Illustrative Program:

Adding two hexadecimal Numbers:

Write instructions to load two hexadecimal numbers 32H and 48H in registers A and B respectively. Add the numbers and display the Sum of LED output port PORT1.

Steps:

(1) Load the numbers in the registers

(2) Add the numbers

(3) Display the sum at output port PORT1.

Assumptions:

→ Assume that R/W memory ranges from 2000H to 20FFH.

→ System has an LED output port with address 01H.

Mnemonics	Hex code	Memory contents	Memory Address
MVI A, 32H	3E	0011 1110	2000
	32	0011 0010	2001
MVI B, 48H	06	0000 0110	2002
	48	0100 1000	2003
ADD B	80	1000 0000	2004
OUT 01H	D3	1101 0011	2005
	01	0000 0001	2006
HLT	76	0111 0110	2007

Program :

Subtracting Two hexadecimal numbers and storing the result in memory.

Write instructions to subtract two bytes stored in memory locations 2051H and 2052H. Location 2051H holds 49H, 2052H hold 9FH. ~~Store the~~ an Subtract 49H from 98H and store the answer in memory location 2053H.

```
LDA 2051H
MOV B, A
LDA 2052H
SUB B
STA 2053H
HLT or RST7
```

Ex:- Load the Accumulator with data byte 82H and save the data in register B.

Sol

```
MVI   A, 82H
MOV   B, A
```

Ex:- Write instruction to read eight ON/OFF switches connected to input port with address 00H and turn on the devices connected to the output port with address 01H

S1

```
IN   00H
OUT  01H
HLT
```

Ex:- Load hexadecimal no. 37H in register B and display the no. at the output port labelled PORT1

```
MVI  B, 37H
MOV  A, B
OUT  PORT1
HLT
```

Memory Address	Memory Contents	Hex code
2000	0000 0110	06 (MVI)
2001	0011 0111	37
2002	0111 1000	78 (MOV)
2003	1101 0011	D3 (OUT)
2004	0000 0001	01
2005	0111 0110	76 (HLT)

Ex:-

A micro computer is designed to control various appliances and lights in your house. The system has an output port with address 01H. The various units are connected to bits D_7 to D_0. On a cool morning, you want to turn on the radio, the coffee pot and the space heater. Write appropriate instruction, assuming R/W memory starts with address 2000H.

Q1

Memory address	Machine code	Mnemonic	Comments
#HLO			
2000	3E	MVI A, 70H	; copy 70H into ACC.
2001	70		
2002	D3	OUT 01H	; send bit pattern to O/P port
2003	01		
2004	76	HLT	; End of prog.

Ex:-

The contents of Acc. are 93H and contents of reg. C are B7H. Add both the contents

Sol

```
        ADD  C
```

		CY	D_7	D_3	D_0
(A) :	93H		1001	0011	
(C) :	B7H		1011	0111	
Sum (A) :		[1]	0100	1010	

Flag Status : S=0 , Z=0, CY=1

Ex:-

ADD 35H directly to the sum in previous example, when CY=1.

Sol

```
        ADI  35H
```

		CY		
(A) :	4AH	1	0100	1010
(Data) :	35H		0011	0101
		[0]	0111	1111

Flag Status : S=0 Z=0 CY=0

Ex:- Assume Acc. hold FFH. Illustrate the differences in the flags set by adding 01H and by incrementing the Acc. contents.

Sol 1) ADI 01H

(A) : FFH

(Data) : 01H

CY

```
  1111 1111
  0000 0001
-----------
1 0000 0000
```

Flag status: S = 0 Z = 1, CY = 1

2) INR A

(A) : FFH

CY

```
  1111 1111
  0000 0001
-----------
  0000 0000
```

Flag status: S = 0 Z = 1 CY = NA

Note: CY will remain in the previous state only. INR does not affect the CY flag.

Ex:- Write a program to perform the following functions.

1. Load the no. 8BH in reg. D
2. Load the no. 6FH in reg C
3. Increment the contents of Reg. C by 1.
4. Add the contents of Reg C and D and display the sum at output port PORT1.

Sol

```
MVI  D, 8BH
MVI  C, 6FH
INR  C
MOV  A, C
ADD  D
OUT  PORT1
HLT
```

→ After INR C

(C) = 70H.

ADD D

```
0111 0000
1000 1011
1111 1011
```

Eg: Reg. B has 65H and Acc. has 97H. Subtract the contents of Reg B from the contents of Acc.

Sol: Minuend = (A) = 97H

Subtrahend = (B) = 65H

∴ (B) = 0110 0101

2's complement of (B) = 1001 1011

```
  1001  0111
  1001  1011
-------------
1 0011  0010
0
```

Flag status S=0, Z=0, CY=0

Note: If the answer is negative, it will be shown in the 2's complement of actual magnitude. For ex, if 65H - 97H is performed, the answer will be 2's complement of 32H with the CY (Borrow) flag set.

Ex: Write a program to do the following

1. Load the no. 30H in reg. B and 39H in reg. C.
2. Subtract 39H from 30H
3. Display the answer at PORT1

Ans

```
MVI   B, 30H
MVI   C, 39H
MOV   A, B
SUB   C
OUT   PORT1
HLT
```

Discussion:

(C) : 39H : 0011 1001

2's compl. of (C) : : 1100 0111

∴ 30-39H : 0011 0000

1100 0111

---

[0] 1111 0111

No end carry

complement carry CY=1

Flag status : S=1 Z=0 CY=1

∴ The no. F7H is the 2's complement of the magnitude (39H - 30H) = 09H.

OUT. displays F7H at PORT1.

Ex:- Data masking with logic AND.

To conserve energy and to avoid an electrical overload on a hot afternoon, implement the following procedures to control the appliances throughout the house. Assume that the control switches are located in the kitchen and they are available to any one.

Write a set of instructions to

1. turn on the air conditioner if switch 57 of the input port 00H is ON.
2. Ignore all other switches of the input port even if some one attempts to turn on other appliances.

Sol Assumption: We simulate the reading of the input port with the instruction MVI A, 8bit data

Program

Memory Address	M/c code	Instruction opcode	operand	Comments
xx 00	3E	MVI	A, Data	; Read port (Simulate IN 01H)
xx 01	9F			
xx 02	E6	ANI	80 H	; Mask all bits except D7
xx 03	80			
xx 04	D3	OUT	01H	; Turn on AC if S_7 is D7
xx 05	01			
xx 06	76	HLT		; End of Program.

OR, Ex-OR, NOT :

Ex :- Assume Reg B holds 93H and Acc holds 15H. Illustrate the result of the instruction ORA B, XRA B, CMA

Sol

i) ORA B

(B) : 93H : 1001 0011

(A) : 15H : 0001 0101

1001 0111

ORA B

Flag status : S = 1 CY = 0 Z = 0

ii) XRA B

(B) : 93H : 1001 0011

(A) : 15H : 0001 0101

1000 0110

XRA B

Flag status : S = 1 , CY = 0 , Z = 0

(iii) CMA

(A) : 15H : 0001 0101

1110 1010

CMA

Flag status : No flag will be affected. (The previous status of flags will be maintained).

Setting and Resetting Specific bits:

→ At various times we may want to set or reset a specific bit without affecting the other bits.

OR logic can be used to set the bit.

AND logic can be used to reset the bit.

Ex:- In the control appliances problem, keep the (a) radio ON continuously w/o affecting the functions of other appliances

(b). In the same problem, assume it is winter and turn off the air conditioner without affecting the other appliances

Q1

(a) IN 00H (A) : $D_7D_6D_5D_4$ $D_3D_2D_1D_0$

ORI 10H : 0001 0000

(A) : $D_7D_6D_5$ 1 $D_3D_2D_1D_0$

Flag Status : CY = 0 ; other will depend on data.

(b) IN 00H (A) : $D_7D_6D_5D_4$ $D_3D_2D_1D_0$

ANI 7FH : 0 ϕ 1 1 1 1 1 1

(A) 0 $D_6D_5D_4$ $D_3D_2D_1D_0$

Flag Status CY = 0 ; others will depend on data.

Ex:-

Load the hexadecimal number 9BH and A7H in registers D and E respectively and add the numbers. If sum is greater than FFH, display 01H at PORT0; otherwise display the sum at PORT0.

Sol

```
        MVI  D, 9BH
        MVI  E, A7H
        MOV  A, D
        ADD  E
        JNC  DISPLAY
        MVI  A, 01H
DISPLAY: OUT  00H
```

Memory Address	M/C code	Label	Mnemonic
2000	16	START	MVI D, 98H
2001	9B		
2002	1E		MVI E, A7H
2003	A7		
2004	7A		MOV A, D
2005	83		ADD E
2006	D2		JNC DISPLAY
2007	XX		
2008	XX		
2009	3E		MVI A, 01H
200A	01		
200B	D3	DISPLAY	OUT 00H
200C	00		
200D	76		HLT

Memory Address	M/c code	Label	Mnemonic
2000	16	START	MVI D, 98H
2001	9B		
2002	1E		MVI E, A7H
2003	A7		
2004	7A		MOV A, D
2005	83		ADD E
2006	D2		JNC DISPLAY
2007	XX		
2008	XX		
2009	3E		MVI A, 01H
200A	01		
200B	D3	DISPLAY	OUT 00H
200C	00		
200D	76		HLT

Ex:- Write instruction to load 16 bit number 2050H in the register pair HL using LXI and MVI opcodes and explain the difference between them

Sol (a) LXI H, 2050H

(b) MVI H, 20H
MVI L, 50H

What are differences, which is preferable.

Q: The memory location 2050H holds the data byte FFH. write instruction to transfer the data byte to accumulator using MOV, LDAX, and LDA

Sol (a) using MOV.

```
LXI H, 2050H
MOV A, M
```

(b) using LDAX

```
LXI B, 2050H
LDAX B
```

(c)

```
LDA 2050H
```

what differences you observe?

Ex:

① Register B contains 32H. Illustrate the instructions MOV and STAX to copy the contents of reg B into memory location 8000H ~~specified~~ using indirect addressing.

(a) LXI H, 8000H

MOV M, B.

(b) LXI D, 8000H

MOV A, B.

~~STAX~~

STAX D

(2) The Accumulator contains F2H.

(a) copy A into memory location 8000H.
use direct Addressing

(b) Load F2H directly in memory location 8000H using indirect addressing

Ans

(a) STA 8000H

(b) LXI H, 8000H

~~MOV~~

MVI M, F2H

6:- Block Transfer of Data Bytes.

Sixteen bytes of data are stored in memory locations XX50H to XX5FH. Transfer the entire block of data to new memory location starting at XX70H.

```
        LXI   H, XX50H
        LXI   D, XX70H
        MVI   B, 10H
NXT :   MOV   A, M
        STAX  D
        INX   H
        INX   D
        DCR   B
        JNZ   NXT
        HLT
```

Ex:-

Write the instruction to load the no. 2050H in the register pair BC. Increment the no. using the instructions INXB. and check whether INX B instruction is equal to the instructions INR B and INR C.

Sol

LXI B, 2050H

INX B.

Ex:-

Write instructions to add the contents of memory location 2040H to (A), and subtract the contents of memory location 2041H from the first sum. Assume Acc. has 30H, the memory location 2040H has 68H and location 2041H has 7FH.

Sol

(A): 30H

(2040H): 68H

(A): ——

(20 A): ——

(A):

```
LXI H, 2040H
ADD M
INX H
SUB M
```

Discussion

(A) → 98H → (19)

```
  30H
  68H
  ---
  98H
```

(A): 98H

```
  98H
- 7FH
  ---
  19H.
```

```
  0011 0000
  0110 1000
  ---------
  1001 1000
    9   8 H
```

```
  1001 1000
  1000 0001
  ---------
(1) 0001 1001
```

Discard 19H

7F: 0111 1111

-7F: 1000 0001

Ex:- Write instruction to

1. load 59H in memory location 2040H, and increment the contents of memory location
2. load 90H in the memory location and decrement the contents of memory location

Sol

```
LXI  H, 2040H
MVI  M, 59H
INR  M
INX  H
MVI  M, 90H
DCR  M
```

Ex: Illustrative program: Addition with carry:

Problem statement:

Six bytes of data are stored in memory locations starting at XX50H. Add all the data bytes. Use register B to save any carries generated while adding the data bytes. Display the entire sum at two ports & store the sum at two consecutive memory locations.

Data (H): A2, FA, DF, E5, 98, 8B.

```
        XRA   A
        MOV   B , A
        MVI   C, 06H
        LXI   H , 2050H
NXTBYTADD:  ADD   M
        JNC   NXTMEM
        INR   B
NXTMEM:  INX H
        DCR C
        JNZ   NXTBYTADD
        OUT   PORT1
        MOV   B, A
        OUT   PORT2
        HLD
```

Alternate code for output

```
LXI H, XX70H
MOV M, A
INX H
MOV M, B
HLT
```

Logic operations : Rotate :

RLC → Rotate Accumulator left

RAL → Rotate accumulator left through carry

RRC → Rotate accumulator right

RAR → Rotate accumulator right through carry.

1. RLC : Rotate Accumulator left

→ Each bit is shift to the adjacent left position.
Bit D_7 becomes D_0

→ CY flag is modified according to bit D_7.

Ex:- Assume Acc. contents are AAH and CY=0.
Illustrate the contents of Acc. after RLC twice.

Acc.(A) :	AAH	1010 1010	CY=0	AA
	RLC	0101 0101	CY=1	55H
	RLC	1010 1010	CY=0	AA

(2) RAL: Rotate accumulator left through carry

→ Each bit is shifted to the adjacent left position.
Bit D_7 becomes the carry bit and carry bit is shifted into D_0.

→ The carry flag is modified as per bit D_7

Ex:- Assume Acc. A has AAH and CY=0. Illustrate the accumulator contents and CY flag after the execution of RAL twice.

		CY=D	ACC.
Acc-(A) :	AAH	1010 1010	AAH
		CY=1	
RAL		0101 0100	54H
		CY=0	
RAL		1010 1001	A9H

(3) RRC: Rotate Accumulator right

→ Each bit is shifted right to adjacent position. Bit D_0 becomes D_7

→ CY flag is modified as per bit D_0.

(4) RAR: Rotate Accumulator right through carry

→ Each bit is shifted right to adj. position. Bit D_0 becomes Carry and CY bit is shifted into D_7.

Q:- Assume contents of Acc are 81H and CY = 0. Illustrate the Acc contents after RRC and RAR instructions.

Sol

CY = 0

ACC - 81H 1000 0001

CY = 1

RRC 1100 0000 Acc = C0H

CY = 1

RAR 0100 0000 Acc = 40H

Ex:- Illustrative program: checking sign with Rotate instruction.

Problem Statement :

A list of ten current readings is stored in memory locations starting at XX60H. The readings are expected to be positive (<127$_{10}$). Write a program to

1. check each reading to determine whether it is positive or negative.
2. reject all negative reading.
3. add all positive readings
4. output FFH to port 1 at any time when the sum exceeds 8 bits to indicate overload; otherwise display the sum.
   If no output port is available in system, go to step 5.
5. Store FFH in memory location XX70H when the sum exceeds eight bits; otherwise store the sum.

Data (H) : 28, D8, C2, 21, 24, 30, 2F, 19, F2, 9F.

```
        MVI  B, 00H
        MVI  C, DAH
        LXI  H, XX60H
NEXT:   MOV  A, M
        RAL
        JC   REJECT
        RAR
        ADD  B
        JC   OVRLOD
        MOV  B, A
REJECT: INX  H
        DCR  C
        JNZ  NEXT
        MOV  A, B
        OUT  PORT1
        HLT
OVRLOD: MVI  A, FFH
        OUT  PORT1
        HLT.
```

Logic Operations COMPARE

① CMP : Compare with Accumulator

② CPI : Compare Immediate with Accumulator

Compares the data byte with Acc. by subtracting the data byte from (A).

① CMP R/M : compare (Reg or memory) with Accumulator.

→ 1 byte instruction

→ If (A) < (R/m), CY = 1, Z = 0

→ If (A) = (R/m), Z = 1, CY = 0

→ If (A) > (R/m) CY, Z are both reset.

→ When memory is operand, its address is specified by HL

→ No contents are modified; however all flags (S, P, AC) are affected according to the result of subtraction

② CPI 8bit : compare Immediate with Acc.

→ 2 byte instruction

→ If (A) < 8bit data CY = 1, Z = 0

→ If (A) = 8bit data Z = 1, CY = 0

→ If (A) > 8 bit data Z = 0, CY = 0

→ No contents are modified. All flags (S, P, AC) are affected based on result of subtraction.

6. Write an instruction to load the Acc with data byte 64H. verify whether the data byte in memory location 2050H is equal to the accumulator contents.

If both data bytes are equal jump to memory location ~~buffer~~ BUFFER

Sol

```
LXI H, 2050H
MVI A, 64H
CMP M
JZ BUFFER
```

Ex:- Illustrative program: Use of Compare instructions to indicate End of Data String.

Problem statement:

A set of current readings is stored in memory locations starting at XX50H. The end of data string is indicated by the data byte 00H. Add the set of readings. The answer may be larger than FFH. Display the entire sum at PORT1 and PORT2 or store the answer in memory locations XX70, XX71H.

Data (H): 32, 52, F2, A5, 00.

```
        LXI   H, XX50H
        MVI   C, 00H
        MOV   B, C
NXTBYT: MOV   A, M
        CPI   00H
        JZ    DISPLAY
        ADD   C
        JNC   SAVE
        INR   B
SAVE:   MOV   C, A
        INX   H
        JMP   NXTBYT
DISPLAY: MOV  A, C
        OUT   PORT1
        MOV   A, B
        OUT   PORT2
        HLT.
```