



8086 Addressing Modes

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Lecture References:

▣ **Book:**

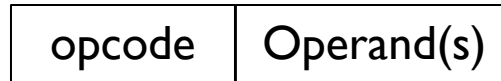
- ▣ *Microprocessors and Interfacing: Programming and Hardware,*
Chapter # 2, **Author:** Douglas V. Hall
- ▣ *The 8086/8088 Family: Design, Programming, And Interfacing,*
Chapter # 2, **Author:** John Uffenbeck.

Addressing Mode and Categories

- The different ways in which a microprocessor can access data are referred to as its addressing modes.
- Addressing modes of 8086 Microprocessor are categorized as:
 - *Addressing Data*
 - *Addressing Program codes in memory*
 - *Addressing Stack in memory*
 - *Addressing I/O*
 - *Implied addressing*

Things to know...

□ Instruction format



□ Instructions can have 1, 2 or no operands

□ **INC AX** ; 1 operand

□ **ADD CX, DX** ; 2 operands \longrightarrow $CX = CX + DX$

□ **HLT** ; no operand

Destination
source

□ Instruction cannot have:

□ **SUB [DI], [1234h]** ; memory locations as both operands

□ **MOV 1234, AX** ; immediate data as destination operand

1. Addressing Data

- I. Immediate addressing
- II. Direct addressing
- III. Register [direct] addressing
- IV. Register indirect addressing
- V. Base-plus-index addressing
- VI. Register relative addressing
- VII. Base-relative-plus-index addressing

1. Addressing Data

I. Immediate addressing

- Data is immediately given in the instruction

MOV BL, 11h

II. Direct addressing

- Data address is directly given in the instruction

MOV BX, [437AH]

1. Addressing Data

III. Register [direct] addressing

- Data is in a register (here BX register contains the data)

MOV AX, BX

MOV AL, BX

IV. Register [indirect] addressing

- Register supplies the address of the required data

MOV CX, [BX]



1. Addressing Data

v. **Base-plus-index addressing**

- Base register is either BX or BP
- Index register is either DI or SI

MOV DX, [BX+DI]

vi. **Register relative addressing**

- Register can be a base (BX, BP) or an index register (DI, SI)
- Mainly suitable to address array data

MOV AX, [BX+1000]



1. Addressing Data

VII. **Base-relative-plus-index addressing**

- Suitable for array addressing

MOV AX, [BX+DI+10]

2. Addressing Program Codes in Memory

- Used with JMP and CALL instructions
- 3 distinct forms:
 - I. Direct
 - II. Indirect
 - III. Relative



2. Addressing Program Codes in Memory

- Address is directly given in the instruction

JMP ^{*IP*}1000:^{*CS*}0000

JMP doagain ; doagain is a **label** in code

CALL 1000:0000

CALL doagain ; doagain is a **procedure** in code

- Often known as *far* jump or *far* call

2. Addressing Program Codes in Memory

□ Address can be obtained from

□ **a)** any GP registers (AX,BX,CX,DX,SP,BP,DI,SI)

JMP AX
*IP = AX ; then CS :
IP*

□ **b)** any relative registers ([BP],[BX],[DI],[SI])

JMP [BX]
*IP = what is inside the physical address of DS : BX ; then CS
: IP*

□ **c)** any relative register with displacement

JMP [BX + 100h]
*IP = what is inside the physical address of DS : BX + 100h ; then CS
: IP*

3. Addressing Stack in Memory

- **PUSH** and **POP** instructions are used to move data to and from stack (in particular from stack segment).

PUSH AX

POP CX

- **CALL** also uses the stack to hold the return address for procedure.

CALL SUM ; SUM is a procedure name

4. Addressing Input and Output Port

- IN and OUT instructions are used to address I/O ports
- Could be *direct addressing*

IN AL, 05h ; Here 05h is a input port number

- or *indirect addressing*

OUT DX, AL ; DX contains the address of I/O port

- Only DX register can be used to point a I/O port

5. Implied Addressing

- No explicit address is given with the instruction
- implied within the instruction itself
- Examples:

CLC ; clear carry flag

HLT ; halts the program

RET ; return to DOS



8086 Machine Codes

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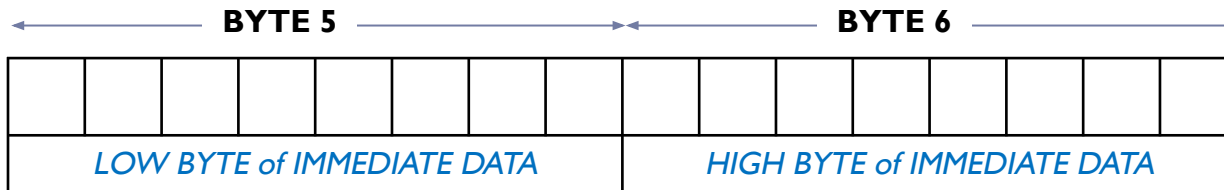
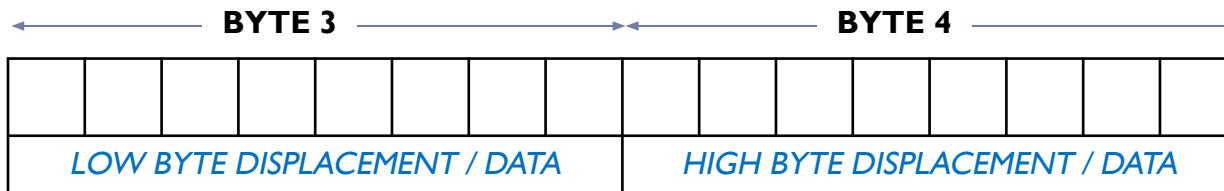
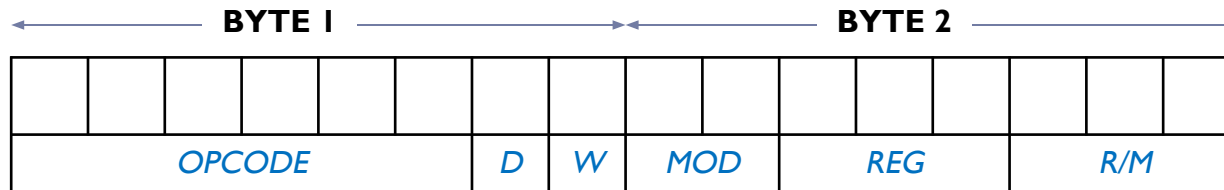
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Instruction template

- For 8085: Just look up the hex code for each instruction.
- For 8086 it is not simple.
- E.g 32 ways to specify the source in **MOV CX, source**.
- **MOV CX, source**
 - a 16-bit register (8 in number)*
 - a memory location (24 possible memory addressing modes)*
- Each of these 32 instructions require different binary code.
- Impractical to list them all in a table.
- Instruction templates help code the instruction properly.



Instruction template (6 bytes)



An instruction after conversion can have 1 to 6 bytes long of machine code

Constructing Machine Codes for 8086

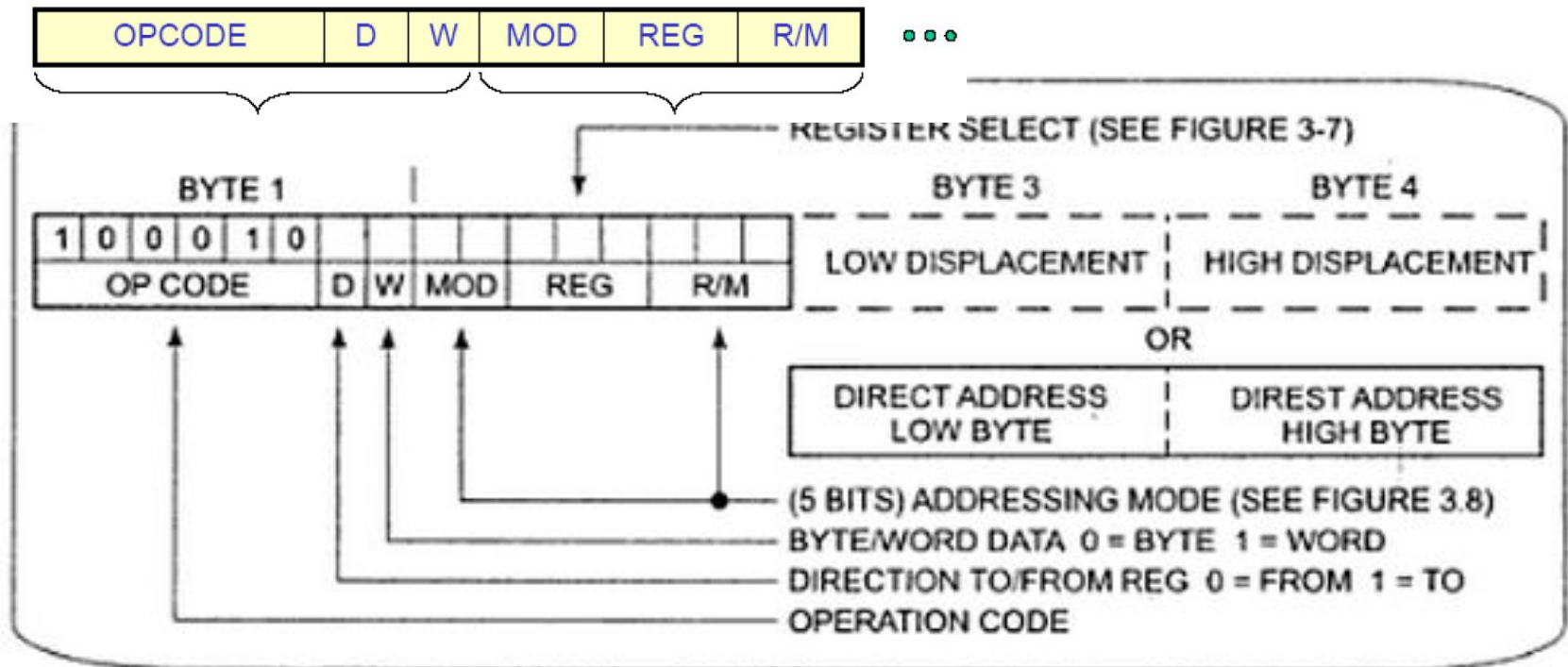
- Each instruction in 8086 is associated with the binary code.
- You need to locate the codes appropriately.
- Most of the time this work will be done by assembler
- The things needed to keep in mind is:
 - Instruction templates and coding formats
 - MOD and R/M Bit patterns for particular instruction



MOV Instruction Coding

- MOV data from a register to a register/to a memory location or from a memory location to a register.

(Operation Code of MOV: 100010)



MOD and R/M Field

- 2-bit Mode (MOD) and 3-bit Register/Memory (R/M) fields specify the other operand.
- Also specify the addressing mode.

RM \ MOD	MOD			
	00	01	10	11
				W = 0 W = 1
000	[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL AX
001	[BX] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL CX
010	[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL DX
011	[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL BX
100	[SI]	[SI] + d8	[SI] + d16	AH SP
101	[DI]	[DI] + d8	[DI] + d16	CH BP
110	d16 (direct address)	[BP] + d8	[BP] + d16	DH SI
111	[BX]	[BX] + d8	[BX] + d16	BH DI

MOD and R/M Field

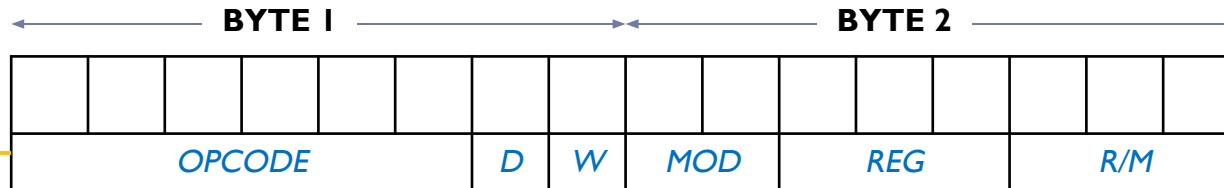
- If the other operand in the instruction is also one of the eight register then put in 11 for MOD bits in the instruction code.
- If the other operand is memory location, there are 24 ways of specifying how the execution unit should compute the effective address of the operand in the main memory.
- If the effective address specified in the instruction contains displacement less than 256 along with the reference to the contents of the register then put in 01 as the MOD bits.
- If the expression for the effective address contains a displacement which is too large to fit in 8 bits then out in 10 in MOD bits.

REG Field

- REG field is used to identify the register of the one operand

REG	W = 0	W = 1
000	AL	AX
001	CL	CX
010	DL	DX
011	BL	BX
100	AH	SP
101	CH	BP
110	DH	SI
111	BH	DI

Instruction template



6 bits of
MOV, ADD etc

D - direction

If **D=0**, then direction is from a register (source)
If **D=1**, then direction is to a register (destination)

W - word

If **W=0**, then only a byte is being transferred (8 bits)
If **W=1**, then a whole word is being transferred (16 bits)

- 34h here is an 8-bit displacement
- [BX+34h] is a memory/offset address

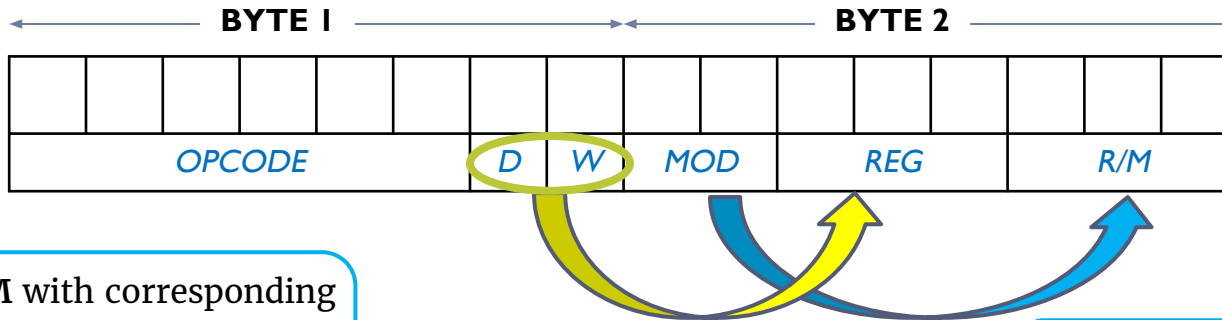
MOV [BX + 34h], AL

MOV AX, 1234h

- 1234h here is a 16-bit immediate data value

MODE	OPERAND NATURE
00	Memory with no displacement → MOV AX, [BX]
01	Memory with 8-bit displacement → MOV AX, [BX + 12h]
10	Memory with 16-bit displacement → MOV AX, [BX + 1234h]
11	Both are registers → MOV AX, BX

Instruction template



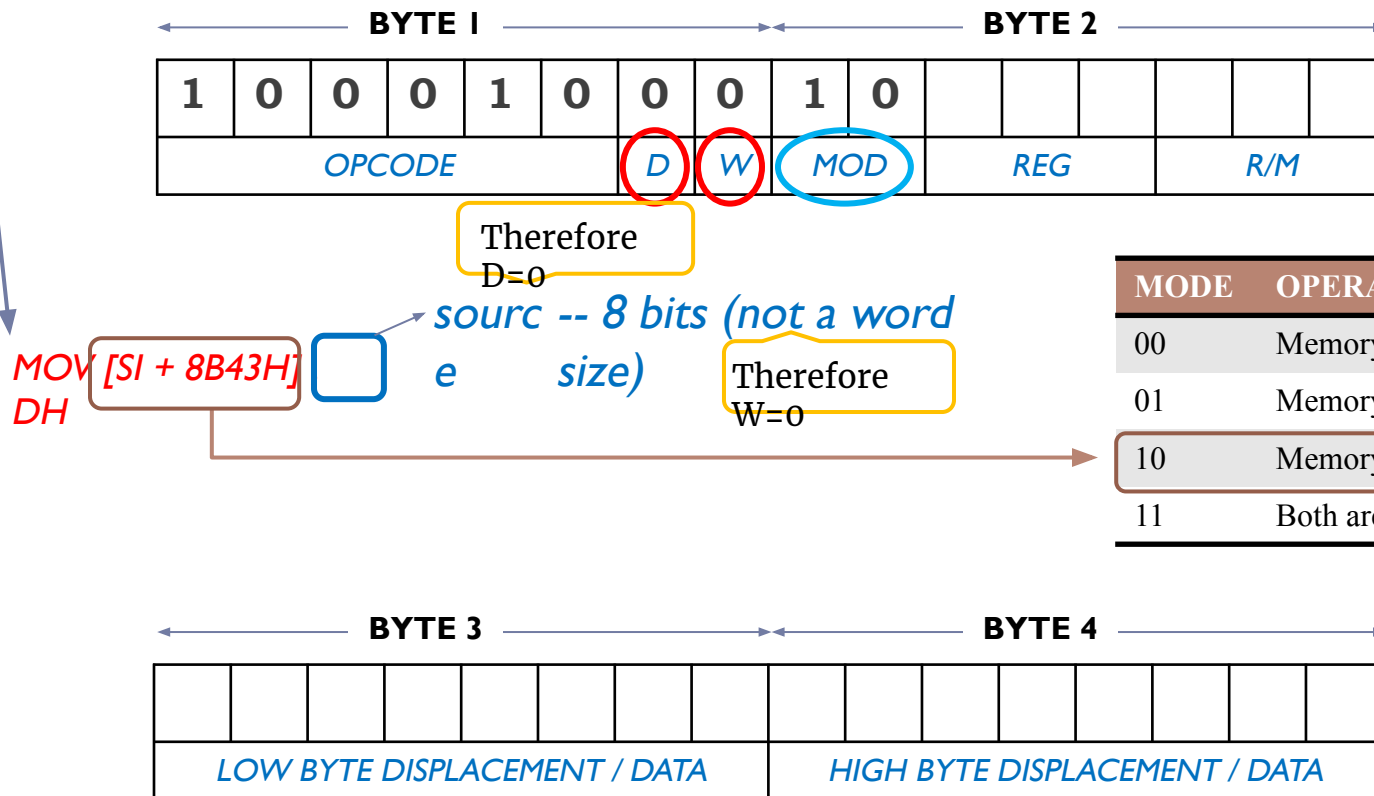
- Value for R/M with corresponding MOD value
- Value for REG with corresponding W value and the register considered in D

Check column that matches with MOD value

RM \ MOD		00	01	10	11	
					W = 0	W = 1
000		[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL	AX
001		[BXI] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL	CX
010		[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL	DX
011		[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL	BX
100		[SI]	[SI] + d8	[SI] + d16	AH	SP
101		[DI]	[DI] + d8	[DI] + d16	CH	BP
110		d16 (direct address)	[BP] + d8	[BP] + d16	DH	SI
111		[BX]	[BX] + d8	[BX] + d16	BH	DI

Example 1

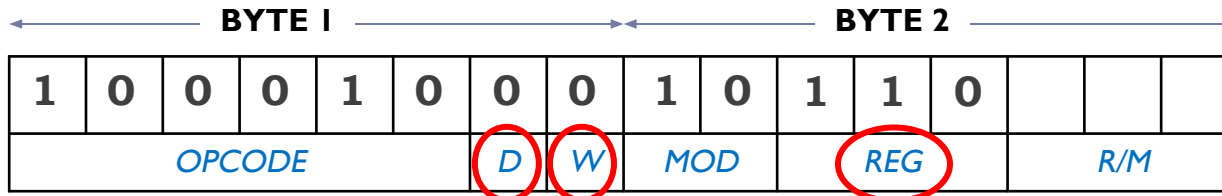
- **MOV 8B43H [SI], DH:** Copy a byte from DH to memory with 16 bit displacement given the opcode for MOV=100010



MODE	OPERAND NATURE
00	Memory with no displacement
01	Memory with 8-bit displacement
10	Memory with 16-bit displacement
11	Both are registers

Example 1

- **MOV 8B43H [SI], DH:** Copy a byte from DH to memory with 16 bit displacement given the opcode for MOV=100010

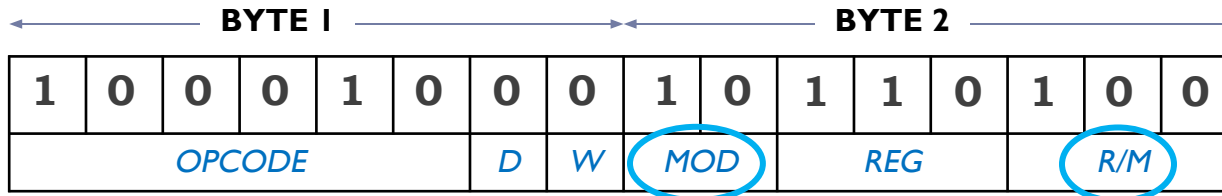


MOV [SI + 8B43H],
DH

RM \ MOD	MOD					
	00	01	10	11	W = 0	W = 1
000	[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL	AX	
001	[BXI] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL	CX	
010	[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL	DX	
011	[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL	BX	
100	[SI]	[SI] + d8	[SI] + d16	AH	SP	
101	[DI]	[DI] + d8	[DI] + d16	CH	BP	
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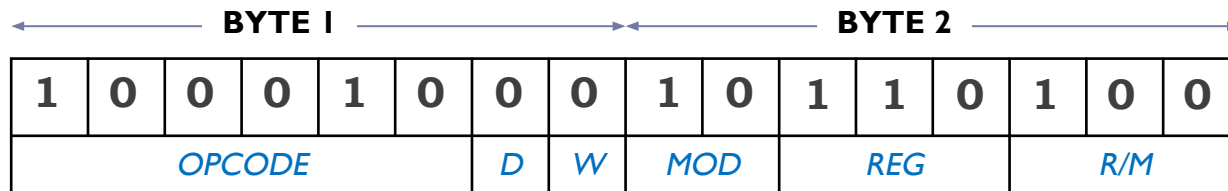


MOV [SI + 8B43H],
DH

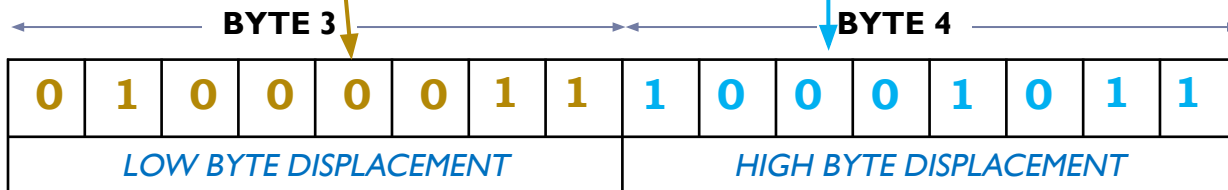
RM \ MOD	MOD				
	00	01	10	11	
				W = 0	W = 1
000	[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL	AX
001	[BX] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL	CX
010	[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL	DX
011	[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL	BX
100	[SI]	[SI] + d8	[SI] + d16	AH	SP
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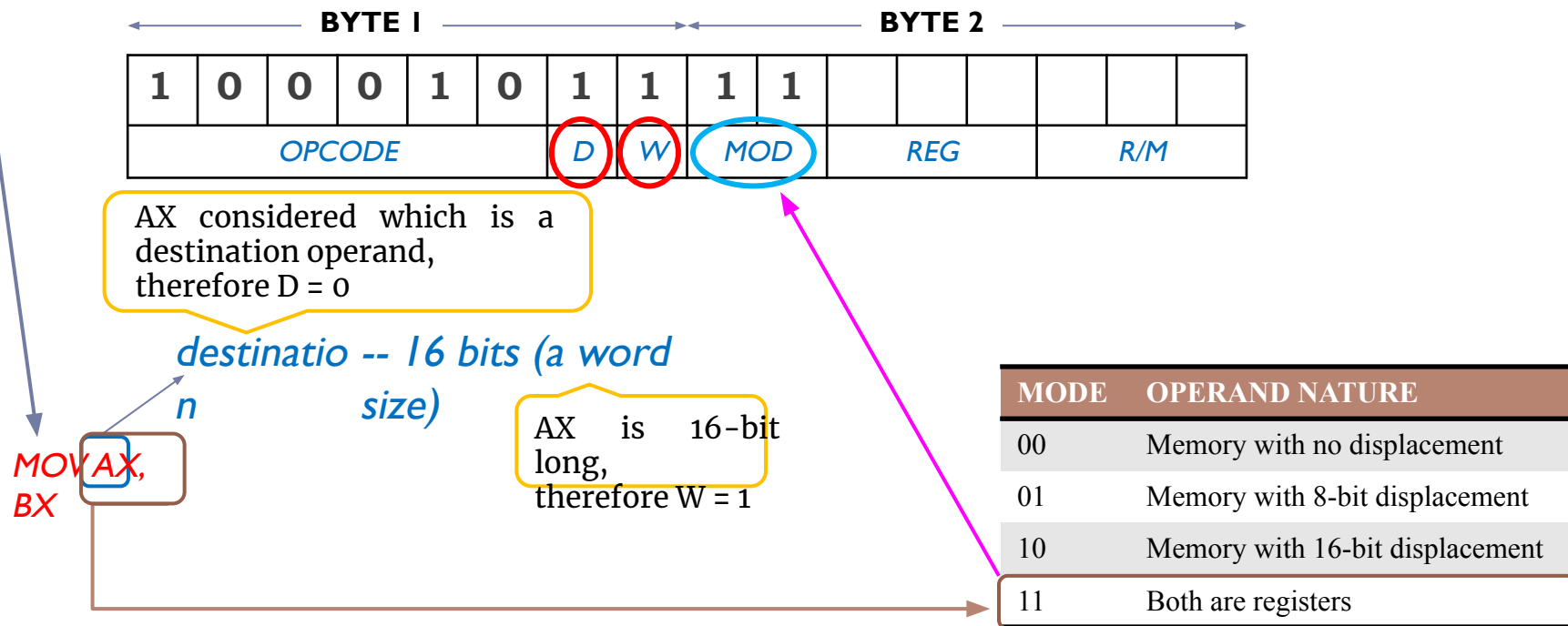
MOV [SI + 8B43H],
DH



Machine Code: 1000 1000 1011 0100 0100 0011 1000 1011₂ or 88 B4 43 8B₁₆

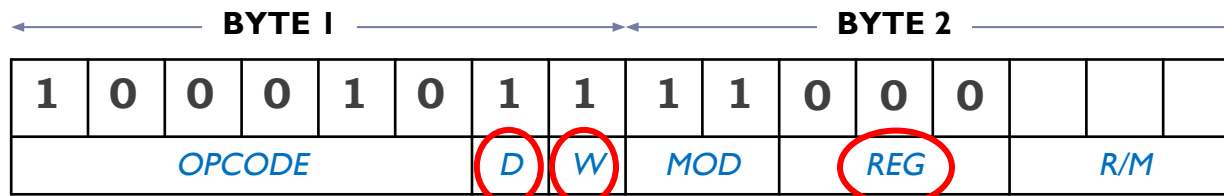
Example 2

□ **MOV AX, BX:** given the opcode for MOV=100010



Example 2

□ **MOV AX, BX**: given the opcode for MOV=100010

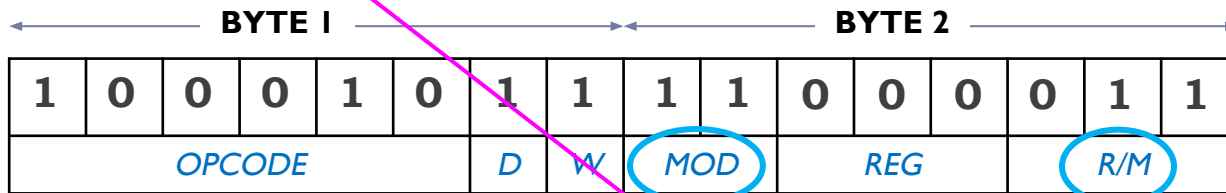


RM \ MOD	00	01	10	11	
				W = 0	W = 1
000	[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL	AX
001	[BXI] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL	CX
010	[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL	DX
011	[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL	BX
100	[SI]	[SI] + d8	[SI] + d16	AH	SP
101	[DI]	[DI] + d8	[DI] + d16	CH	BP
110	d16 (direct address)	[BP] + d8	[BP] + d16	DH	SI
111	[BX]	[BX] + d8	[BX] + d16	BH	DI

Example 2

Machine Code: *1000 1011 1100 0011*₂ or *8B C3*₁₆

□ **MOV AX, BX**: given the opcode for MOV=100010



RM \ MOD		MOD			
		00	01	10	11
					W = 0 W = 1
000		[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL AX
001		[BX] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL CX
010		[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL DX
011		[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL BX
100		[SI]	[SI] + d8	[SI] + d16	AH SP
101		[DI]	[DI] + d8	[DI] + d16	CH BP
110		d16 (direct address)	[BP] + d8	[BP] + d16	DH SI
111		[BX]	[BX] + d8	[BX] + d16	BH DI

QUIZ

Compute the machine code for the following using the table below and the opcode for MOV as 100010

a) MOV AX, 5E9Ch

b) MOV DH, [BP+SI+7Dh]

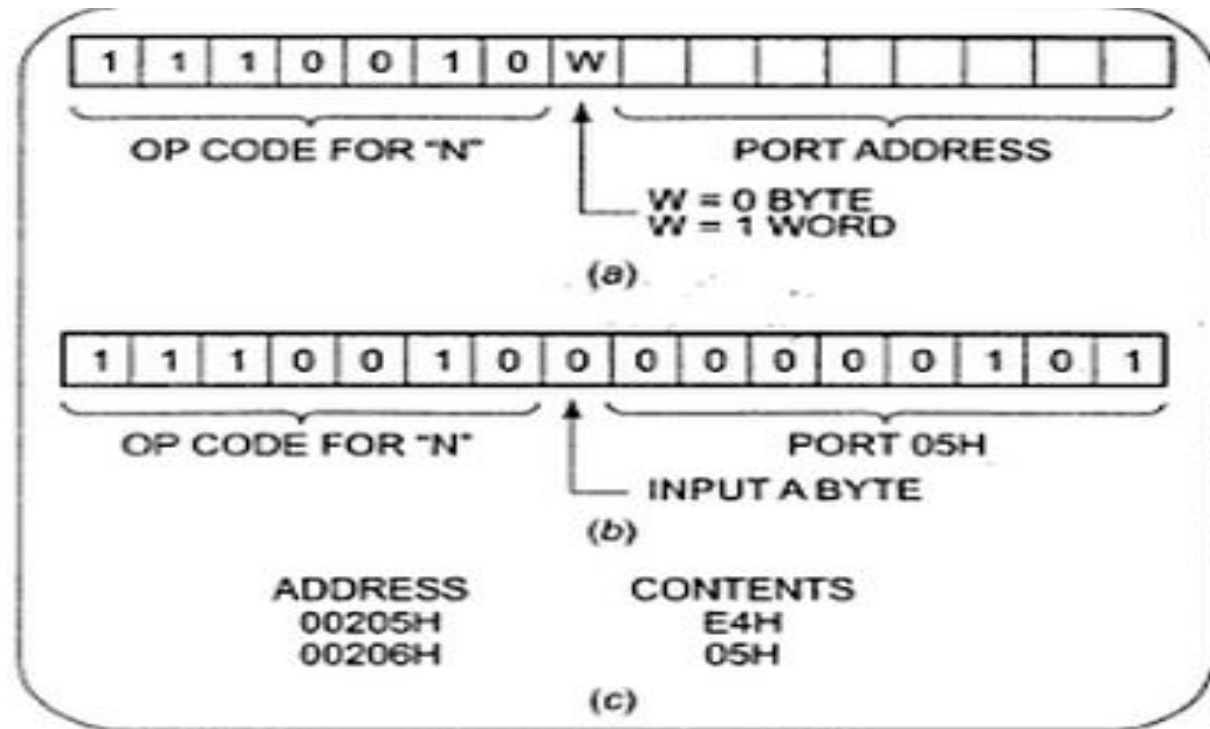
RM \ MOD	MOD			
	00	01	10	11
				W = 0 W = 1
000	[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL AX
001	[BXI] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL CX
010	[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL DX
011	[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL BX
100	[SI]	[SI] + d8	[SI] + d16	AH SP
101	[DI]	[DI] + d8	[DI] + d16	CH BP
110	d16 (direct address)	[BP] + d8	[BP] + d16	DH SI
111	[BX]	[BX] + d8	[BX] + d16	BH DI

Instruction Template

- The Intel literature shows two different formats for coding 8086 instructions.
- Instruction templates help you to code the instruction properly.

□ Example:

IN AL, 05H



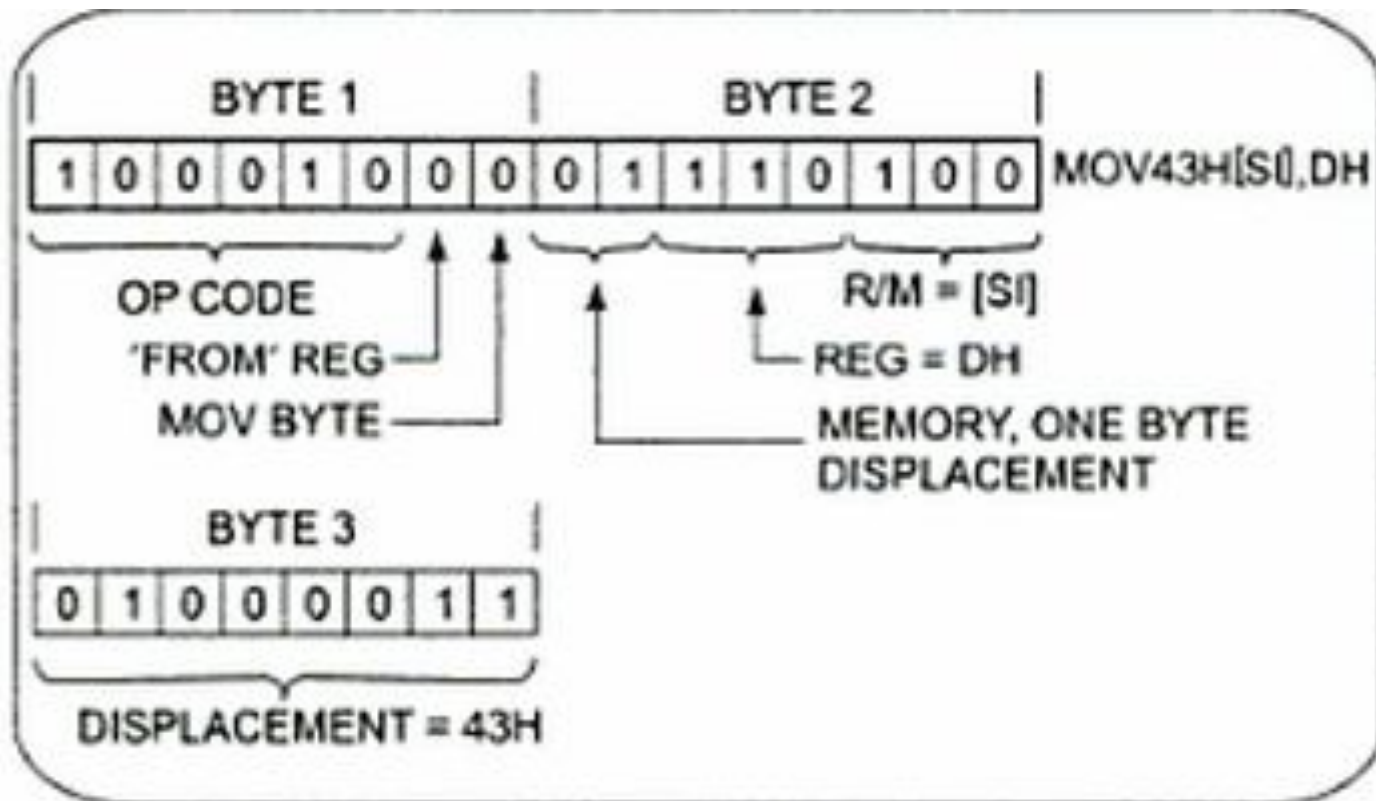
Example

- MOV BL,AL
- Opcode for MOV = 100010
- We'll encode AL so
 - D = 0 (AL source operand)
- W bit = 0 (8-bits)
- MOD = 11 (register mode)
- REG = 000 (code for AL)
- R/M = 011

OPCODE	D	W	MOD	REG	R/M
100010	0	0	11	000	011

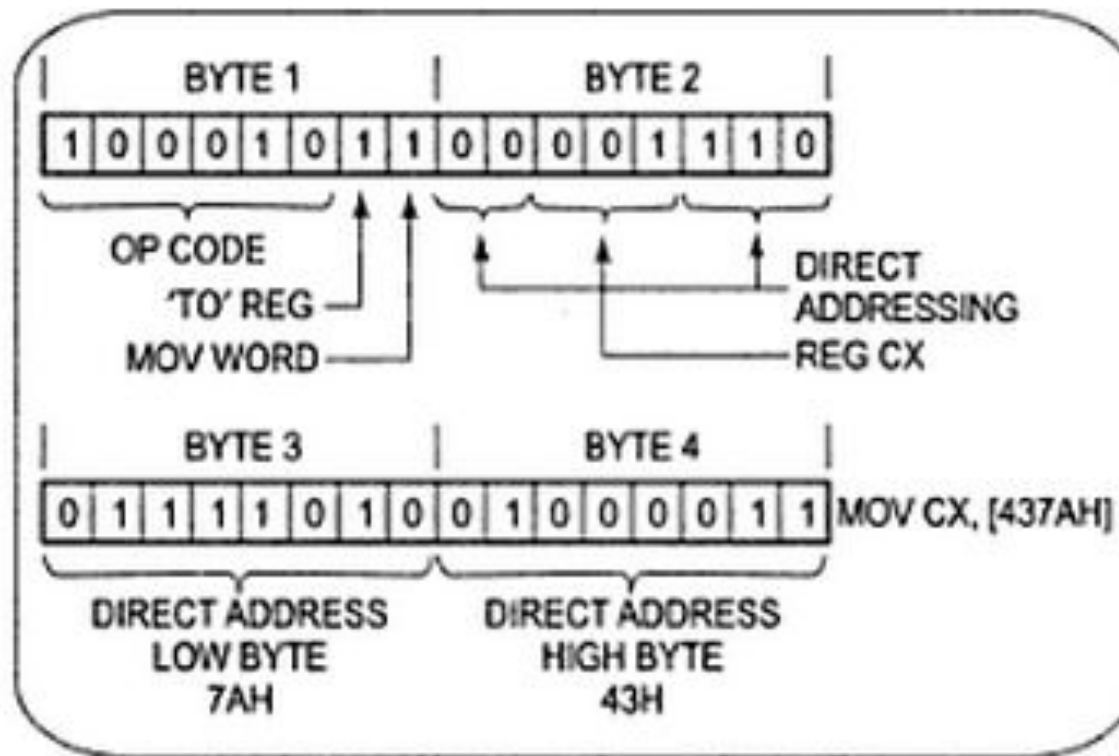
Example

- ▣ **MOV 43H [SI], DH:** Copy a byte from DH register to memory location.



Example 3

- **MOV CX, [437AH]:** Copy the contents of the two memory locations to the register CX.



QUIZ

Compute the machine code for the following using the table below and the opcode for MOV as 100010

a) MOV AX, 5E9Ch

b) MOV DH, [BP+SI+7Dh]

RM \ MOD	MOD			
	00	01	10	11
				W = 0 W = 1
000	[BX] + [SI]	[BX] + [SI] + d8	[BX] + [SI] + d16	AL AX
001	[BXI] + [DI]	[BX] + [DI] + d8	[BX] + [DI] + d16	CL CX
010	[BP] + [SI]	[BP] + [SI] + d8	[BP] + [SI] + d16	DL DX
011	[BP] + [DI]	[BP] + [DI] + d8	[BP] + [DI] + d16	BL BX
100	[SI]	[SI] + d8	[SI] + d16	AH SP
101	[DI]	[DI] + d8	[DI] + d16	CH BP
110	d16 (direct address)	[BP] + d8	[BP] + d16	DH SI
111	[BX]	[BX] + d8	[BX] + d16	BH DI

Thank You !!!