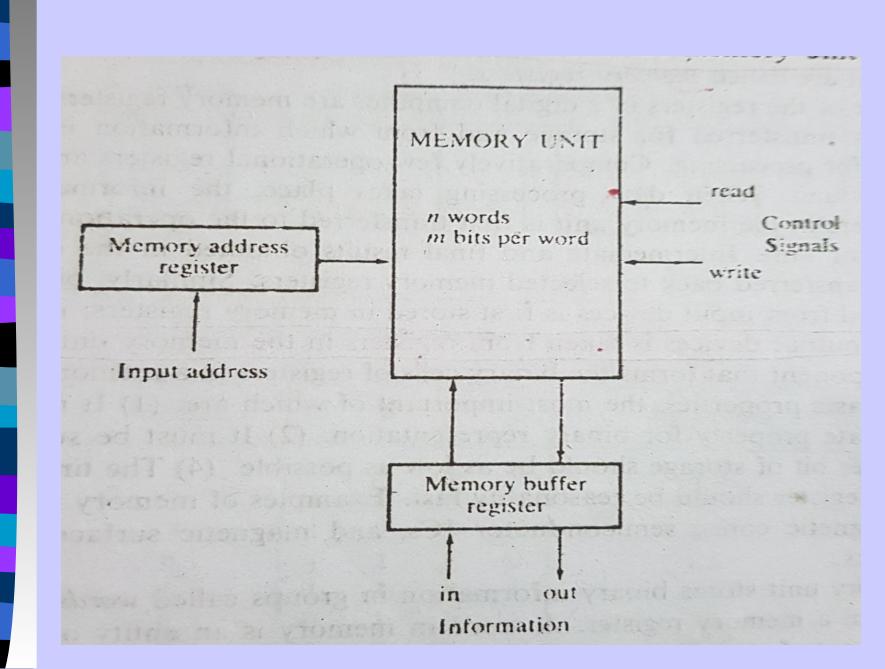
Memory

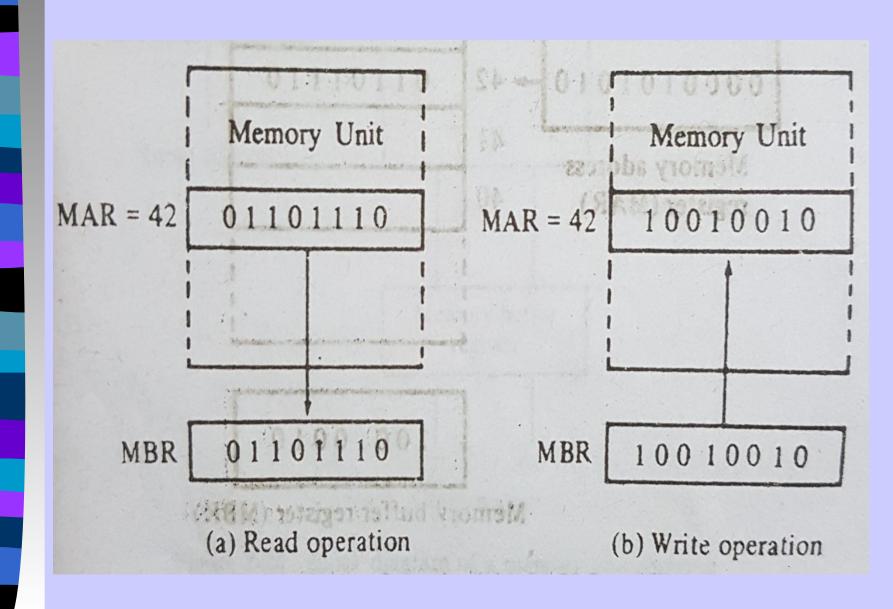
BRAC University

What is Memory Unit?

- A memory unit is a collection of registers together with associated circuits needed to transfer information in and out of registers.
- Binary cell: An elementary unit of computer storage (i.e. memory register) that can have one or the other of two stable states and can thus store one bit of information.
- The memory cell is an electronic circuit that stores one bit of binary information and it must be set to store a logic 1 (high voltage level) and reset to store a logic 0 (low voltage level). Its value is maintained/stored until it is changed by the set/reset process.
- A memory unit stores binary information in **groups of bits** called *words*.
- Communication between memory unit and its environment is achieved through 2 controls (read and write) and 2 external registers (memory address register and memory buffer register).
- To communicate with a memory word, its address is transferred to memory address register. Internal circuit then opens the path to select that word. A n-bit address register can specify up to 2^n address. (note: # of address=# of word)
- Before writing and after reading information are kept in **Memory Buffer** registers. In each case, the address register specifies location of writing or reading.



READ WRITE Operation Example



Content of a 1024 x 16-bit memory:

Memory address

binary	decimal 0	
000000000		
000000001	1	
000000010	2	
:	:	
:	:	
1111111101	1021	
1111111110	1022	
1111111111	1023	

Memory content

1011010111011101			
1010000110000110			
0010011101110001			
:			
:			
1110010101010010			
00111110101011110			
1011000110010101			



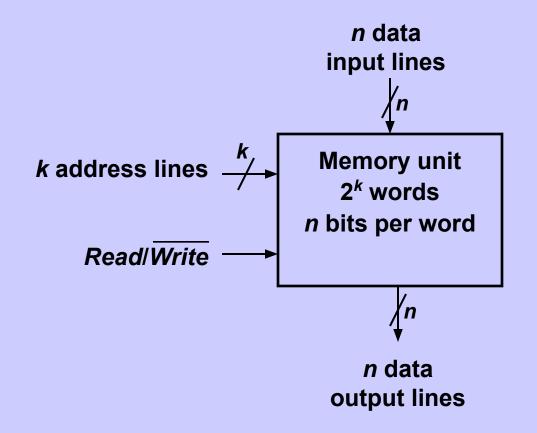
The data consists of *n* lines (for *n*-bit words). Data input lines provide the information to be stored (*written*) into the memory, while data output lines carry the information out (*read*) from the memory.

The address consists of k lines which specify which word (among the 2^k words available) to be selected for reading or writing.

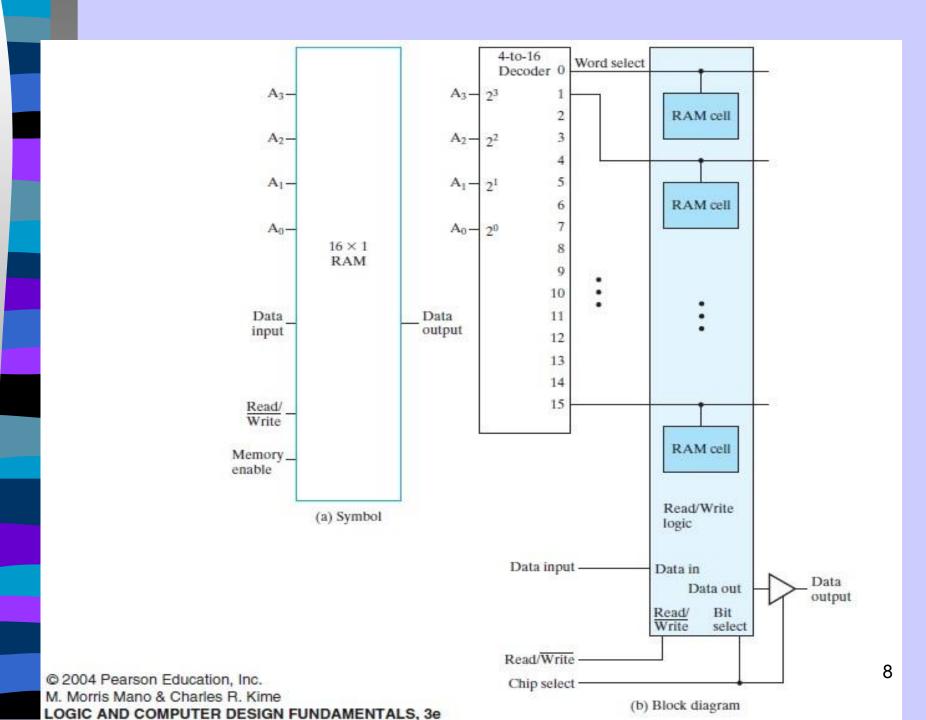
The control lines *Read* and *Write* (usually combined into a single control line *Read/Write*) specifies the direction of transfer of the data.

Example: A memory unit of 1024 words with 8 bit/word needs, 10 address line (i.e. address register must contain 10 FF) and buffer register must have 8 FF to store words transferred in and out of it.

Block diagram of a memory unit:









- The Write operation:
 - Transfers the address of the desired word to the address lines
 - Transfers the data bits (the word) to be stored in memory to the data input lines
 - Activates the Write control line (set Read/Write to 0)
- The Read operation:
 - Transfers the address of the desired word to the address lines
 - Activates the Read control line (set Read/Write to 1)



The Read/Write operation:

Memory Enable	Read/Write	Memory Operation	
0	X	None	
1	0	Write to selected word	
1	1	Read from selected word	

- Two types of RAM: Static and dynamic.
 - Static RAMs use flip-flops as the memory cells.
 - Dynamic RAMs use capacitor charges to represent data. Though simpler in circuitry, they have to be constantly refreshed.

Memory Size

- Memory sizes might be specified in bits or byte(=8bit)
- Symbol: Bytes (B) and bits(b)
- Example, 2^28 b = 2^28/8 B= 2^28/2^3 B=2^25 B=
 2^5*2^20 B = 32 MB

	Prefix	Base 2	Base 10
K	Kilo	2^10= 1024	10^3=1,000
М	Mega	2^20 =1,048,576	10^6= 1,000,000
G	Giga	2^30 =1,073,741,824	10^9= 1,000,000,000

```
1 KB = 1024 Bytes

1 MB = 1024 KB

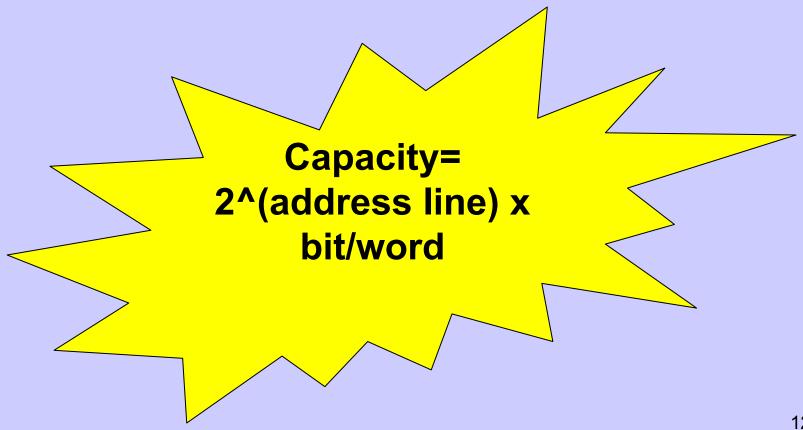
1 GB = 1024 MB

1 TB = 1024 GB

1 PB = 1024 TB
```

2 formula to remember

- Capacity = no. of word x bit/word
- No. of word= 2 ^ (address lines)



Test your self

- Capacity = no. of word x bit/word
- No. of word= 2 ^ (address lines)
- What is the total capacity of a 2¹⁶ X 16 memory:

- A: 256 KB

- B: 1 MB

- C: 128 KB

D: 512 KB

Solution: c

- = 2¹6 x 16 bits/words
- = 1048576 bits
- = 1048576/8 bytes
- = 131072 bytes
- = 131072/1024 KB
- = 128 KB

Test yourself

- Capacity = no. of word x bit/word
- No. of word= 2 ^ (address lines)
 - How many address lines do we need for a 64 MB RAM with 32-bit words?
 - A: 23
 - B: 20
 - C: 24
 - D: 21

Solution

Answer: C

```
Formula:
```

```
Capacity = no. of word x bit/word

64MB = no. of word x 32bits/word

no. of word = 64MB / 32 bits/word

= (64x1024x1024x8)(/32[ 1 byte = 2^3 bits]

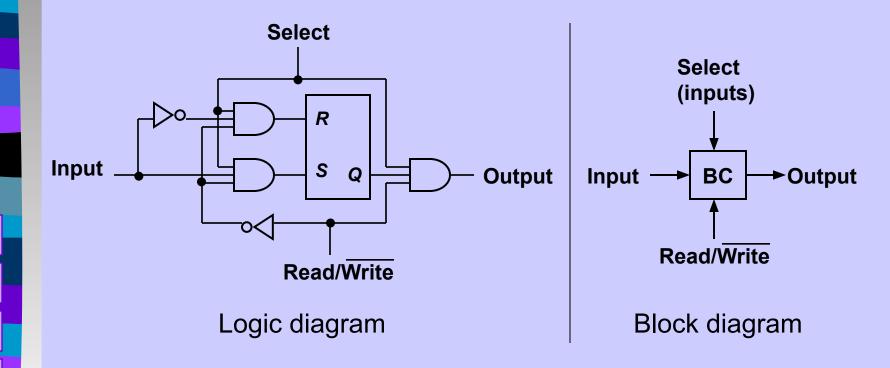
= 16777216 bits = 2^24 bits
```

no. of address lines = 24

Binary cell

- Must be small so that many binary cell (BC) can fit in a small area
- Select input enable cell for reading/writing
- Read/write determines operation to be preformed on cell. A 1 in read/write input forms a path to the output terminal. A 0 in read/write input, information in the input terminal is transferred into the FF

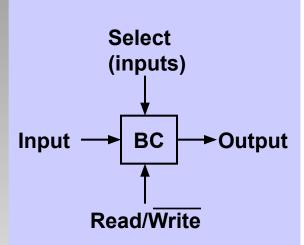
 A single memory cell of the static RAM has the following logic and block diagrams.

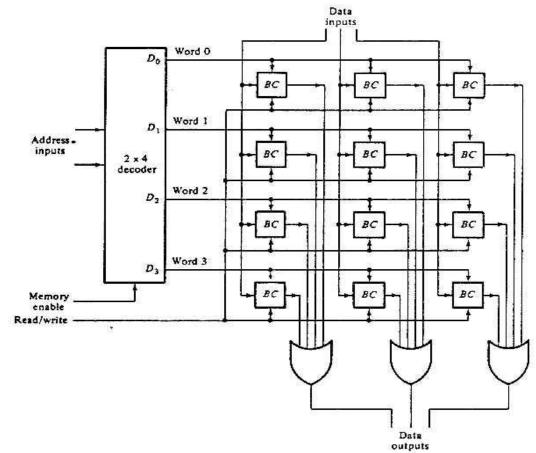


of word

Logic construction of a 4 x 3 RAM (with decoder and

OR gates):





Bit/word

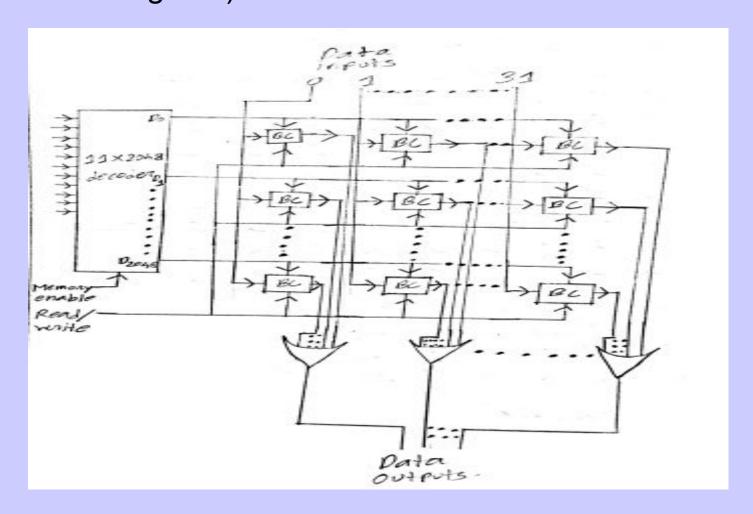
Since no of word is 4, that would be equivalent to the decoder's output. Since, the decoder will have 4 outputs, so we should use a 2x4 decoder



Random Access Memory (RAM) # of word

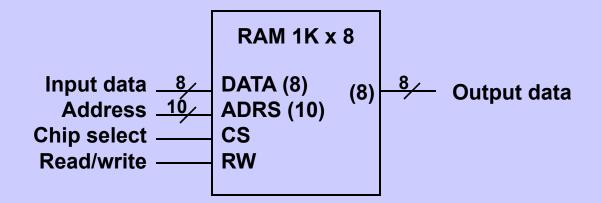
Logic construction of a 2048 x 32 RAM (with decoder and OR gates):

Bit/word





- An array of RAM chips: memory chips are combined to form larger memory.
- A 1K x 8-bit RAM chip:



Block diagram of a 1K x 8 RAM chip