

Exercise 7 – BCD Addition and Subtraction

7A – BCD Addition

Aim:

To add two BCD numbers.

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. Move the augend into AL.
3. Add the contents of AL with addend and store it in place.
4. On decimal adjust accumulator(DAA), we get the BCD adjusted sum at AL and carry at CF.
5. Move the sum at AL to memory, sum.
6. If CF is set, move 01H to carry to indicate generation of carry.
7. Terminate the program.

Program:

Program	Comment
<pre> ; 7a - BCD Addition assume cs: code, ds: data data segment augend db 99H addend db 99H carry db 00H sum db 00H data ends code segment start: mov ax, data mov ds, ax mov al, augend add al, addend daa mov sum, al jnc term mov carry, 01H term: mov ah, 4cH int 21H code ends end start </pre>	<p>Comment after ';' </p> <p>Map CS to code segment, DS to data segment</p> <p>Initialise data segment and extra segment db = define a byte Initialise augend and addend Initialise carry and sum with 00H</p> <p>Initialise code segment Move the starting address of data segment in ax, then move ax to ds.</p> <p>Move augend to AL Add AL with addend (AL = AL + Addend) Decimal Adjust Accumulator</p> <p>Move AL to sum</p> <p>If CF not set, terminate, else, Move 01H to Carry</p> <p>Set ah = 4cH Call interrupt routine 21H for DOS, which terminates if ah = 4cH</p>

Unassembled code:

```

D:\>debug add.exe
-u
076B:0000 B86A07      MOV     AX,076A
076B:0003 8ED8         MOV     DS,AX
076B:0005 A00000      MOV     AL,[0000]
076B:0008 02060100    ADD     AL,[0001]
076B:000C 27           DAA
076B:000D A20300      MOV     [0003],AL
076B:0010 7305         JNB     0017
076B:0012 C606020001    MOV     BYTE PTR [0002],01
076B:0017 B44C         MOV     AH,4C
076B:0019 CD21         INT     21

```

Snapshot of sample input and output:

Case i: No carry

Augend = 31 Addend = 68

Carry = 00 Sum = 99

```

-d 076a:0000
076A:0000 31 68 00 00 00 00 00 00-00 00 00 00 00 00 00 00 1h.....
076A:0010 B8 6A 07 8E D8 A0 00 00-02 06 01 00 27 A2 03 00 .j.....'...
076A:0020 73 05 C6 06 02 00 01 B4-4C CD 21 F8 EB 1E 8A 5E s.....L.!....^
076A:0030 F9 B7 00 D1 E3 8B 87 AE-16 3B 46 FE 77 09 89 46 .....;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.
-g

Program terminated normally
-d 076a:0000
076A:0000 31 68 00 99 00 00 00 00-00 00 00 00 00 00 00 00 1h.....
076A:0010 B8 6A 07 8E D8 A0 00 00-02 06 01 00 27 A2 03 00 .j.....'...
076A:0020 73 05 C6 06 02 00 01 B4-4C CD 21 F8 EB 1E 8A 5E s.....L.!....^
076A:0030 F9 B7 00 D1 E3 8B 87 AE-16 3B 46 FE 77 09 89 46 .....;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.

```

Case ii: Carry generated

Augend = 99 Addend = 99

Carry = 01 Sum = 98

```

-d 076a:0000
076A:0000 99 99 00 00 00 00 00 00-00 00 00 00 00 00 00 00 .....
076A:0010 B8 6A 07 8E D8 A0 00 00-02 06 01 00 27 A2 03 00 .j.....'...
076A:0020 73 05 C6 06 02 00 01 B4-4C CD 21 F8 EB 1E 8A 5E s.....L.!....^
076A:0030 F9 B7 00 D1 E3 8B 87 AE-16 3B 46 FE 77 09 89 46 .....;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.
-g

Program terminated normally
-d 076a:0000
076A:0000 99 99 01 98 00 00 00 00-00 00 00 00 00 00 00 00 .....
076A:0010 B8 6A 07 8E D8 A0 00 00-02 06 01 00 27 A2 03 00 .j.....'...
076A:0020 73 05 C6 06 02 00 01 B4-4C CD 21 F8 EB 1E 8A 5E s.....L.!....^
076A:0030 F9 B7 00 D1 E3 8B 87 AE-16 3B 46 FE 77 09 89 46 .....;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 add 2 BCD numbers is assembled, executed and verified.

7B - BCD Subtraction

Aim:

To subtract two BCD numbers.

Algorithm:

1. Initialise data and extra segment using their respective registers.
2. Move the minuend into AL.
3. Subtract the contents of AL with subtrahend and store it in place.
4. On decimal adjust after subtraction (DAS), we get the BCD adjusted difference at AL and carry at CF.
5. Move the sum at AL to memory, diff.
6. If CF is not set, jump to term (Step 8).
7. If CF is set,
 - a. Move 01H to sign to indicate that minuend was smaller than subtrahend.
 - b. Take the 10's complement of the result: move 99H to BL, and subtract AL from BL and increment BL.
 - c. Move BL back to AL.
 - d. Decimal adjust accumulator after performing all operations.
8. Move AL to memory, diff.
9. Terminate the program.

Program:

Program	Comment
<i>; 7b - BCD subtraction</i>	Comment after ';'
assume cs: code, ds: data	Map CS to code segment, DS to data segment
data segment	Initialise data segment and extra segment
minuend db 38H	db = define a byte
subtrahend db 61H	Initialise minuend and subtrahend
sign db 00H	Initialise sign and diff with 00H
diff db 00H	
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 al, minuend	Move minuend to AL
sub al, subtrahend	Add AL with subtrahend (AL = AL - Subtrahend)
das	Decimal Adjust after Subtraction
jnc term	If CF not set, jump to term, else,
mov sign, 01H	Move 01H to Sign
mov bl, 99H	Move 99H to BL
sub bl, al	Subtract AL from BL (BL = BL - AL)
inc bl	Increment BL
mov al, bl	Move BL back to AL
daa	Decimal Adjust Accumulator
term: mov diff, al	Move AL to memory, diff
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:

```
D:\>debug sub.exe
-u
076B:0000 B86A07      MOV     AX,076A
076B:0003 8ED8              MOV     DS,AX
076B:0005 A00000           MOV     AL,[0000]
076B:0008 2A060100        SUB     AL,[0001]
076B:000C 2F              DAS
076B:000D 730E           JNB     001D
076B:000F C606020001      MOV     BYTE PTR [0002],01
076B:0014 B399           MOV     BL,99
076B:0016 2AD8          SUB     BL,AL
076B:0018 FEC3           INC     BL
076B:001A 8AC3           MOV     AL,BL
076B:001C 27             DAA
076B:001D A20300         MOV     [0003],AL
076B:0020 B44C           MOV     AH,4C
076B:0022 CD21           INT     21
```

Snapshot of sample input and output:

```
Case i: Minuend > Subtrahend
Minuend = 30H Subtrahend = 10H
Sign    = 00H Difference = 20H
```

```

-d 076a:0000
076a:0000  30 10 00 00 00 00 00 00-00 00 00 00 00 00 00 00  0.....
076a:0010  B8 6A 07 8E D8 A0 00 00-2A 06 01 00 2F 73 0E C6  .j.....*/s..
076a:0020  06 02 00 01 B3 99 2A D8-FE C3 8A C3 27 A2 03 00  .....*,.....'...
076a:0030  B4 4C CD 21 E3 8B 87 AE-16 3B 46 FE 77 09 89 46  .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.
-g
Program terminated normally
-d 076a:0000
076a:0000  30 10 00 20 00 00 00 00-00 00 00 00 00 00 00 00  0.. .....
076a:0010  B8 6A 07 8E D8 A0 00 00-2A 06 01 00 2F 73 0E C6  .j.....*/s..
076a:0020  06 02 00 01 B3 99 2A D8-FE C3 8A C3 27 A2 03 00  .....*,.....'...
076a:0030  B4 4C CD 21 E3 8B 87 AE-16 3B 46 FE 77 09 89 46  .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.

```

Case ii: Minuend < Subtrahend
 Minuend = 10H Subtrahend = 30H
 Sign = 01H Difference = 20H

```
-d 076a:0000
076A:0000  10 30 00 00 00 00 00 00 00-00 00 00 00 00 00 00  .0.....
076A:0010  B8 6A 07 8E D8 A0 00 00-2A 06 01 00 2F 73 0E C6  .j.....*/s..
076A:0020  06 02 00 01 B3 99 2A D8-FE C3 8A C3 27 A2 03 00  .....*/.....'...
076A:0030  B4 4C CD 21 E3 8B 87 AE-16 3B 46 FE 77 09 89 46  .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.
-g

Program terminated normally
-d 076a:0000
076A:0000  10 30 01 20 00 00 00 00 00-00 00 00 00 00 00 00  .0. ....
076A:0010  B8 6A 07 8E D8 A0 00 00-2A 06 01 00 2F 73 0E C6  .j.....*/s..
076A:0020  06 02 00 01 B3 99 2A D8-FE C3 8A C3 27 A2 03 00  .....*/.....'...
076A:0030  B4 4C CD 21 E3 8B 87 AE-16 3B 46 FE 77 09 89 46  .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 subtract 2 BCD numbers is assembled, executed and verified.