorting
6A – Sorting in Ascending Order

Aim:

To perform bubble sort in ascending order.

Procedure for executing MASM:

1. Mount the local folder in the DOS-BOX using a temp disk name: `mount <disk-name> <folder-location>`
2. Change directory into the mounted disk: `<disk-name>: `
3. Assemble the instructions: `masm <file-name>.asm`
4. Link the object file(s) to produce an executable file(.exe): `link <file-name>.obj; ` Note that removal of semi-colon will make linking process interactive.
5. Debug the executable file to read the memory map and execute the program: `debug <file-name>.exe`. After entering debug mode,
    a. `d <segment:offset> ` - dump(read) memory map from the given location
    b. `e <segment:offset> ` - edit memory values from the given location. Use ‘White space’ to continue editing and ‘new line’ to exit editing.
    c. `u ` - unassemble code (with or without <segment:offset>)
    d. `g ` - execute the program
    e. `? ` - display command list
    f. `q` - quit the debugger

Algorithm:

```
1. Initialise data and extra segment using their respective registers.
2. Load CX with count, length of array to sort.
3. Iterate until CX != 0:
      a. Load DX with CX
      b. Load SI, DI with two consecutive elements using base address
         arr
      c. Compare SI and DI using AL as intermediate.
      d. If CF = 1, meaning value at SI < value at DI, since
         consecutive elements already in-place, jump swapping if carry
         is set.
      e. Else if meaning value at SI > value at DI, swap using XCHG.
      f. Increment SI, DI and Decrement DX to run the inner loop
4. Terminate the program.
```

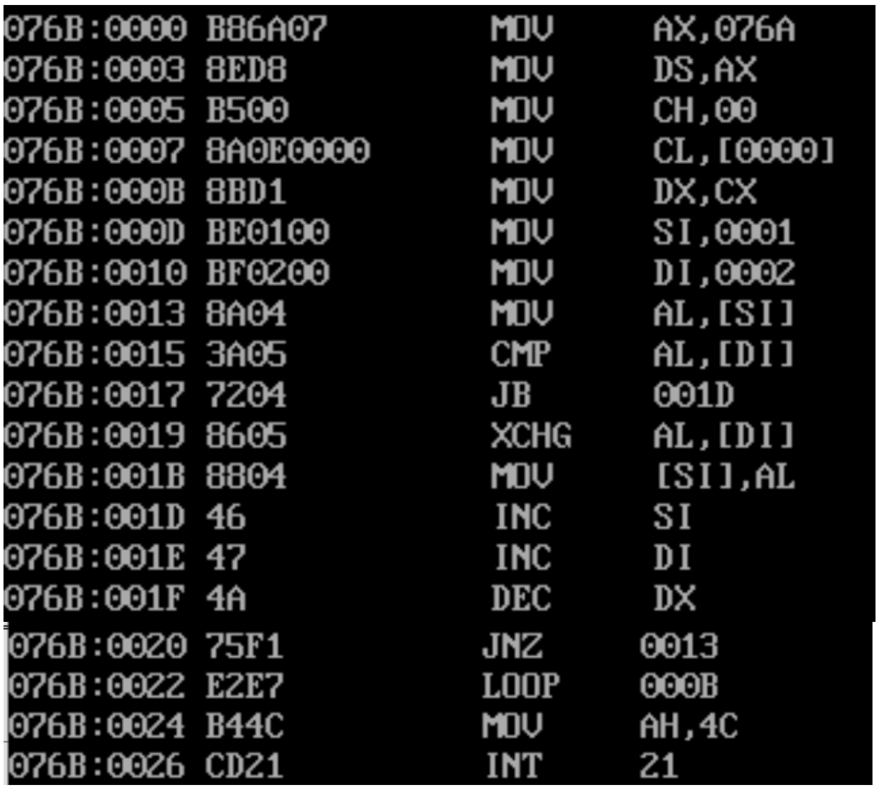
Program:

Program	Comment
; 6a: Sorting in ascending order	Comment after ‘;’
assume cs: code, ds: data	Map CS to code segment, DS to data segment

data segment
    count db 03H
    arr db 75H, 33H, 01H, 25H
data ends
	Initialise data segment and extra segment
	db = define a byte
	Initialise count
	Initialise arr

code segment start: mov ax, data mov ds, ax	Initialise code segment Move the starting address of data segment in ax, then move ax to ds.
mov ch, 00H mov cl, count	Load CX with count, outer loop itr: n - 1
outer: mov dx, cx mov si, offset arr mov di, offset arr + 1	Load DX with CX of each iteration, inner loop itr: n - i – 1 Load SI, DI with two consecutive elements
inner: mov al, [si] cmp al, [di]	Load AL with value at SI Compare AL against value at DI
jc skip	SI < DI => CF = 1, already in place, so can skip swapping
xchg al, [di] mov [si], al	Exchange value at SI with DI using AL as intermediate.
skip: inc si inc di	Increment SI and DI
dec dx jnz inner	Decrement DX to run the inner loop, jump if ZF not set.
loop outer	Loop if CX != 0
mov ah, 4cH int 21H	Set ah = 4cH Call interrupt routine 21H for DOS, which terminates if ah = 4cH
code ends end start	

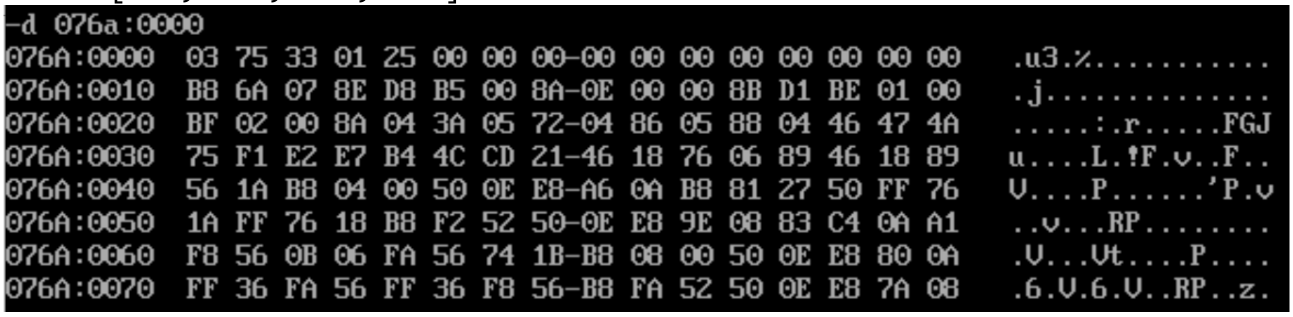
Unassembled code:


```
076B:0000 B86A07        MOV     AX,076A
076B:0003 8ED8          MOV     DS,AX
076B:0005 B500          MOV     CH,00
076B:0007 8A0E0000      MOV     CL,[0000]
076B:000B 8BD1          MOV     DX,CX
076B:000D BE0100        MOV     SI,0001
076B:0010 BF0200        MOV     DI,0002
076B:0013 8A04          MOV     AL,[SI]
076B:0015 3A05          CMP     AL,[DI]
076B:0017 7204          JB      001D
076B:0019 8605          XCHG    AL,[DI]
076B:001B 8804          MOV     [SI],AL
076B:001D 46            INC     SI
076B:001E 47            INC     DI
076B:001F 4A            DEC     DX
076B:0020 75F1          JNZ     0013
076B:0022 E2E7          LOOP    000B
076B:0024 B44C          MOV     AH,4C
076B:0026 CD21          INT     21
```

Snapshot of sample input and output:

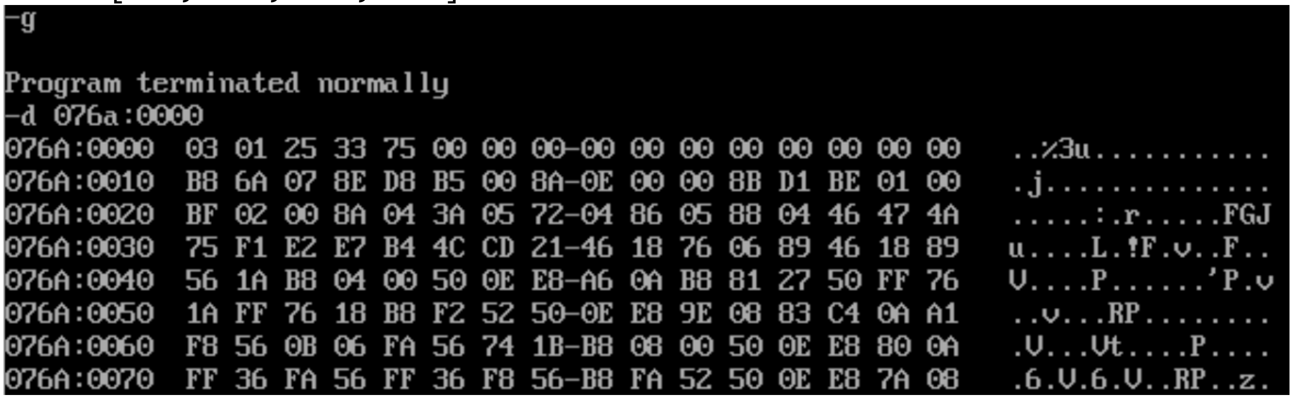
Before execution:

count = 03H
arr = [75H, 33H, 01H, 25H]


```
-d 076a:0000
076A:0000  03 75 33 01 25 00 00 00-00 00 00 00 00 00 00 00   .u3.%...........
076A:0010  B8 6A 07 8E D8 B5 00 8A-0E 00 00 8B D1 BE 01 00   .j..............
076A:0020  BF 02 00 8A 04 3A 05 72-04 86 05 88 04 46 47 4A   .....:.r.....FGJ
076A:0030  75 F1 E2 E7 B4 4C CD 21-46 18 76 06 89 46 18 89   u....L.!F.v..F..
076A:0040  56 1A B8 04 00 50 0E E8-A6 0A B8 81 27 50 FF 76   V....P......'P.v
076A:0050  1A FF 76 18 B8 F2 52 50-0E E8 9E 08 83 C4 0A A1   ..v...RP........
076A:0060  F8 56 0B 06 FA 56 74 1B-B8 08 00 50 0E E8 80 0A   .V...Vt....P....
076A:0070  FF 36 FA 56 FF 36 F8 56-B8 FA 52 50 0E E8 7A 08   .6.V.6.V..RP..z.
```

After execution:

```
count = 03H
arr = [01H, 25H, 33H, 75H]
```



```
-g

Program terminated normally
-d 076a:0000
076A:0000  03 01 25 33 75 00 00 00-00 00 00 00 00 00 00 00   ..%3u...........
076A:0010  B8 6A 07 8E D8 B5 00 8A-0E 00 00 8B D1 BE 01 00   .j..............
076A:0020  BF 02 00 8A 04 3A 05 72-04 86 05 88 04 46 47 4A   .....:.r.....FGJ
076A:0030  75 F1 E2 E7 B4 4C CD 21-46 18 76 06 89 46 18 89   u....L.!F.v..F..
076A:0040  56 1A B8 04 00 50 0E E8-A6 0A B8 81 27 50 FF 76   V....P......'P.v
076A:0050  1A FF 76 18 B8 F2 52 50-0E E8 9E 08 83 C4 0A A1   ..v...RP........
076A:0060  F8 56 0B 06 FA 56 74 1B-B8 08 00 50 0E E8 80 0A   .V...Vt....P....
076A:0070  FF 36 FA 56 FF 36 F8 56-B8 FA 52 50 0E E8 7A 08   .6.V.6.V..RP..z.
```

Result:

Program to sort an array in ascending order using bubble sort is assembled, executed and verified.

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6B – Sorting in Descending Order

Aim:

To perform bubble sort in descending order.

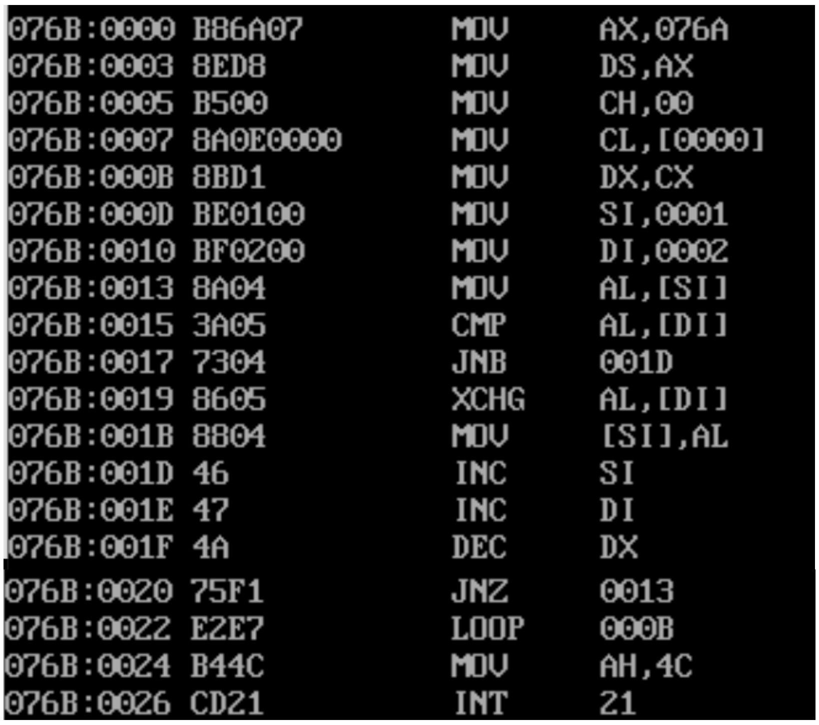
Algorithm:

1. Initialise data and extra segment using their respective registers.
2. Load CX with count, length of array to sort.
3. Iterate until CX != 0:
    a. Load DX with CX
    b. Load SI, DI with two consecutive elements using base address arr
    c. Compare SI and DI using AL as intermediate.
    d. If CF = 0, meaning value at SI > value at DI, since consecutive elements already in-place, jump swapping if carry is not set.
    e. Else if meaning value at SI < value at DI, swap using XCHG.
    f. Increment SI, DI and Decrement DX to run the inner loop
4. Terminate the program.

Program:

Program	Comment
`; 6b: Sorting in descending order`	Comment after ‘;’
`assume cs: code, ds: data`	Map CS to code segment, DS to data segment
`data segment`	Initialise data segment and extra segment
`    count db 03H`	db = define a byte Initialise count
`    arr db 75H, 33H, 01H, 25H`	Initialise arr
`data ends`	
`code segment`	Initialise code segment
`start:  mov ax, data`	Move the starting address of data segment in ax, then move ax to ds.
`        mov ds, ax`	
`        mov ch, 00H`	Load CX with count, outer loop itr: n - 1
`        mov cl, count`	
`outer:  mov dx, cx`	Load DX with CX of each iteration, inner loop itr: n - i – 1
`        mov si, offset arr`	Load SI, DI with two consecutive elements
`        mov di, offset arr + 1`	
`inner:  mov al, [si]`	Load AL with value at SI
`        cmp al, [di]`	Compare AL against value at DI
`        jnc skip`	SI > DI => CF = 0, already in place, so can skip swapping
`        xchg al, [di]`	Exchange value at SI with DI using AL as intermediate.
`        mov [si], al`	
`skip:   inc si`	Increment SI and DI
`        inc di`	
`        dec dx`	Decrement DX to run the inner loop, jump if ZF not set.
`        jnz inner`	
`        loop outer`	Loop if CX != 0
`        mov ah, 4cH`	Set ah = 4cH
`        int 21H`	Call interrupt routine 21H for DOS, which terminates if ah = 4cH
`code ends`	
`end start`	

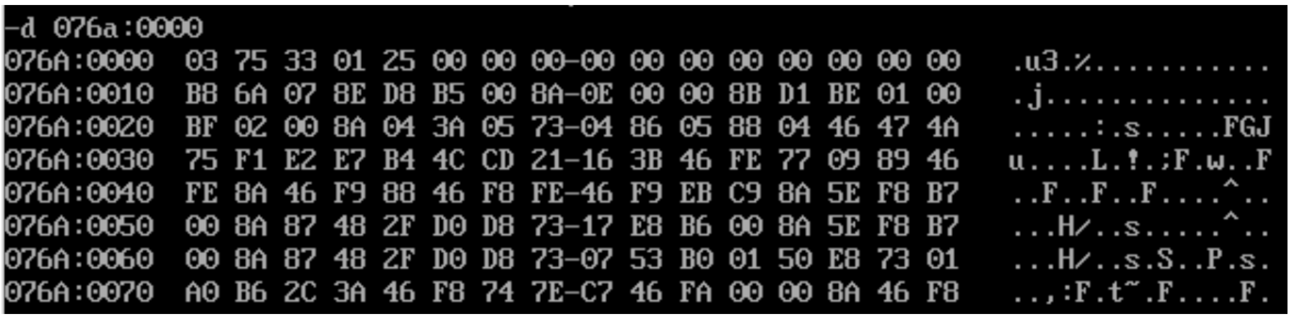
Unassembled code:


```
076B:0000 B86A07        MOV     AX,076A
076B:0003 8ED8          MOV     DS,AX
076B:0005 B500          MOV     CH,00
076B:0007 8A0E0000      MOV     CL,[0000]
076B:000B 8BD1          MOV     DX,CX
076B:000D BE0100        MOV     SI,0001
076B:0010 BF0200        MOV     DI,0002
076B:0013 8A04          MOV     AL,[SI]
076B:0015 3A05          CMP     AL,[DI]
076B:0017 7304          JNB     001D
076B:0019 8605          XCHG    AL,[DI]
076B:001B 8804          MOV     [SI],AL
076B:001D 46            INC     SI
076B:001E 47            INC     DI
076B:001F 4A            DEC     DX
076B:0020 75F1          JNZ     0013
076B:0022 E2E7          LOOP    000B
076B:0024 B44C          MOV     AH,4C
076B:0026 CD21          INT     21
```

Snapshot of sample input and output:

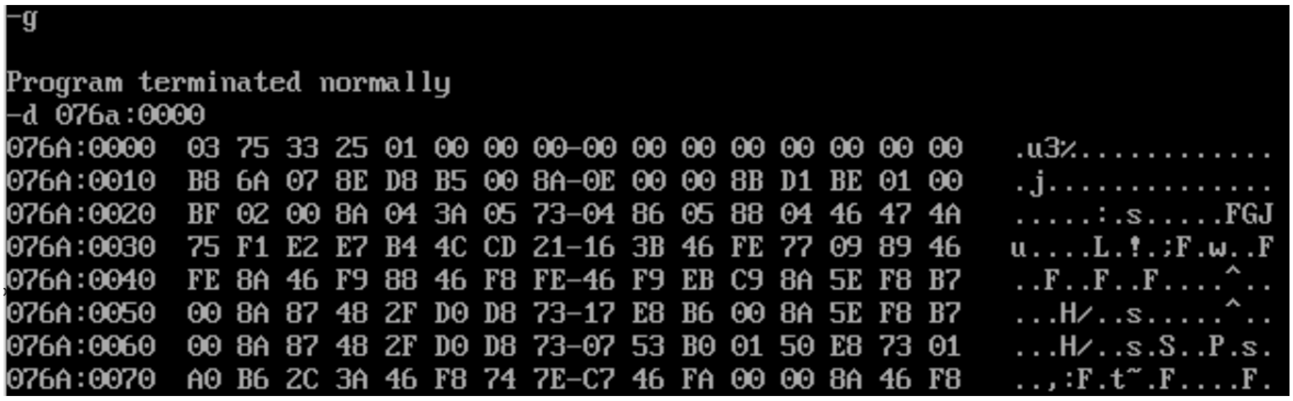
Before execution:

count = 03H
arr = [75H, 33H, 01H, 25H]


```
-d 076a:0000
076A:0000  03 75 33 01 25 00 00 00-00 00 00 00 00 00 00 00   .u3.%...........
076A:0010  B8 6A 07 8E D8 B5 00 8A-0E 00 00 8B D1 BE 01 00   .j..............
076A:0020  BF 02 00 8A 04 3A 05 73-04 86 05 88 04 46 47 4A   .....:.s.....FGJ
076A:0030  75 F1 E2 E7 B4 4C CD 21-16 3B 46 FE 77 09 89 46   u....L.!.;F.w..F
076A:0040  FE 8A 46 F9 88 46 F8 FE-46 F9 EB C9 8A 5E F8 B7   ..F..F..F....^..
076A:0050  00 8A 87 48 2F D0 D8 73-17 E8 B6 00 8A 5E F8 B7   ...H/..s.....^..
076A:0060  00 8A 87 48 2F D0 D8 73-07 53 B0 01 50 E8 73 01   ...H/..s.S..P.s.
076A:0070  A0 B6 2C 3A 46 F8 74 7E-C7 46 FA 00 00 8A 46 F8   ..,:F.t~.F....F.
```

```
After execution:

count = 03H
arr = [75H, 33H, 25H, 01H]
```



```
-g

Program terminated normally
-d 076a:0000
076A:0000  03 75 33 25 01 00 00 00-00 00 00 00 00 00 00 00   .u3%............
076A:0010  B8 6A 07 8E D8 B5 00 8A-0E 00 00 8B D1 BE 01 00   .j..............
076A:0020  BF 02 00 8A 04 3A 05 73-04 86 05 88 04 46 47 4A   .....:.s.....FGJ
076A:0030  75 F1 E2 E7 B4 4C CD 21-16 3B 46 FE 77 09 89 46   u....L.!.;F.w..F
076A:0040  FE 8A 46 F9 88 46 F8 FE-46 F9 EB C9 8A 5E F8 B7   ..F..F..F....^..
076A:0050  00 8A 87 48 2F D0 D8 73-17 E8 B6 00 8A 5E F8 B7   ...H/..s.....^..
076A:0060  00 8A 87 48 2F D0 D8 73-07 53 B0 01 50 E8 73 01   ...H/..s.S..P.s.
076A:0070  A0 B6 2C 3A 46 F8 74 7E-C7 46 FA 00 00 8A 46 F8   ..,:F.t~.F....F.
```

Result:

Program to sort an array in descending order using bubble sort is assembled, executed and verified.