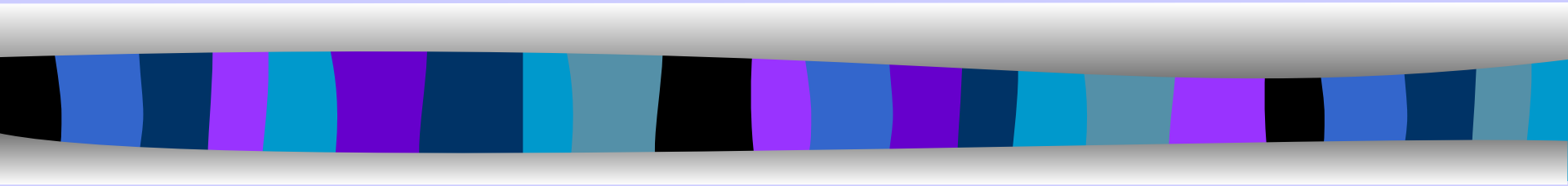
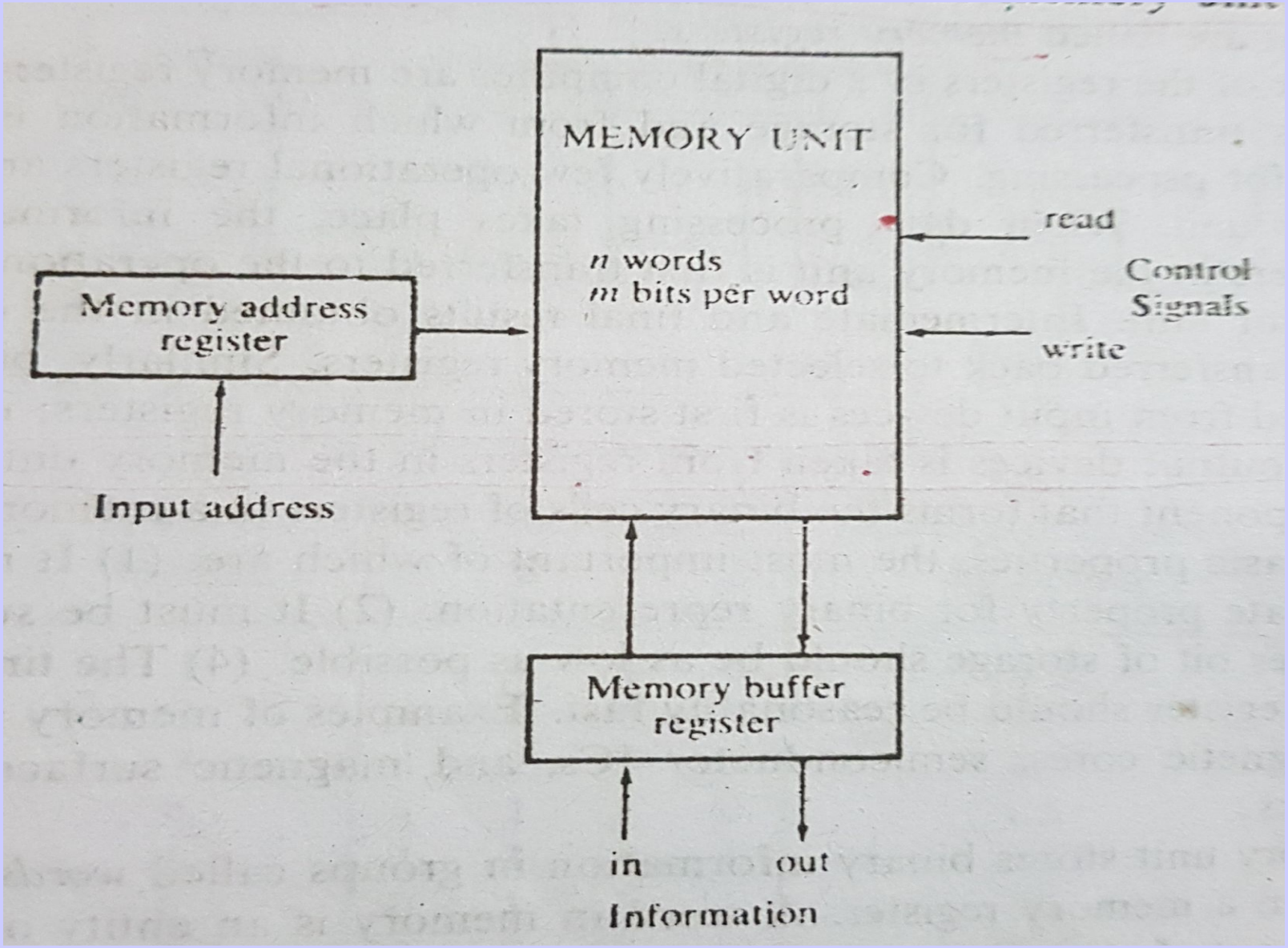


Memory

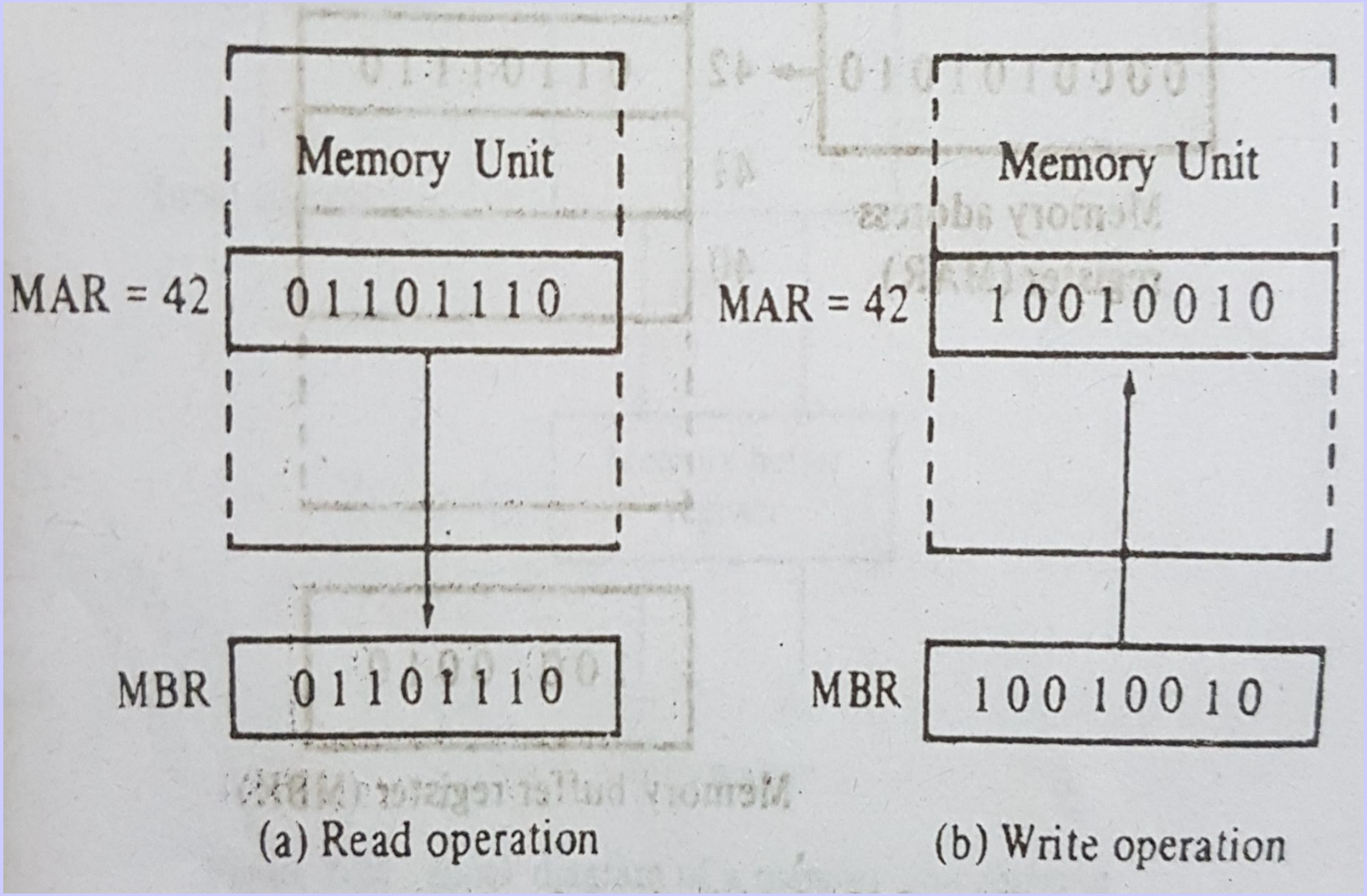
BRAC University

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.


MEMORY UNIT
n words
m bits per word
read
Control
Signals
write
Memory address
register
Input address
Memory buffer
register
in
out
Information

READ WRITE Operation Example



Random Access Memory (RAM)

- Content of a 1024 x 16-bit memory:

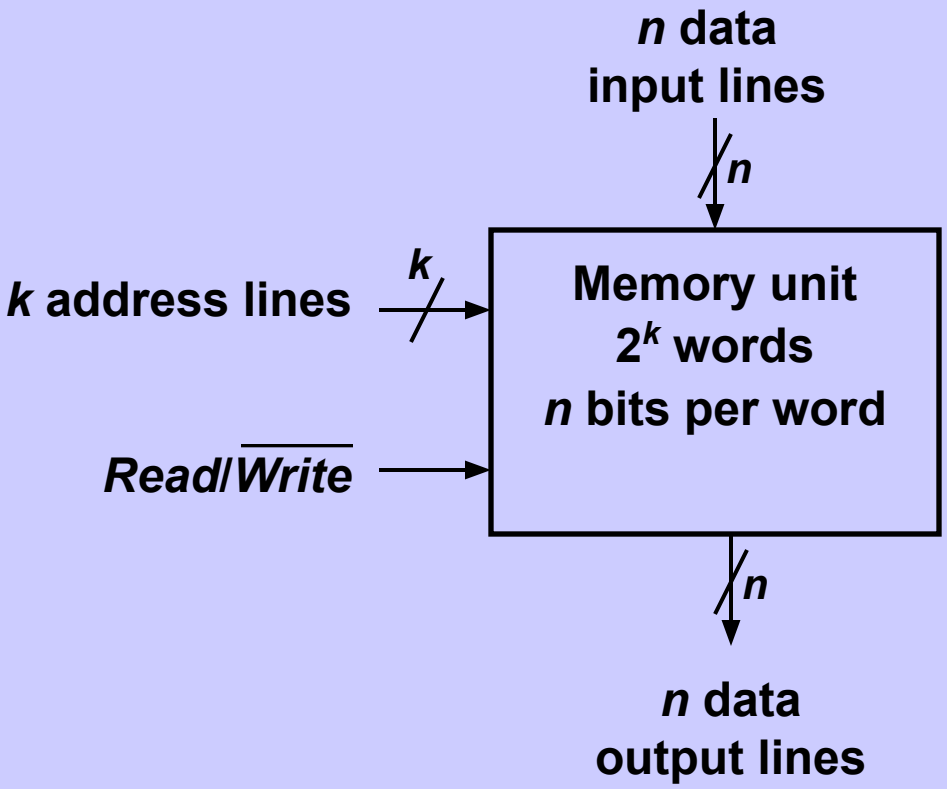
Memory address		Memory content
binary	decimal	
0000000000	0	1011010111011101
0000000001	1	1010000110000110
0000000010	2	0010011101110001
:	:	:
:	:	:
1111111101	1021	1110010101010010
1111111110	1022	0011111010101110
1111111111	1023	1011000110010101

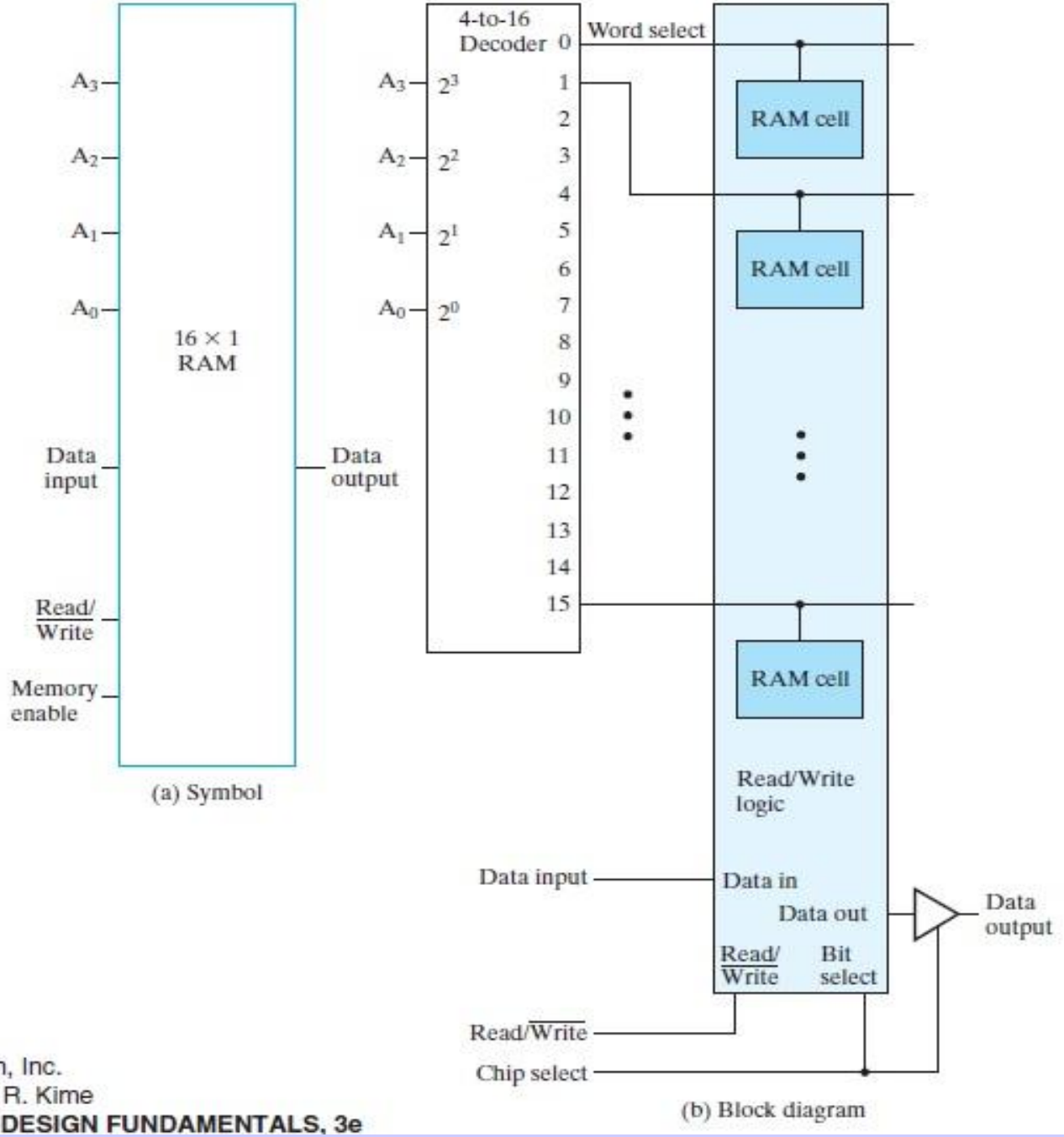
Random Access Memory (RAM)

- 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.

Random Access Memory (RAM)

- Block diagram of a memory unit:





Random Access Memory (RAM)

- 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*/$\overline{Write}$ to 0)
- The Read operation:
  - Transfers the address of the desired word to the address lines
  - Activates the *Read* control line (set *Read*/$\overline{Write}$ to 1)

Random Access Memory (RAM)

- The Read/Write operation:

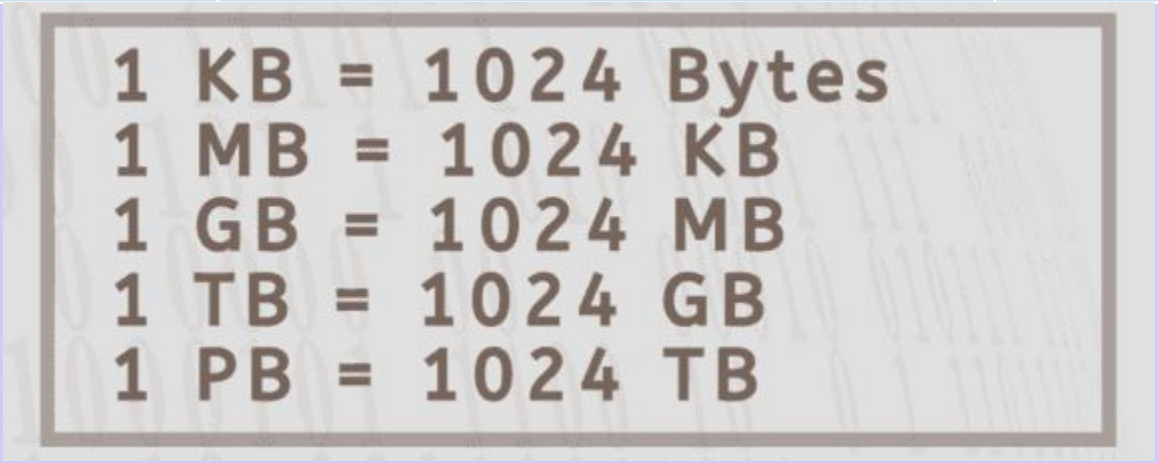
Memory Enable	*Read/Write*	Memory Operation
0	X	None
1	0	Write to selected word
1	1	Read from selected word

- 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

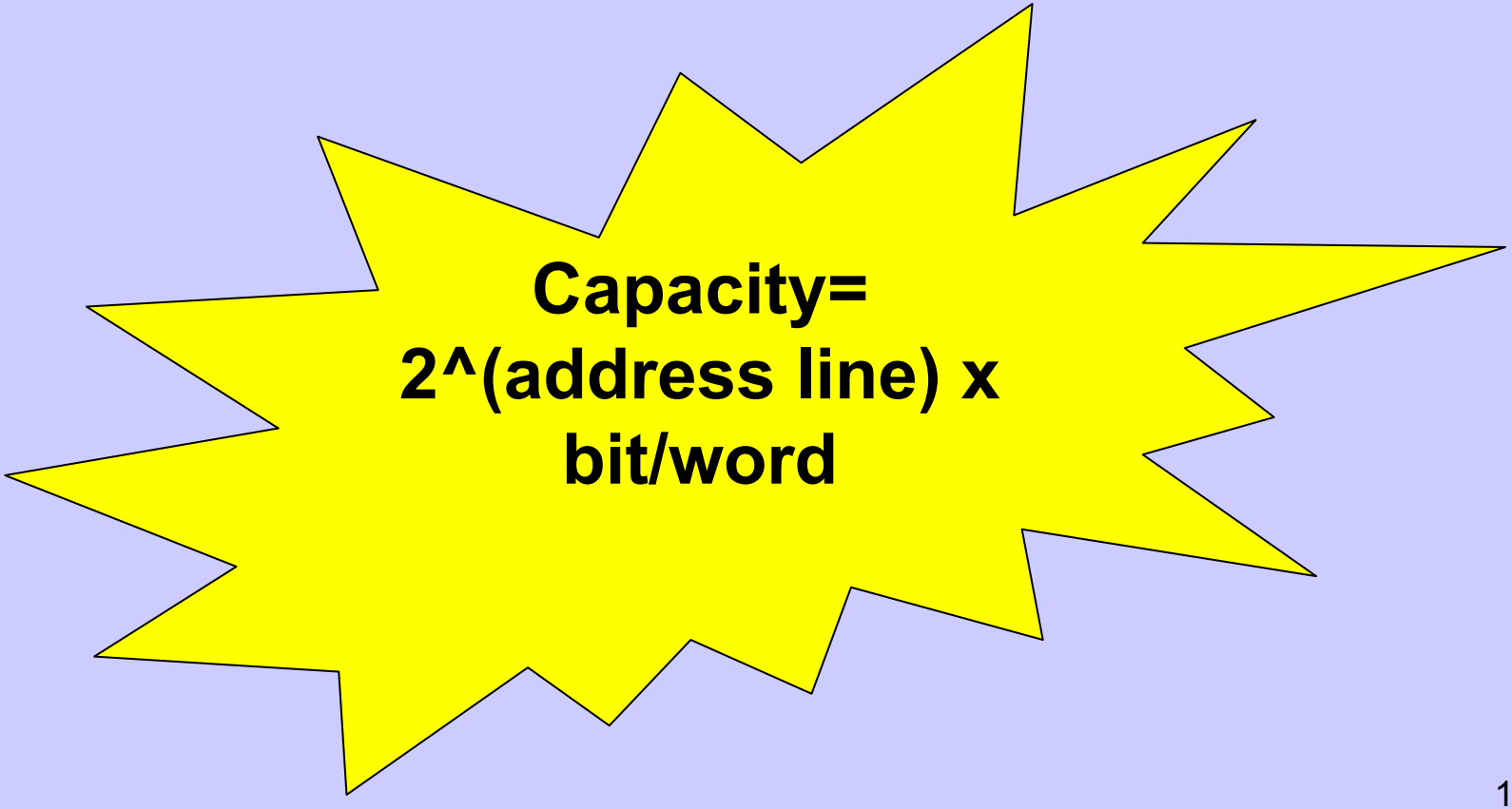
- Memory sizes might be specified in bits or byte(=8bit)
- Symbol: Bytes (B) and bits(b)
- Example, 2^28 b = 2^28/8 B= 2^28/2^3 B=2^25 B= 2^5*2^20 B = 32 MB

	Prefix	Base 2	Base 10
K	Kilo	2^10= 1024	10^3=1,000
M	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



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 2^{16} X 16 memory:
  - A: 256 KB
  - B: 1 MB
  - C: 128 KB
  - D: 512 KB

- Solution: c

= 2^16 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

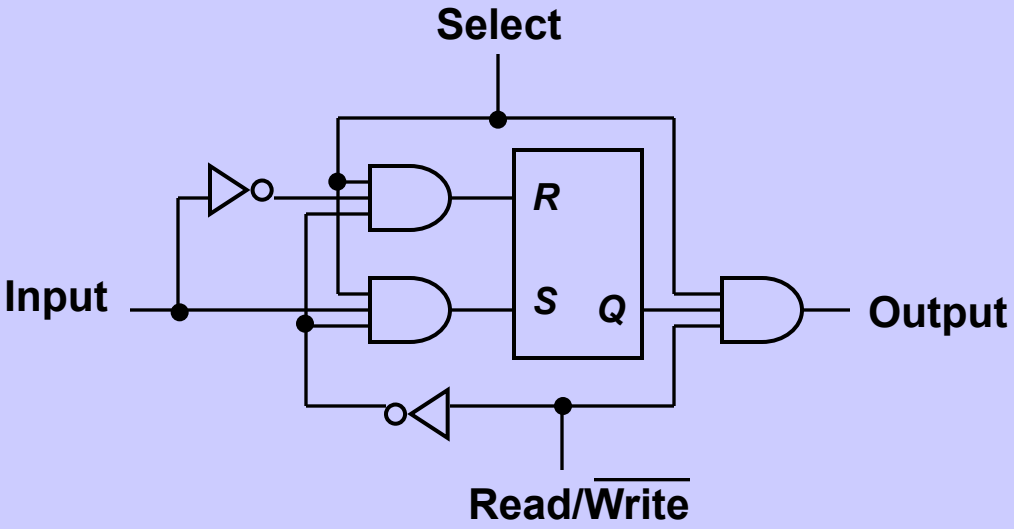
no. of address lines = 24

Binary cell

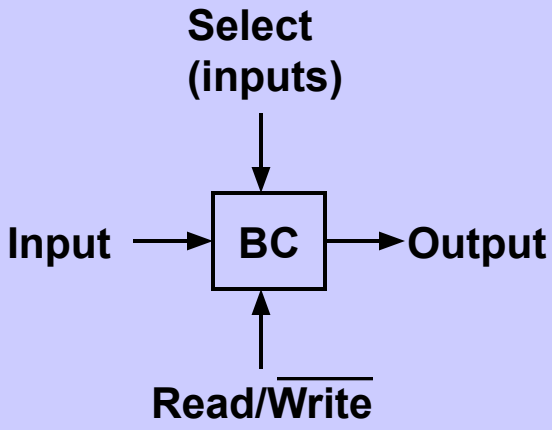
- Must be small so that many binary cell (BC) can fit in a small area
- Select input enable cell for reading/writing
- Read/write determines operation to be preformed on cell. A **1 in read/write** input forms a path to the output terminal. A **0 in read/write** input, information in the input terminal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

Random Access Memory (RAM)

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



Logic diagram



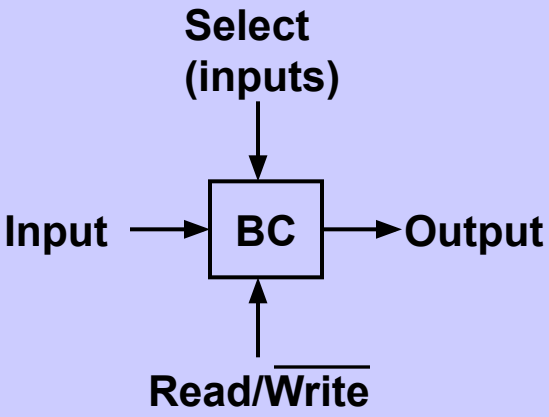
Block diagram

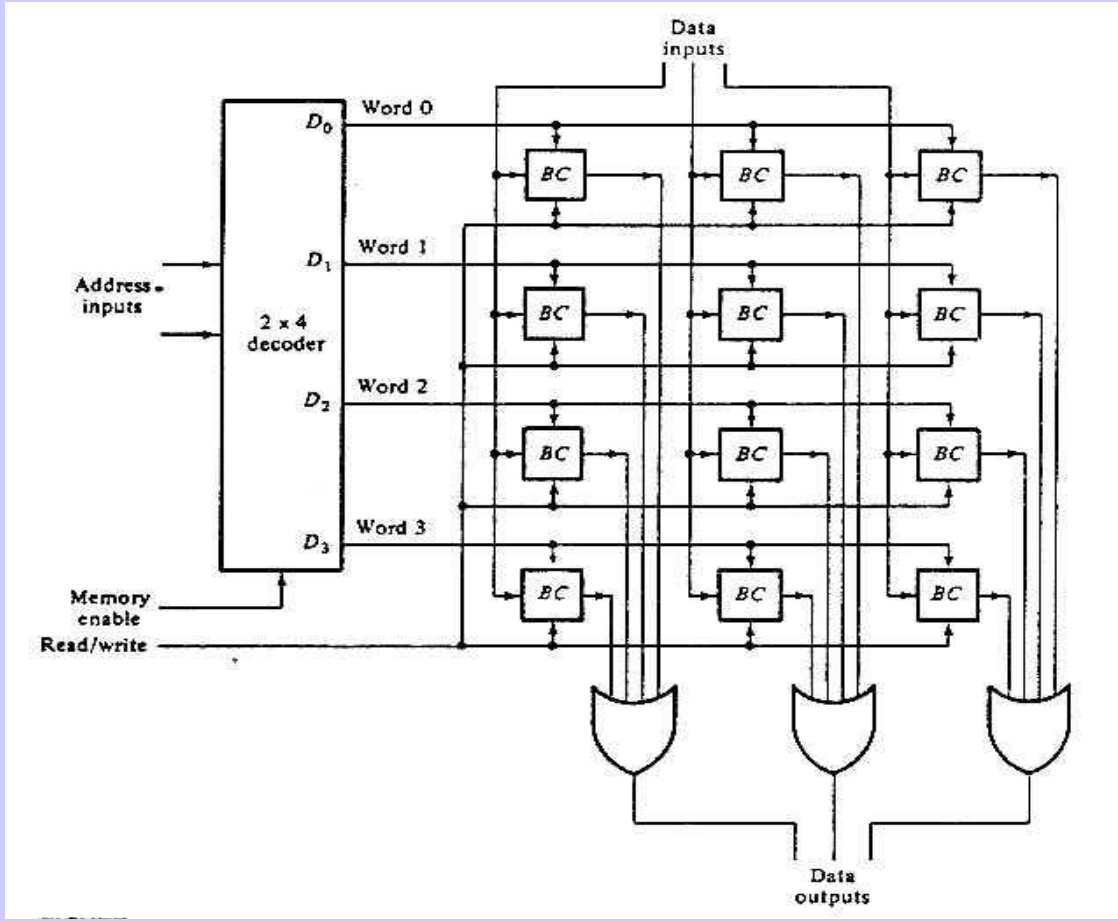
Random Access Memory (RAM)

of word

Bit/word

- Logic construction of a 4 x 3 RAM (with decoder and OR gates):





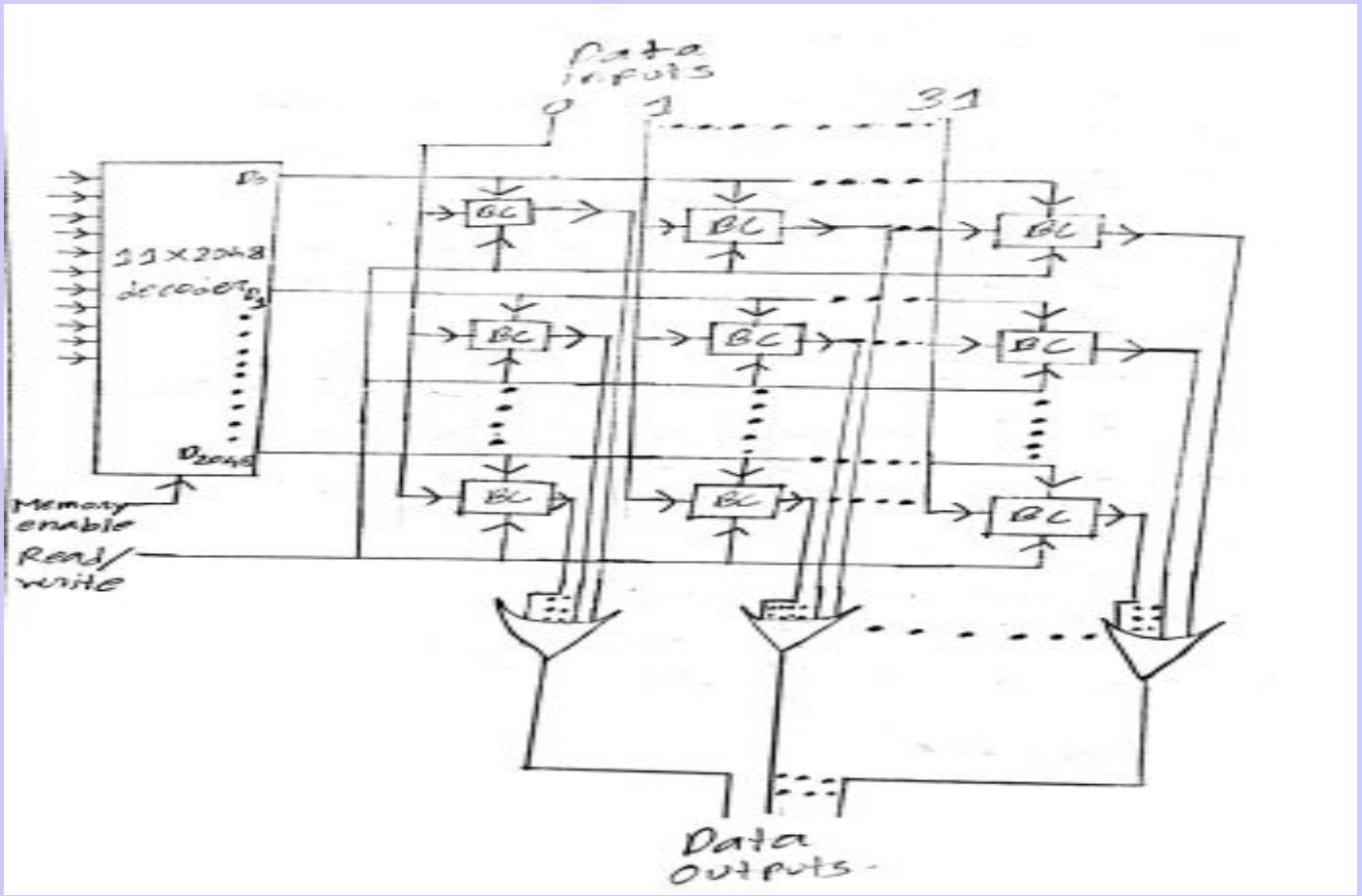
- Since no of word is 4, that would be equivalent to the decoder's output. Since, the decoder will have 4 outputs, so we should use a 2x4 decoder

Random Access Memory (RAM)

of word

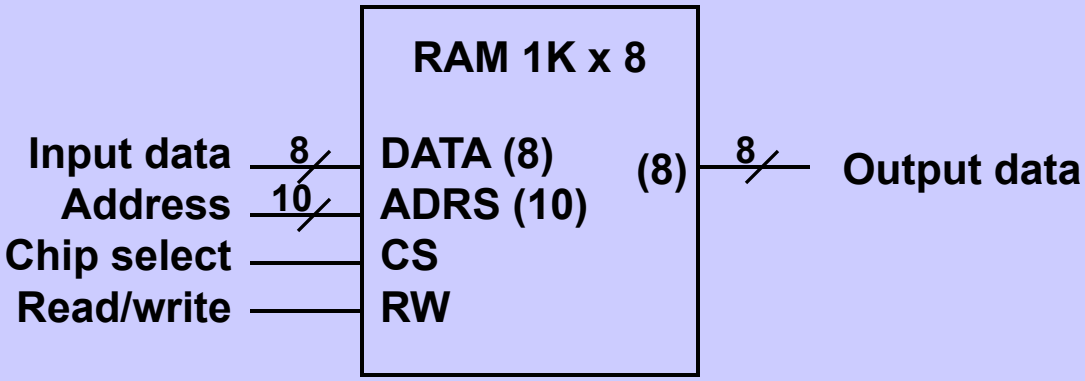
Bit/word

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



Random Access Memory (RAM)

- 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