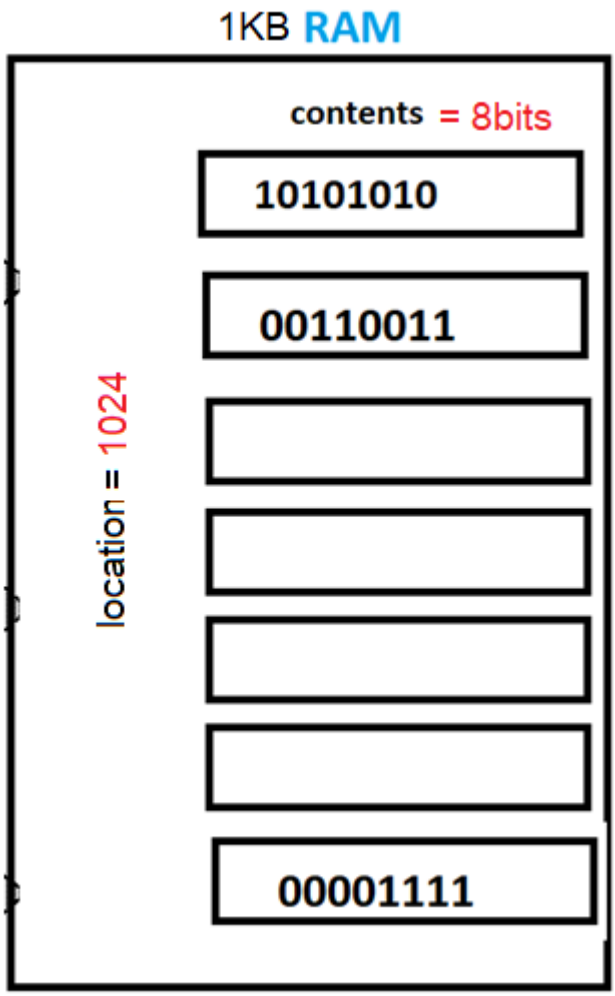
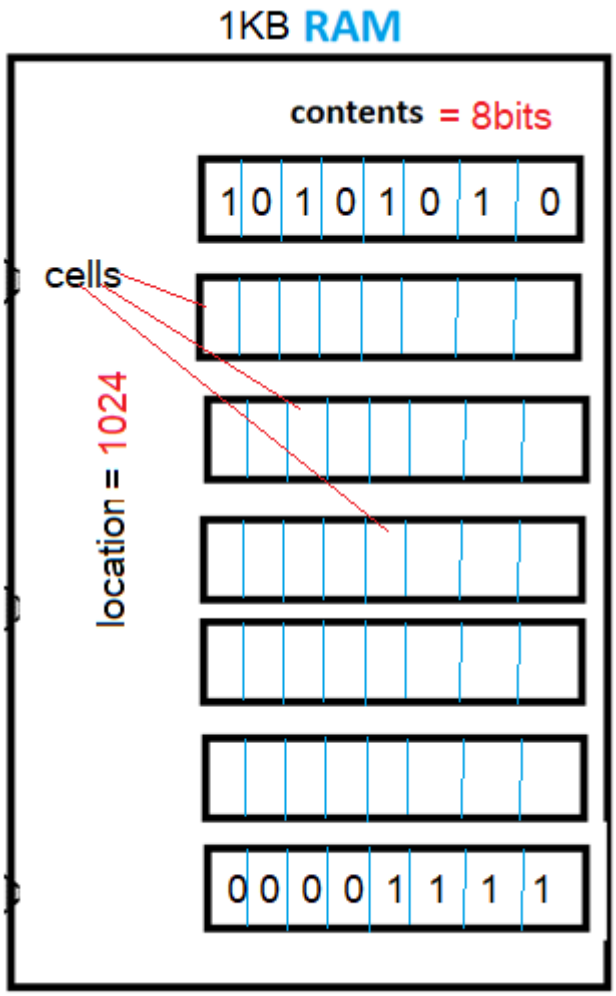
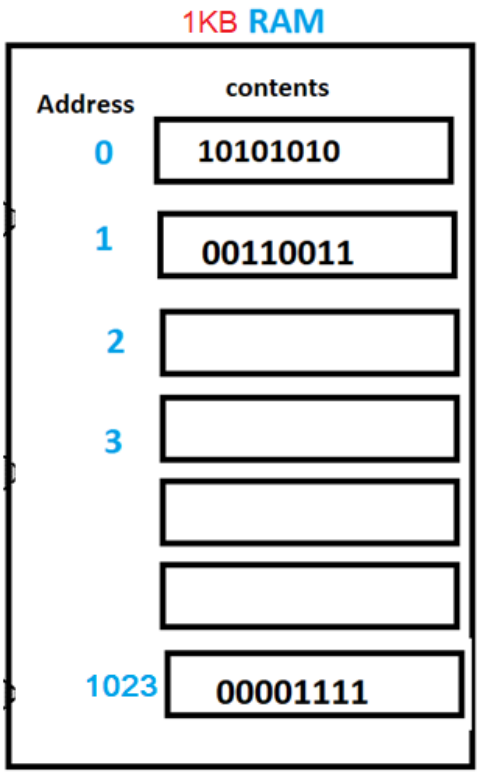
Sample questions: Lec-2

	What is stored program computer? User programs and data are represented in binary and can be stored in secondary storage. In this model, programs can be modified easily like data. Binary coded program and data are loaded into RAM and then CPU processes machine codes sequentially but one at a time. Earlier approach to design computer was mainly hardware-based, called non-stored program computer. Electronic and electrical design required huge number of discrete components placed on many circuit-boards, connected with long wires, cables and switches of different types. To solve any problem, expert technicians and engineers had to designed, choose electrical and electronic components, placed those on boards and connected using wires and cables. There were no options to store/preserve the design for long. To solve another problem, similar steps were followed for the new design.
	How does CPU run a program? Computers are designed to follow predefined number of steps to run any program. The steps are: a) Programs written in high level language are compiled to generate a list of instructions by compilers. b) Instructions are converted into machine codes by assembler. c) Machine coded and binary codes of data are stored to secondary storage. d) Machine codes and data are loaded into RAM e) CPU reads first machine code, it means, machine code of 1^{st} instruction is copied from RAM to a register within the CPU. f) Machine code of instruction is decoded at the control unit. g) Control unit will decode instruction, it means, a number of control signals are generated in a sequence to activate a particular circuit within ALU, activate registers or RAM so that data are transferred to ALU from sources indicated in machine codes, operation is performed electronically and finally stored to register field as pointed in the machine code. h) Above steps are repeated for each instruction in the list.
	How memory (RAM) is designed/organized? Memory (RAM) is a semiconductor device and is designed as an array of storage location where each location can store/hold a number of bits. Given the Capacity, number of storage locations and number of bits stored in each location can be defined. For example, in 1KB memory Number of locations is defined by first part 1K which is $2^{10} = 1024$ Number of bits in each location is 8 bits which is usually represented by B for byte.



It is to be noted that, in RAM, an elementary electronic circuit/system is designed to hold/store 1 bit, called cell.

	 Memory devices are designed as a matrix of cells. For example, a 1KB RAM contains 1024 x 8 = 8196 cells and cells are arranged in 1024 rows and 8 columns. It is also noted that all cells in any row are used together to hold either binary data or binary machine code. Moreover, it is noted that each cell is designed using a number of transistors or a combination of one transistor and one capacitor.
	What is Read operation? Content of a location of RAM is copied to a register within CPU.
	What is Write operation? Content of a Register is copied/saved to a location of RAM.
	What is memory address? Each memory location is uniquely identified by a code, called address. CPU uses this code to specify a location for READ/WRITE operation. Addresses are numbers assigned sequentially to memory locations, starting with 0 for the first storage location and number for highest location depends on total locations of memory device.



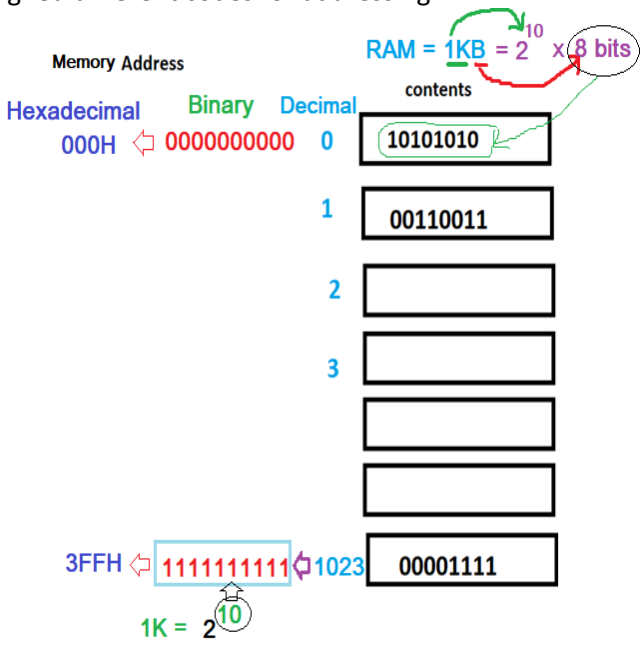
How many addresses are represented?

Memory addresses are usually represented in binary. However, a long string of binary 1's and 0's are represented in Hexadecimal codes for ease of writing in programs and discussions.

Given the number of locations, minimum number of binary bits are calculated to form unique codes for all locations. Same number of binary bits are used to form addresses for all locations.

Example: for 1KB RAM

The minimum number of bits required to form address each location uniquely identified is 10 bits. If the decimal code for highest location is converted in binary, it is: 1111111111, means, it requires 10 bits. Another way, the same value could be obtained by representing the number of addressable location in terms of 2^n. In 1KB memory, 1K = 2^{10} and 10 is the minimum number of bits required to form address so that all locations are assigned different codes for addressing.



For ease of writing, a long strings of 1's and 0's are converted into Hexadecimal format by replacing 4-bits binary groups with corresponding hexadecimal digits.
Example: 1111111111

Binary	00 11	1111	1111
Hexadecimal	3	F	F

What is the minimum number of bits required to form address for 16KB memory?
$16K = 2^4 \times 2^{10} = 2^{14}$, so 14 bits are required.

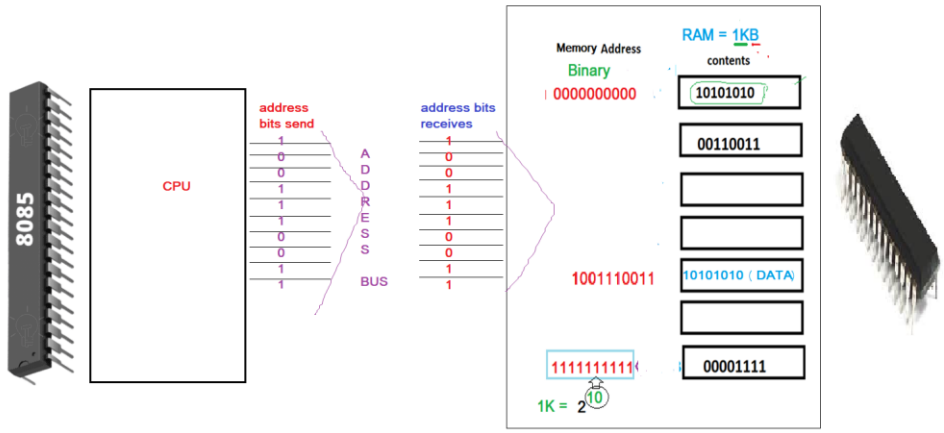
What is the minimum and maximum memory address for 16KB memory in binary and hexadecimal formats?

	Minimum address	Maximum address
Binary	00000000000000	11 1111 1111 1111
Hexadecimal	0000H	3 F F F H

Here H is the notation for hexadecimal number format.
…

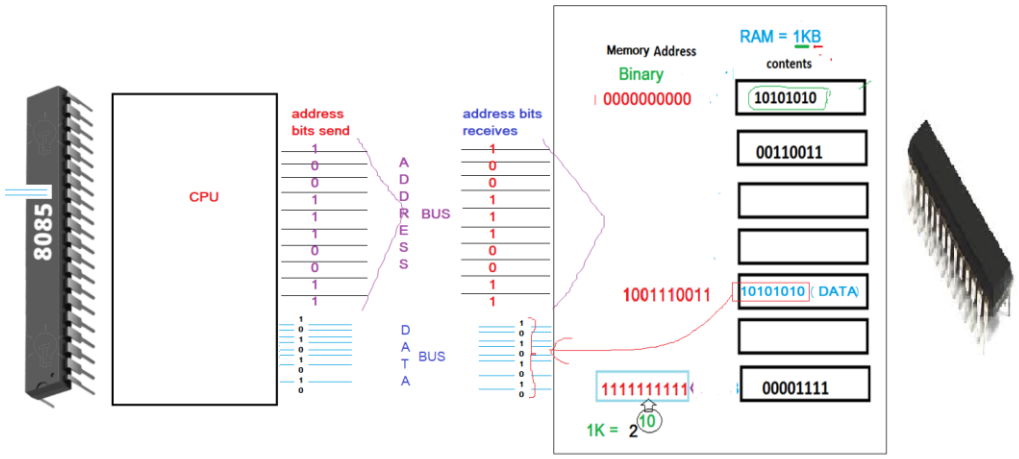
What is byte addressable memory?
If content of each addressable location is 8 bits, called byte addressable memory.
Example: 1KB, 16KB, 1MB etc are byte addressable memory devices.

How does CPU send address to memory device?
Each CPU has some pins, called address pins/bus, to send address information to Memory. Similarly each memory device has some pins, called address pins/bus to receive address information from CPU.

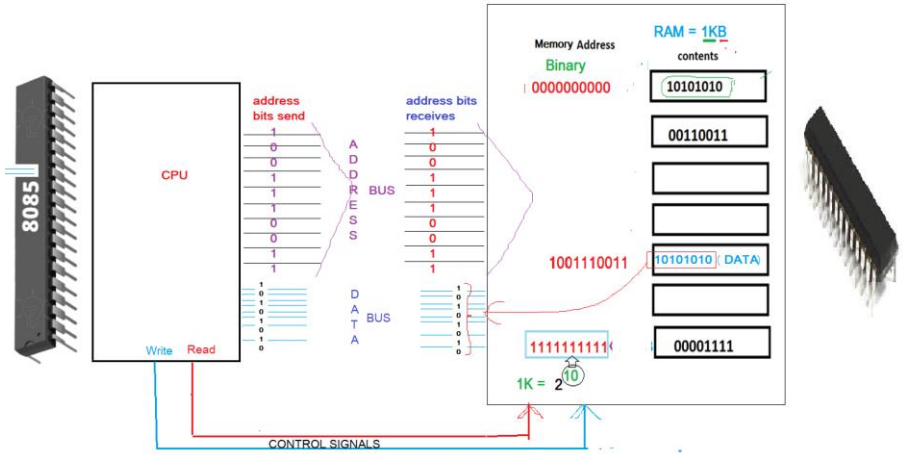


The number of address pins, called size of address bus, should be same for CPU and Memory. These pins are connected.

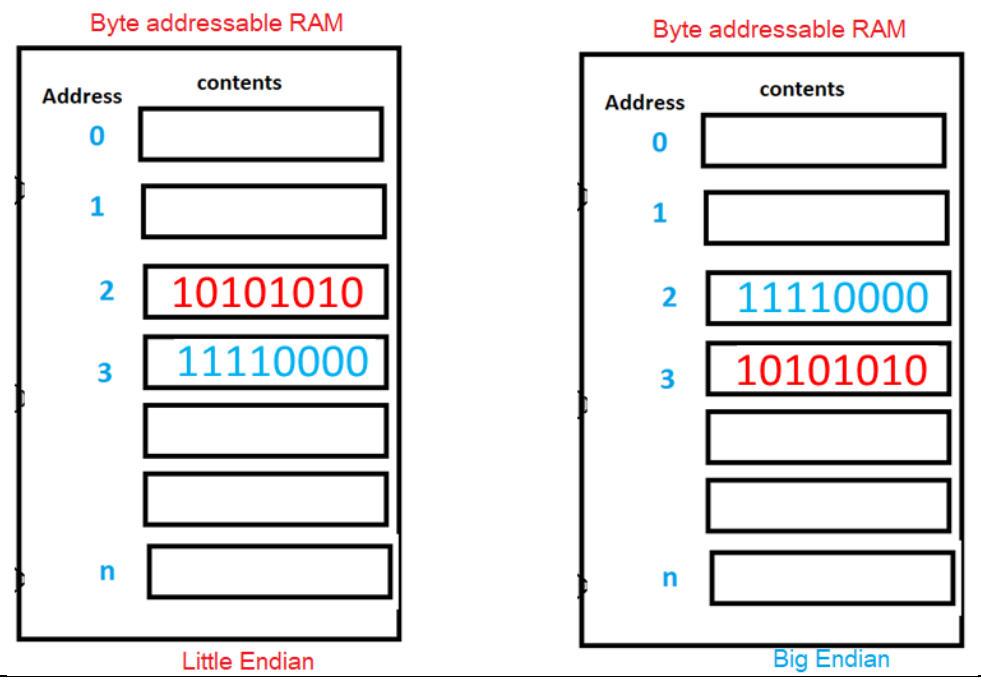
How data is transferred from CPU to Memory and from memory to CPU.
Both CPU and Memory devices have some pins for data transfer, called data pins/data bus and these pins are connected. Contents of memory are received at CPU through data bus during read operation. The same pins are used to send data from CPU to RAM during write operation.



How read and write operations are selected/activated?
Both CPU and memory devices have two control pins, called Read and Write and corresponding pins are connected as shown below:



How 16 bits data are stored in a Byte addressable RAM?
To save a 16-bit data to a byte addressable RAM, two consecutive memory locations are used.
Example: Example: 11110000 10101010
The 16-bit data is split into two halves each of 8-bits. The lower 8-bits are called least significant Byte (LSB) and upper 8-bits are called Most significant Byte (MSB).
In Little endian system, LSB is saved to lower address and MSB is saved to higher address of RAM.
In Big endian system, MSB is saved to lower address whereas LSB is saved to higher address of RAM.



How 32 bits data are stored in a Byte addressable RAM?
Example: 00001111 10101010 11001100 01010101