AKTU

GATEWAY CLASSES

B.Tech- II Year

COA

Unit -5

Abhilasha ma'am

Gateway Classes : 7455 961284

UNIT 5 : Input / Output

Lec 1

Today's Target

- Peripheral devices
- I/O Interface
- Purpose of the Communication Link
- Input / Output Ports
- Interrupt
- University Questions

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University Questions

Year	Questions	Marks
2022-23	List down the functions performed by an Input/Output unit.	2 Marks
2022-23	Define interrupt. Also discuss different types of interrupt.	10 Marks
2022-23	Discuss the design of a typical input or output interface.	10 Marks

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Peripheral devices

- A peripheral device is an internal or external device that connects directly to a computer or other digital device but does not contribute to the computer's primary function, such as computing.
- It helps end users access and use the functionalities of a computer.
- Peripheral device, including sensors, are used to enter information and instructions into a computer for storage or processing and to deliver the processed data to a human operator or, in some cases, a machine controlled by the computer.

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Input Devices

Processing Devices

Output Devices

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I/O Interface

- Input Output interface is used as an method which helps in transferring of information between the internal storage devices i.e. memory and the external peripheral device.
- A peripheral device is that which provide input and output for the computer, it is also called Input-Output devices. For Example: A keyboard and mouse provide Input to the computer are called input devices while a monitor and printer that provide output to the computer are called output devices.
- Just like the external hard-drives, there is also availability of some peripheral devices which are able to provide both input and output.

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Purpose of the Communication Link

The purpose of the communication link is to resolve the differences that exist between the central computer and each peripheral. The major differences are:

1) Peripherals are electromechanical and electromagnetic devices and their manner of operation is different from the operation of the CPU and memory, which are electronic devices. Therefore, a conversion of signal values may be required.

2) The data transfer rate of peripherals is usually slower than the transfer rate of the CPU, and consequently, a synchronization mechanism may be needed.

3) Data codes and formats in peripherals differ from the word format in the CPU and memory.

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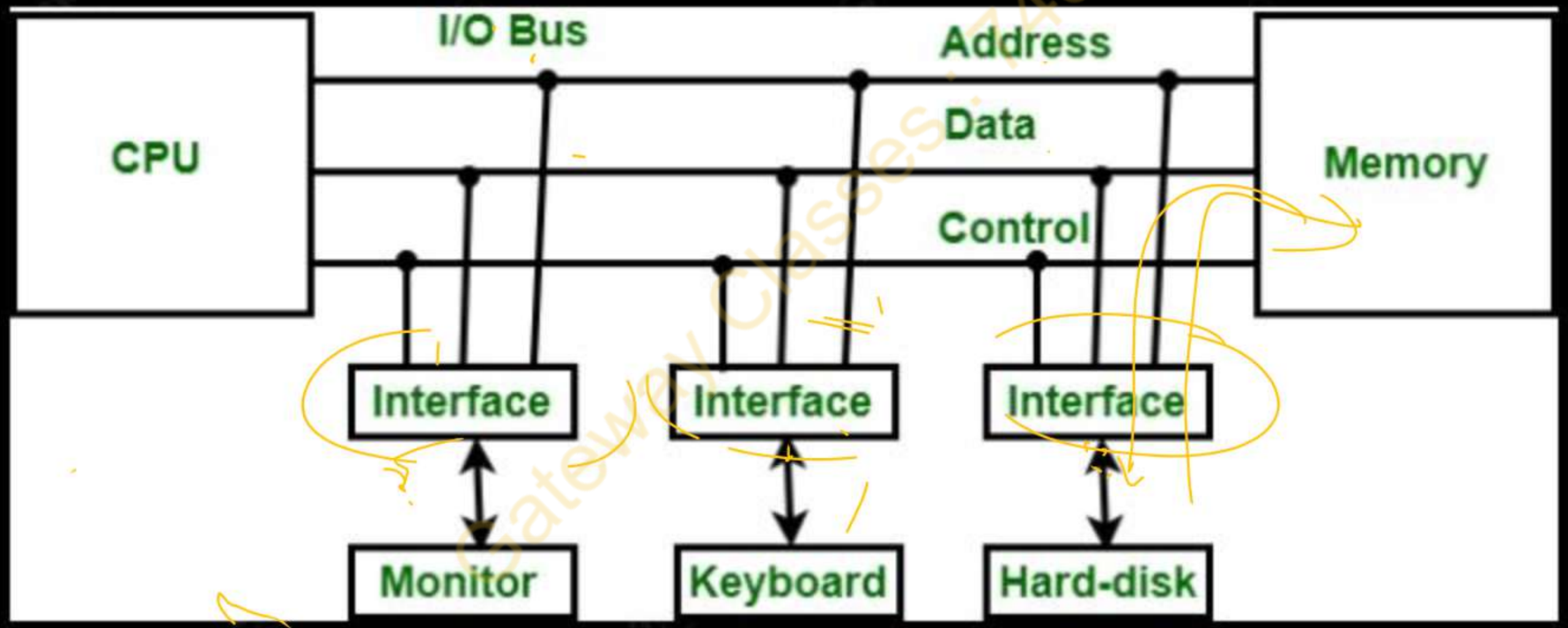
- To resolve these differences, computer systems include special hardware components between the CPU and peripherals to supervise and synchronize all input and output transfers.
- These components are called interface units because they interface between the processor bus and the peripheral device.



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I/O Interface

- In addition to communicating with I/O, the processor must communicate with the memory
- unit. There are three ways that computer buses can be used to communicate with memory
- and I/O:

1) Use two separate buses, one for memory and the other for I/O.
2) Use one common bus for both memory and I/O but have separate control lines for each.
3) Use one common bus for memory and I/O with common control lines.

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Input / Output Ports

- A connection point that acts as interface between the computer and external devices like mouse, printer, modem, etc. is called port.
- Ports are of two types –

Internal port – It connects the motherboard to internal devices like hard disk drive, CD drive, internal modem, etc.

External port – It connects the motherboard to external devices like modem, mouse, printer, flash drives, etc.

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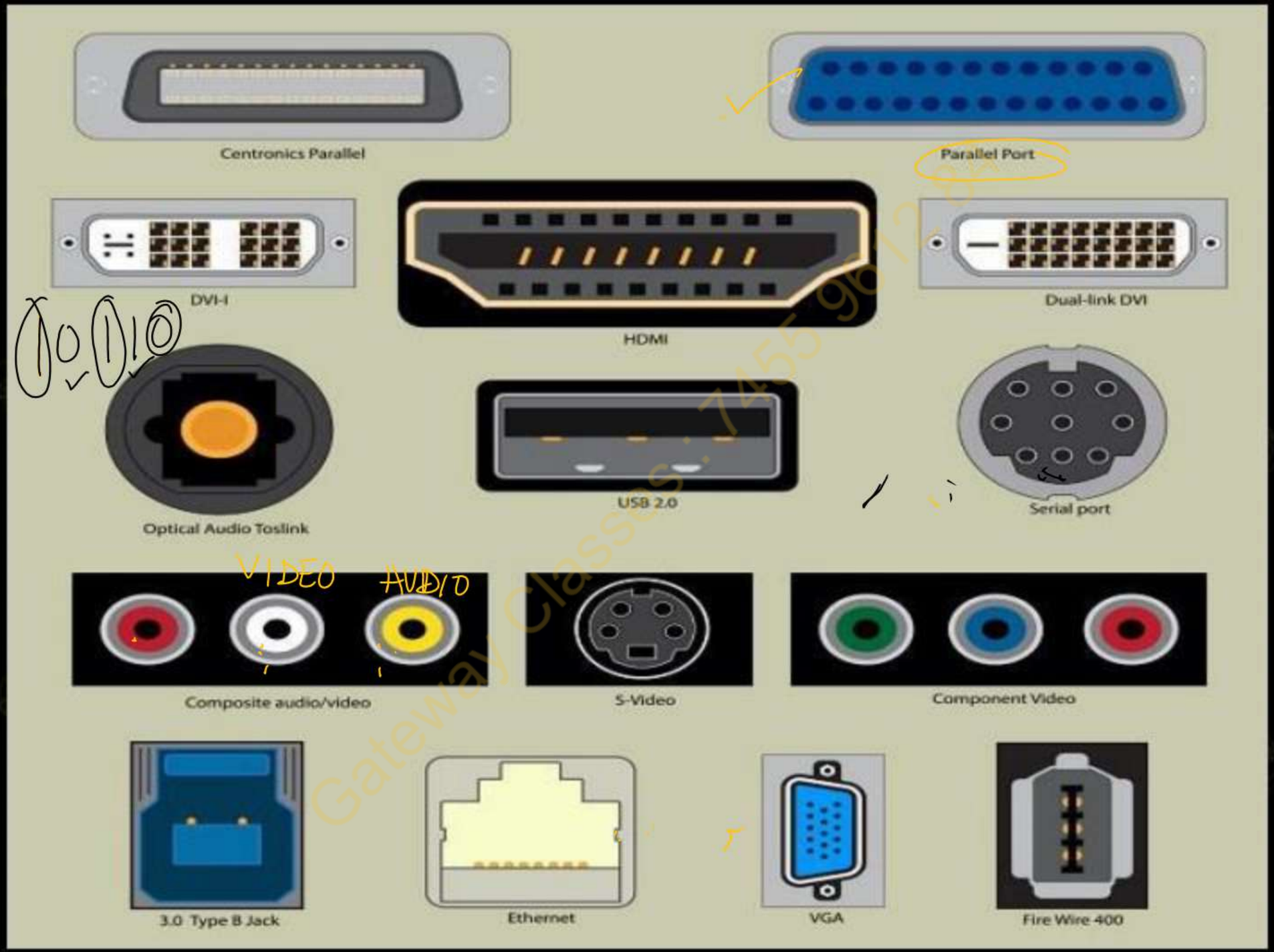
Centronics Parallel
Parallel Port
DVI-I
HDMI
Dual-link DVI
Optical Audio Toslink
USB 2.0
Serial port
VIDEO
AUDIO
Composite audio/video
S-Video
Component Video
3.0 Type B Jack
Ethernet
VGA
Fire Wire 400

Serial Port

- Serial ports transmit data sequentially one bit at a time.
- So they need only one wire to transmit 8 bits.
- However it also makes them slower.
- Serial ports are usually 9-pin or 25-pin male connectors.
- They are also known as COM (communication) ports or RS323C ports

1011 0100

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Parallel Port

- Parallel ports can send or receive 8 bits or 1 byte at a time.
- Parallel ports come in form of 25-pin female pins and are used to connect printer, scanner, external hard disk drive, etc.

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USB Port

- USB stands for Universal Serial Bus.
- It is the industry standard for short distance digital data connection.
- USB port is a standardized port to connect a variety of devices like printer, camera, keyboard, speaker, etc.

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Other Ports

PS-2 Port

- PS/2 stands for Personal System/2.
- It is a female 6-pin port standard that connects to the male mini-DIN cable.
- PS/2 was introduced by IBM to connect mouse and keyboard to personal computers.
- This port is now mostly obsolete, though some systems compatible with IBM may have this port.

Infrared Port

- Infrared port is a port that enables wireless exchange of data within a radius of 10m.
- Two devices that have infrared ports are placed facing each other so that beams of infrared lights can be used to share data.

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Other Ports

Bluetooth Port

- Bluetooth is a telecommunication specification that facilitates wireless connection between phones, computers and other digital devices over short range wireless connection.
- Bluetooth port enables synchronization between Bluetooth-enabled devices.

There are two types of Bluetooth ports –

Incoming – It is used to receive connection from Bluetooth devices.

Outgoing – It is used to request connection to other Bluetooth devices.

FireWire Port

- FireWire is Apple Computer's interface standard for enabling high speed communication using serial bus.
- It is also called IEEE 1394 and used mostly for audio and video devices like digital camcorders.

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Interrupt

- A processor cannot send data to an I/O device unless it is ready to communicate with the processor.
- An interrupt is a SIGNAL sent by an I/O Interface (device) to processor.
- This interrupt indicate a processor that I am ready and you can communicate with me from now.
- Interrupts are a type of computer hardware signal that can be used to pause or temporarily stop a running process in order to allow another process to run.
- They can be generated by hardware devices or software programs.
- When a device is ready to communicate with the CPU, it generates an interrupt signal.
- A number of input-output devices are attached to the computer and each device is able to generate an interrupt request.
- The main job of the interrupt system is to identify the source of the interrupt.

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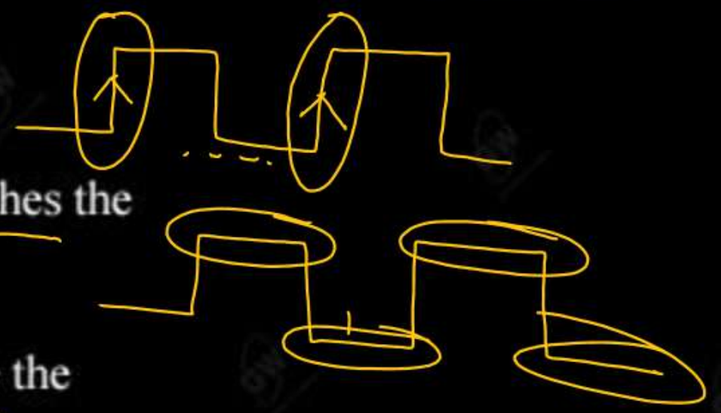
Types of Interrupt

Hardware and software interrupt

- Hardware interrupts are generated by external devices or hardware and are used to communicate with the processor that they require immediate attention.
- Software interrupts are generated by the processor itself and are used to indicate that a certain event has occurred that needs to be handled.

Vectored and Non- vectored Interrupt



- Vectored-When an interrupt is occurred and program control automatically braches the program execution to a specific address
- Non-vectored: When an interrupt device have to provide an address from where the execution of program will begin

Mask able and non-maskable interrupt

- Maskable Interrupt - An Interrupt that can be disabled or ignored by the instructions of CPU are called as Maskable Interrupt. The interrupts are either edge-triggered or level-triggered . Eg: RST6.5,RST7.5,RST5.5 of 8085
- **Non-Maskable Interrupt :** An interrupt that cannot be disabled or ignored by the instructions of CPU are called as Non-Maskable Interrupt. A Non-maskable interrupt is often used when response time is critical or when an interrupt should never be disable during normal system operation. Eg: Trap of 8085

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Hardware Interrupt	Software Interrupt
Hardware interrupt is an interrupt generated from an external device or hardware.	Software interrupt is the interrupt that is generated by any internal system of the computer.
It do not increment the program counter.	It increment the program counter.
Hardware interrupt can be invoked with some external device such as request to start an I/O or occurrence of a hardware failure.	Software interrupt can be invoked with the help of INT instruction.
It has lowest priority than software interrupts	It has highest priority among all interrupts.
Hardware interrupt is triggered by external hardware and is considered one of the ways to communicate with the outside peripherals, hardware.	Software interrupt is triggered by software and considered one of the ways to communicate with kernel or to trigger system calls, especially during error or exception handling.

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Hardware Interrupt	Software Interrupt
It is an asynchronous event.	It is synchronous event.
Hardware interrupts can be classified into two types they are: 1. Maskable Interrupt. 2. Non Maskable Interrupt.	Software interrupts can be classified into two types they are: 1. Normal Interrupts. 2. Exception
Keystroke depressions and mouse movements are examples of hardware interrupt.	All system calls are examples of software interrupts

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Vectored Interrupt	Non Vectored Interrupt
Are those interrupt which are directly connected to a processor and their address is known	Not always directly connected to a processor and their interrupt address is also unknown
Have fixed memory location for transfer of control for normal execution	Do not have fixed memory location for transfer of control for execution
Have a memory address	Do not have a memory address
Low response time	High response time
TRAP is a vectored interrupt	INTR is a non vectored interrupt
Vectored Interrupt	Non Vectored Interrupt
Are those interrupt which are directly connected to a processor and their address is known	Not always directly connected to a processor and their interrupt address is also unknown

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Maskable Interrupt	Non Maskable Interrupt
Maskable interrupt is a hardware Interrupt that can be disabled or ignored by the instructions of CPU.	A non-maskable interrupt is a hardware interrupt that cannot be disabled or ignored by the instructions of CPU.
When maskable interrupt occur, it can be handled after executing the current instruction.	When non-maskable interrupts occur, the current instructions and status are stored in stack for the CPU to handle the interrupt.
Maskable interrupts help to handle lower priority tasks.	Non-maskable interrupt help to handle higher priority tasks such as watchdog timer.
Maskable interrupts used to interface with peripheral device.	Non maskable interrupt used for emergency purpose e.g power failure, smoke detector etc .

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Maskable Interrupt	Non Maskable Interrupt
In maskable interrupts, response time is high.	In non maskable interrupts, response time is low.
It may be vectored or non-vectored.	All are vectored interrupts.
Operation can be masked or made pending.	Operation Cannot be masked or made pending.
RST6.5, RST7.5, and RST5.5 of 8085 are some common examples of maskable Interrupts.	Trap of 8085 microprocessor is an example for non-maskable interrupt.

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What happens when an interrupt occurs

- Whenever an interrupt occurs, it causes the CPU to stop executing the current program.
- Then comes the control to interrupt handler or interrupt service routine.

The steps in which ISR handle interrupts are as follows –

Step 1 – When an interrupt occurs let assume processor is executing i'th instruction and program counter will point to the next instruction (i+1)th.

Step 2 – When an interrupt occurs the program value is stored on the process stack and the program counter is loaded with the address of interrupt service routine.

Step 3 – Once the interrupt service routine is completed the address on the process stack is popped and placed back in the program counter.

Step 4 – Now, it executes the resume for (i+1)th line.

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Multiple interrupts

- Multiple interrupt is an interrupt event which can occur while the processor is handling a previous interrupt.

For example – A program receiving data from a communication line and printing result there is a possibility for communication interrupt to occur while printer interrupt being processed.

- Ways to handle interrupts: There are two ways by which processor can handle interrupts

Disable interrupt – Processor will ignore further interrupts while processing one interrupt. Interrupts remain pending and are checked after the first interrupt has been handled. In this process interrupts are handled in sequence

Define priorities – In this method low priority interrupts can be interrupted by higher priority interrupts. Here, high priority interrupt will be handled then processor returns to previous interrupt on which it was earlier working.

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Priority Interrupt

- A priority interrupt is a system that establishes a priority over the various sources to determine which condition is to be serviced first when two or more requests arrive simultaneously.
- The system may also determine which conditions are permitted to interrupt the computer while another interrupt is being serviced.
- Higher-priority interrupt levels are assigned to requests which, if delayed or interrupted, could have serious consequences.
- Devices with high speed transfers such as magnetic disks are given high priority, and slow devices such as keyboards receive low priority.
- When two devices interrupt the computer at the same time, the computer services the device, with the higher priority first.

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Advantages & Disadvantages of Priority Interrupt

Adv

- Priority interrupts allow for the efficient handling of high-priority tasks that require immediate attention. This is especially important in real-time systems where certain tasks must be completed within strict time constraints.
- They are more efficient than software polling as the processor does not waste time constantly checking for events that have not occurred.
- Priority interrupts are also more deterministic, as the response time to an event can be accurately predicted based on its priority level.

Disadv.

- One potential disadvantage of priority interrupts is the possibility of lower priority tasks being starved of resources if high-priority tasks are continuously interrupting the processor.
- If not implemented properly, priority interrupts can lead to priority inversion, where a low-priority task holds a resource required by a higher-priority task, causing a delay in the high-priority task's execution.

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SOFTWARE METHOD – POLLING

- In this method, all interrupts are serviced by branching to the same service program.
- This program then checks with each device if it is the one generating the interrupt.
- The order of checking is determined by the priority that has to be set.
- The device having the highest priority is checked first and then devices are checked in descending order of priority.
- If the device is checked to be generating the interrupt, another service program is called which works specifically for that particular device.
- The major disadvantage of this method is that it is quite slow.
- To overcome this, we can use hardware solution, one of which involves connecting the devices in series. This is called Daisy-chaining method.

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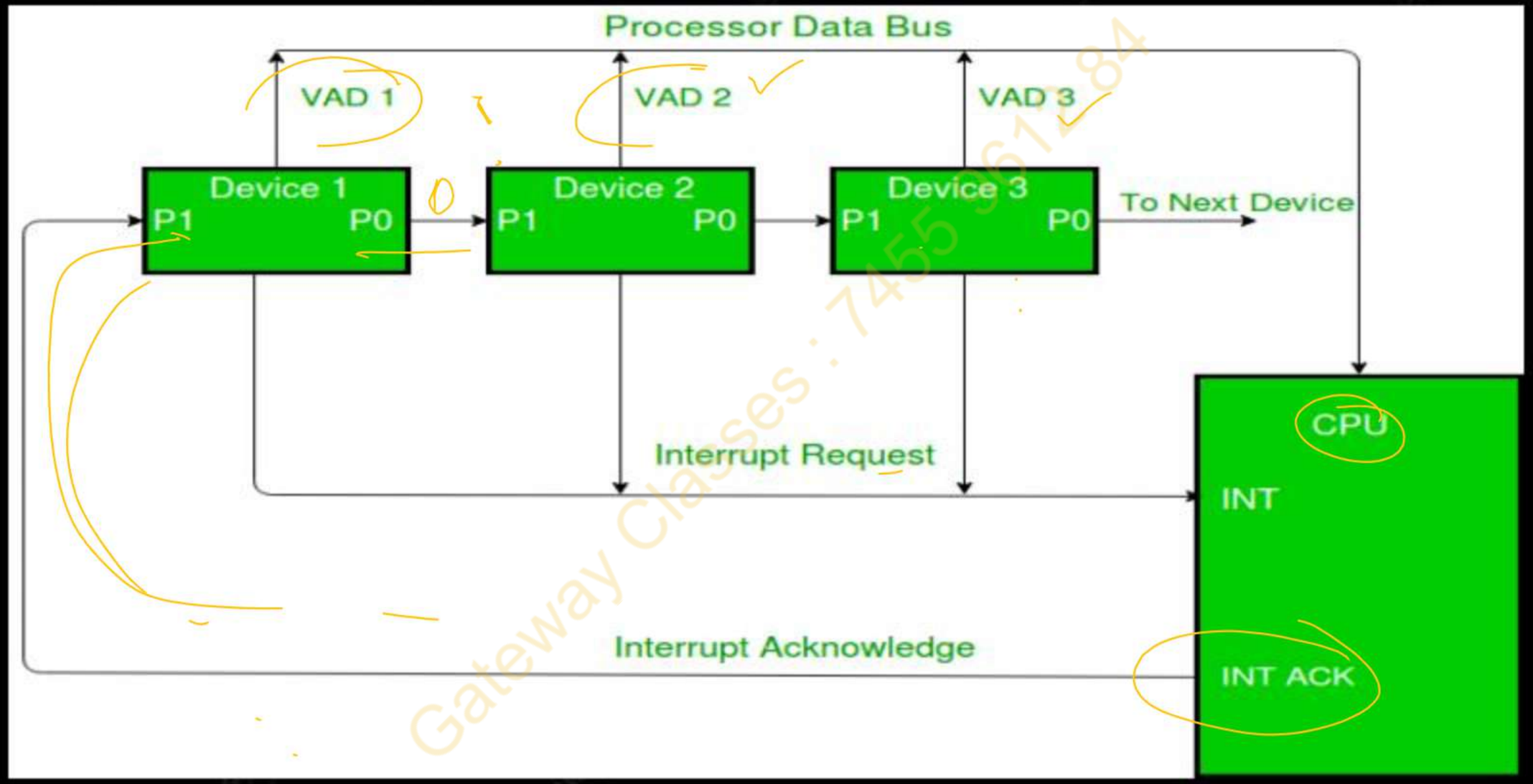

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University Questions

Year	Questions	Marks
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UNIT 5 : Input / Output
Lec 2

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Today's Target

- Data Transfer
- Modes of data transfer
- Programmed I/O
- Interrupt Initiated I/O
- **Isolated I/O**
- Memory Mapped I/O

What is data transfer in computer architecture?

- Data transfer is the process of moving data from one location to another.
- In computer architecture, data transfer is the movement of data

➢ from one Register to another,

➢ from one Memory location to another,

➢ from one I/O device to another.

- It is important to ensure that the data is transferred securely, to avoid any unauthorized access or disclosure.
- A computer is interfaced with many devices of different speeds. Therefore, I/O devices may not be ready to transfer data as soon as the microprocessor issues the instruction for this purpose. Many data transfer schemes have been developed to solve this problem.

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Modes of data transfer

- There are three different modes of transfer:
  - Programmed I/O,
  - Interrupt-initiated I/O, and
  - Direct Memory Access (DMA).

IN 01H

OUT 02H

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Programmed I/O :

- In this mode the data transfer is initiated by the instructions written in a computer program.
- With programmed I/O, data are exchanged between the processor and the I/O module.
- The processor executes a program that gives it direct control of the I/O operation, including sensing device status, sending a read or write command, and transferring the data.
- When the processor issues a command to the I/O module, it must wait until the I/O operation is complete.
- If the processor is faster than the I/O module, this is wasteful of processor time.
- The overall operation of the programmed I/O can be summaries as follow:
- The processor is executing a program and encounters an instruction relating to I/O operation.
- The processor then executes that instruction by issuing a command to the appropriate I/O module.
- The I/O module will perform the requested action based on the I/O command issued by the processor (READ/WRITE) and set the appropriate bits in the I/O status register.
- The processor will periodically check the status of the I/O module until it find that the operation is complete.

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Programmed I/O Mode Input Data Transfer

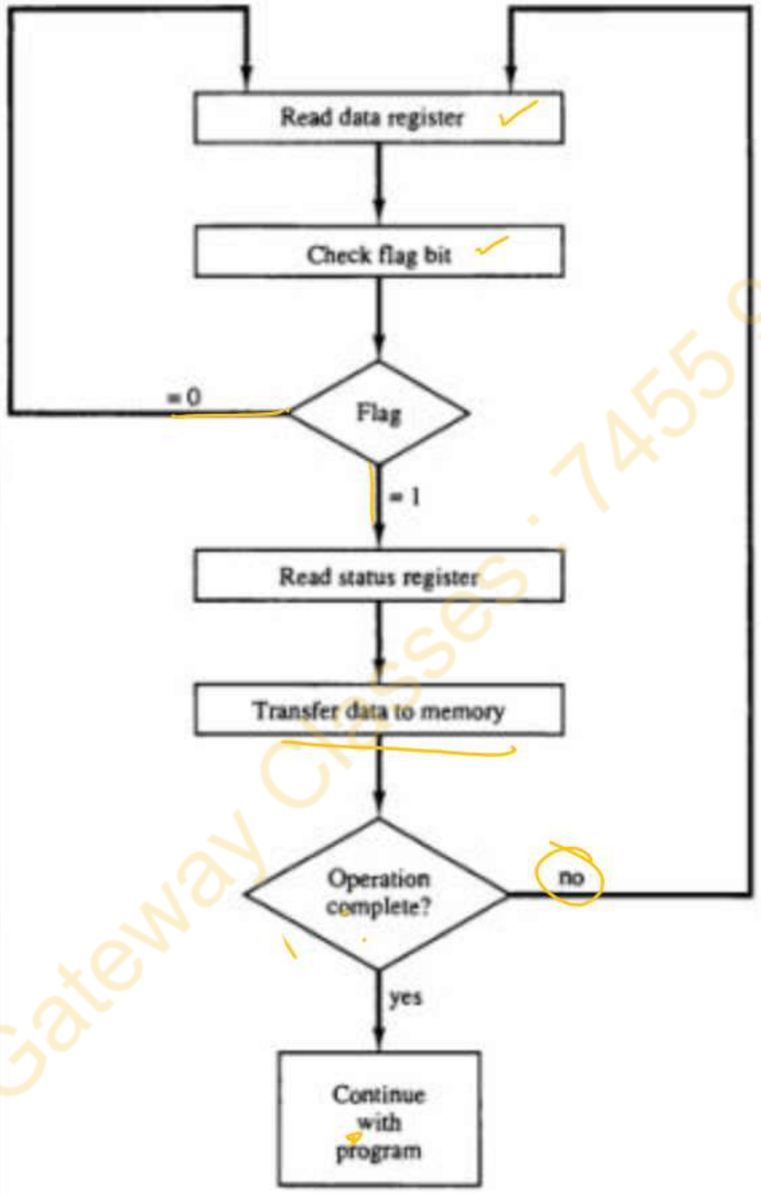

Figure 11 Flowchart for CPU program to input data.

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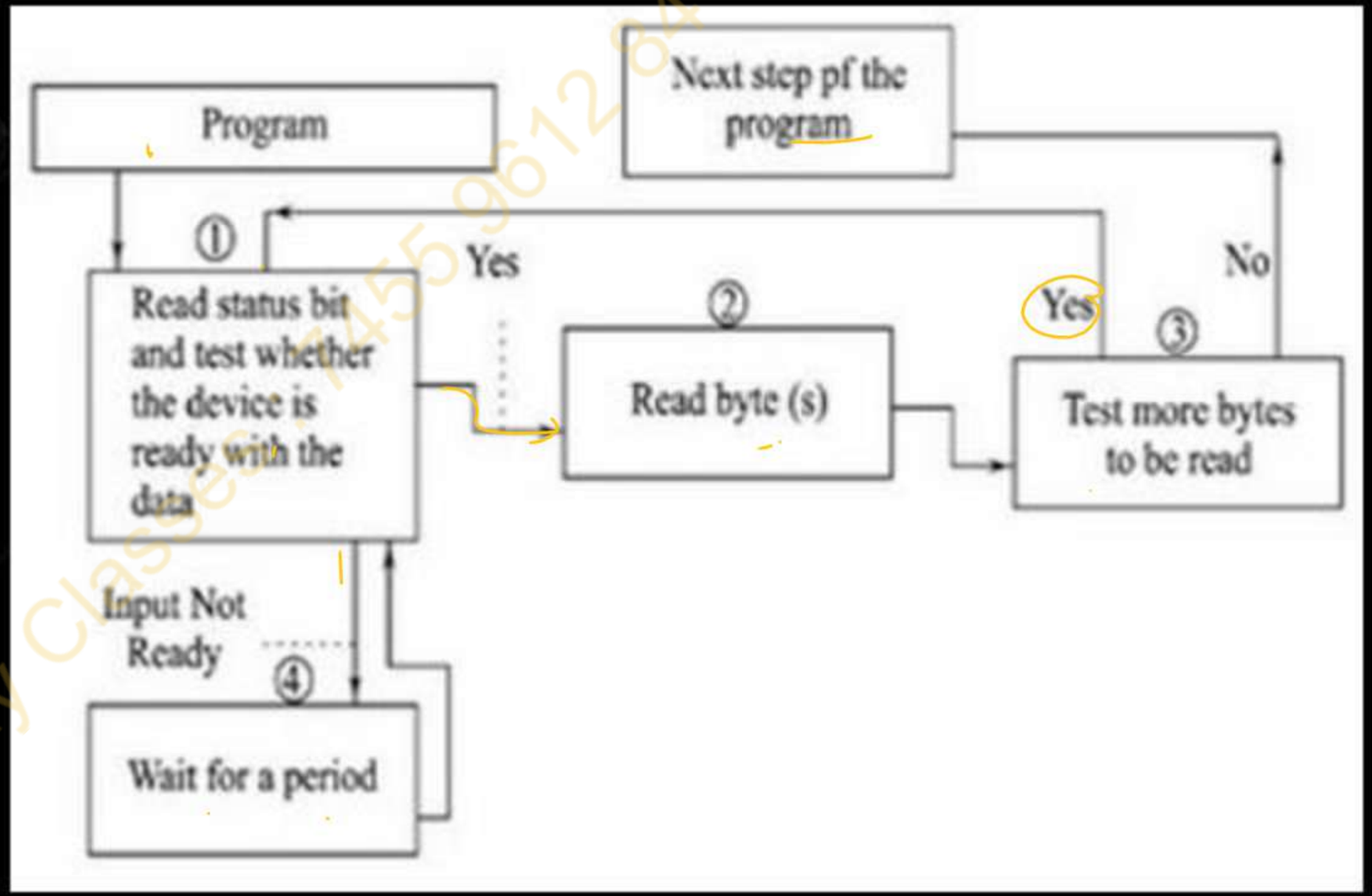
1) Each input is read after first testing whether the device is ready with the input (a state reflected by a bit in a status register).

2) The program waits for the ready status by repeatedly testing the status bit and till all targeted bytes are read from the input device.

3) The program is in busy (non-waiting) state only after the device gets ready else in wait state.



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I/O Commands

- To execute an I/O-related instruction, the processor issues an address, specifying the particular I/O module and external device, and an I/O command.
- There are four types of I/O commands that an I/O module may receive when it is addressed by a processor:

1) Control: Used to activate a peripheral and tell it what to do. For example, a magnetic-tape unit may be instructed to rewind or to move forward one record. These commands are tailored to the particular type of peripheral device.

2) Test: Used to test various status conditions associated with an I/O module and its peripherals. The processor will want to know that the peripheral of interest is powered on and available for use. It will also want to know if the most recent I/O operation is completed and if any errors occurred.

3) Read: Causes the I/O module to obtain an item of data from the peripheral and place it in an internal buffer. The processor can then obtain the data item by requesting that the I/O module place it on the data bus.

4) Write: Causes the I/O module to take an item of data (byte or word) from the data bus and subsequently transmit that data item to the peripheral.

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Advantages & Disadvantages of Programmed I/O

Advantages

- simple to implement
- very little hardware support

Disadvantages

- busy waiting
- ties up CPU for long period with no useful work

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Interrupt Initiated I/O :

- This mode uses an interrupt facility and special commands to inform the interface to issue the interrupt command when data becomes available and interface is ready for the data transfer.
- In the meantime CPU keeps on executing other tasks and need not check for the flag.
- When the flag is set, the interface is informed and an interrupt is initiated.
- This interrupt causes the CPU to deviate from what it is doing to respond to the I/O transfer.
- The CPU responds to the signal by storing the return address from the program counter (PC) into the memory stack and then branches to service that processes the I/O request.
- After the transfer is complete, CPU returns to the previous task it was executing.
- The branch address of the service can be chosen in two ways known as vectored and non-vectored interrupt.
- In vectored interrupt, the source that interrupts, supplies the branch information to the CPU while in case of non-vectored interrupt the branch address is assigned to a fixed location in memory.

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Difference between Programmed and Interrupt Initiated I/O :

Programmed I/O	Interrupt Initiated I/O
Data transfer is initiated by the means of instructions stored in the computer program. Whenever there is a request for I/O transfer the instructions are executed from the program.	The I/O transfer is initiated by the interrupt command issued to the CPU.
The CPU stays in the loop to know if the device is ready for transfer and has to continuously monitor the peripheral device.	There is no need for the CPU to stay in the loop as the interrupt command interrupts the CPU when the device is ready for data transfer.
This leads to the wastage of CPU cycles as CPU remains busy needlessly and thus the efficiency of system gets reduced.	The CPU cycles are not wasted as CPU continues with other work during this time and hence this method is more efficient.

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Difference between Programmed and Interrupt Initiated I/O :

Programmed I/O	Interrupt Initiated I/O
CPU cannot do any work until the transfer is complete as it has to stay in the loop to continuously monitor the peripheral device.	CPU can do any other work until it is interrupted by the command indicating the readiness of device for data transfer
Its module is treated as a slow module.	Its module is faster than programmed I/O module.
It is quite easy to program and understand.	It can be tricky and complicated to understand if one uses low level language.
The performance of the system is severely degraded.	The performance of the system is enhanced to some extent.

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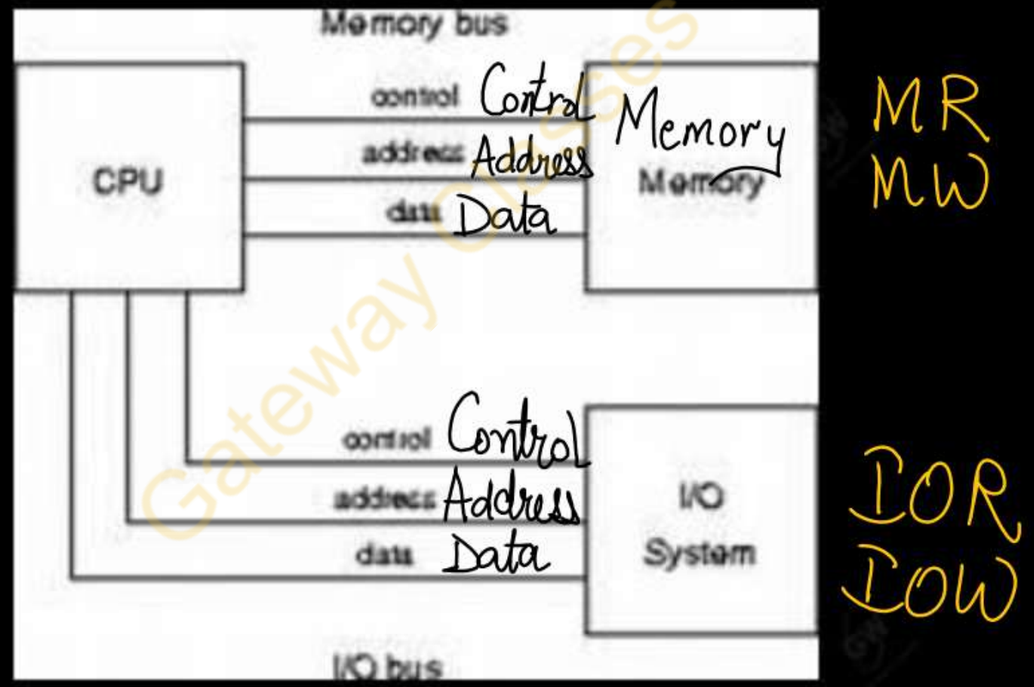
Isolated I/O –

- Isolated I/O is a technique in which we have common bus(data and address) for I/O and memory but separate read and write control lines for I/O.
- So when CPU decode instruction then if data is for I/O then it places the address on the address line and set I/O read or write control line on due to which data transfer occurs between CPU and I/O.
- As the address space of memory and I/O is isolated the address for I/O here is called ports.
- Here we have different read-write instruction for both I/O and memory



MR
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Advantages and Disadvantages of Isolated I/O

Advantages of Isolated I/O:

- Large I/O Address Space: Isolated I/O allows for a larger I/O address space compared to memory-mapped I/O as I/O devices have their own separate address space.
- Greater Flexibility: Isolated I/O provides greater flexibility as I/O devices can be added or removed from the system without affecting the memory address space.
- Improved Reliability: Isolated I/O provides better reliability as I/O devices do not share the same address space as the memory. This means that if an I/O device fails, it does not affect the memory or other I/O devices.

Disadvantages of Isolated I/O:

- Slower I/O Operations: Isolated I/O can result in slower I/O operations compared to memory-mapped I/O as it requires the use of specialized I/O instructions.
- More Complex Programming: Isolated I/O requires specialized I/O instructions, which can lead to more complex programming.

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Isolated I/O applications:

- Embedded systems: Isolated I/O is commonly used in embedded systems where strict isolation between the CPU and peripherals is necessary. This includes applications such as industrial control systems, robotics, and automotive electronics. Isolation ensures that any faults or malfunctions in peripheral devices do not affect the stability of the entire system.
- Microcontrollers: Microcontrollers often rely on isolated I/O to interface with various peripherals, such as sensors, actuators, and displays. Each peripheral is assigned a separate I/O port, allowing the microcontroller to control and communicate with multiple devices independently.
- Real-time systems: Isolated I/O is preferred in real-time systems that require precise timing and deterministic behavior. By isolating the I/O operations, these systems can maintain strict control over the timing and synchronization of external events, ensuring reliable and predictable performance.

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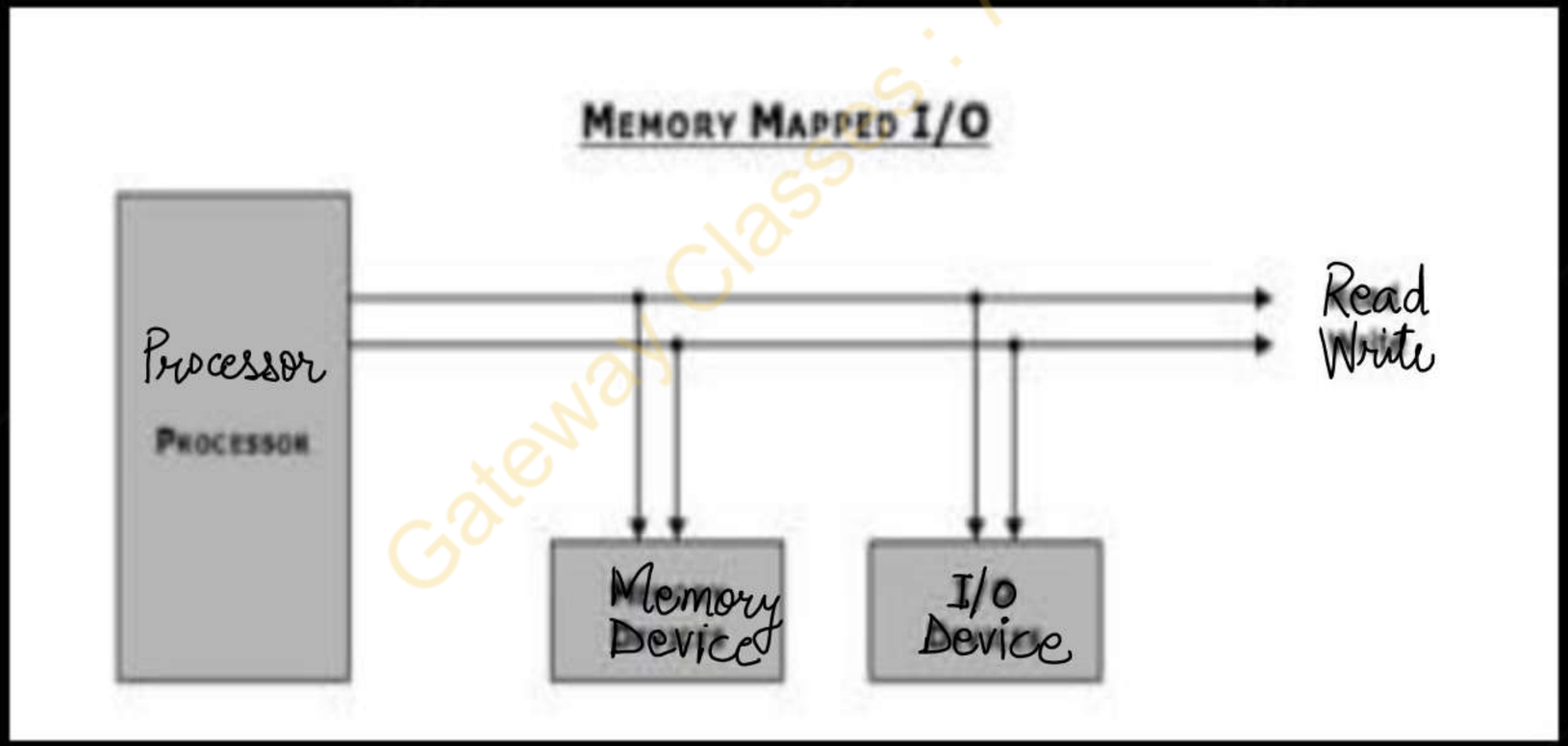
Memory Mapped I/O –

- In this scheme, every bus in common due to which the same set of instructions work for memory and I/O.
- Hence we manipulate I/O same as memory and both have same address space, due to which addressing capability of memory become less because some part is occupied by the I/O.



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Differences between Isolated I/O and Memory Mapped I/O:

Isolated I/O	Memory Mapped I/O
Isolated I/O uses separate memory space.	Memory mapped I/O uses memory from the main memory.
Limited instructions can be used. Those are IN, OUT, INS, OUTS.	Any instruction which references to memory can be used.
The address for Isolated I/O devices are called ports	Memory mapped I/O devices are treated as memory locations on the memory map.

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UNIT 5 : Input / Output
Lec 3

Today's Target

- Direct Memory Access
- DMA Controller Diagram
- Types of Direct Memory Access (DMA)
- Working of DMA Controller
- Modes of Data Transfer in DMA
- Advantages of DMA Controller
- University Questions

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UNIVERSITY QUESTIONS

YEAR	QUESTIONS	MARKS
22-23	Why does the DMA get priority over CPU when both request memory transfer?	2 Marks
22-23	With a neat schematic diagram, explain about DMA controller and its mode of data transfer.	10 Marks
20-21	Explain the term cycle stealing	2 Marks
20-21	Draw and explain the block diagram of typical DMA controller	10 Marks

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Direct Memory Access

- Direct memory access (DMA) is the process of transferring data without the involvement of the processor itself.
- It is often used for transferring data to/from input/output devices.
- A separate DMA controller is required to handle the transfer.
- The controller notifies the DSP processor that it is ready for a transfer.
- DMA Controller is a hardware device that allows I/O devices to directly access memory with less participation of the processor.
- DMA controller needs the same old circuits of an interface to communicate with the CPU and Input/Output devices.

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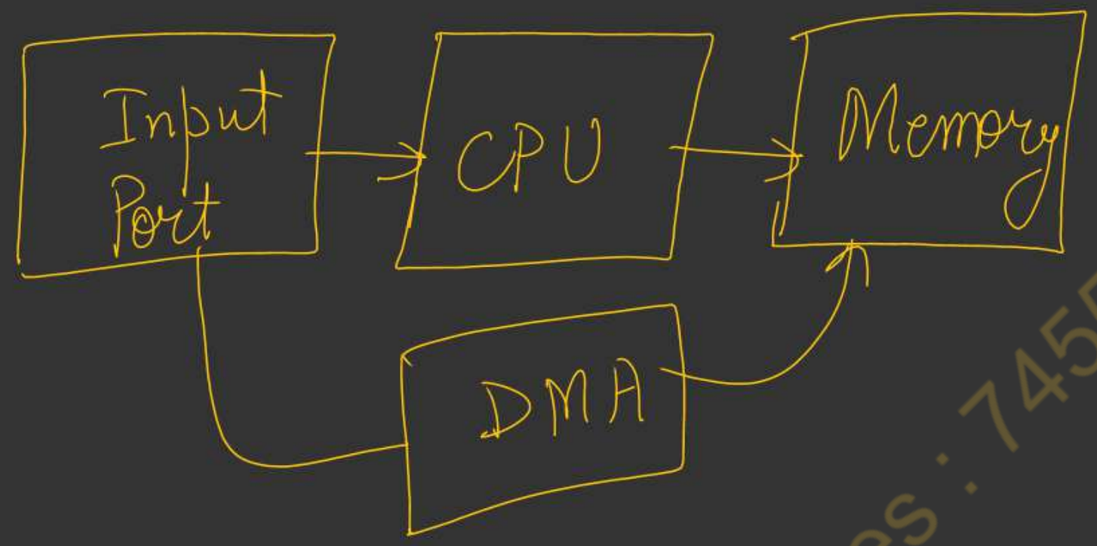

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DMA Controller Diagram

- DMA Controller is a type of control unit that works as an interface for the data bus and the I/O Devices.
- Processors can control the data transfer.
- DMA Controller also contains an address unit, which generates the address and selects an I/O device for the transfer of data.
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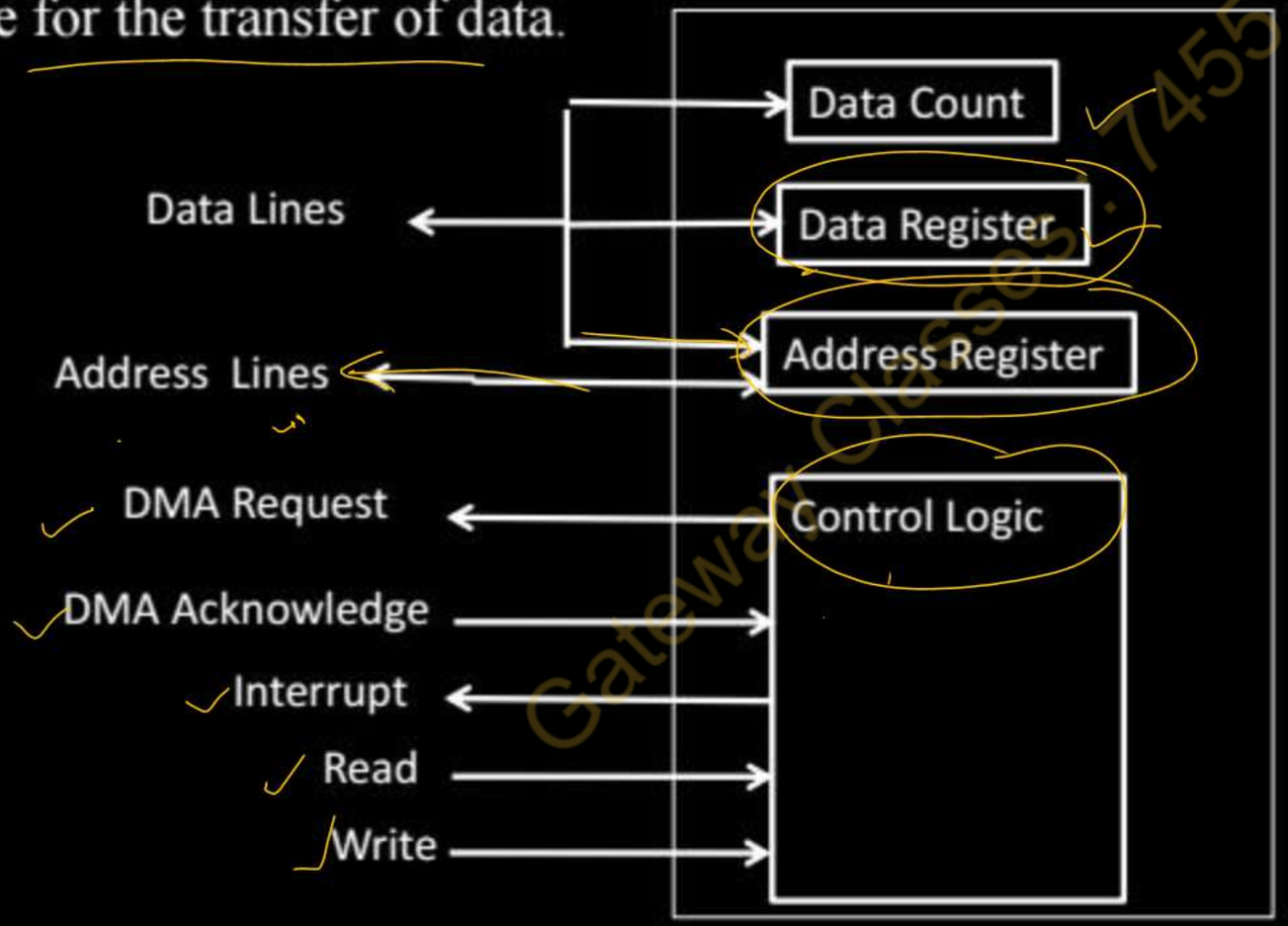

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Types of Direct Memory Access (DMA)

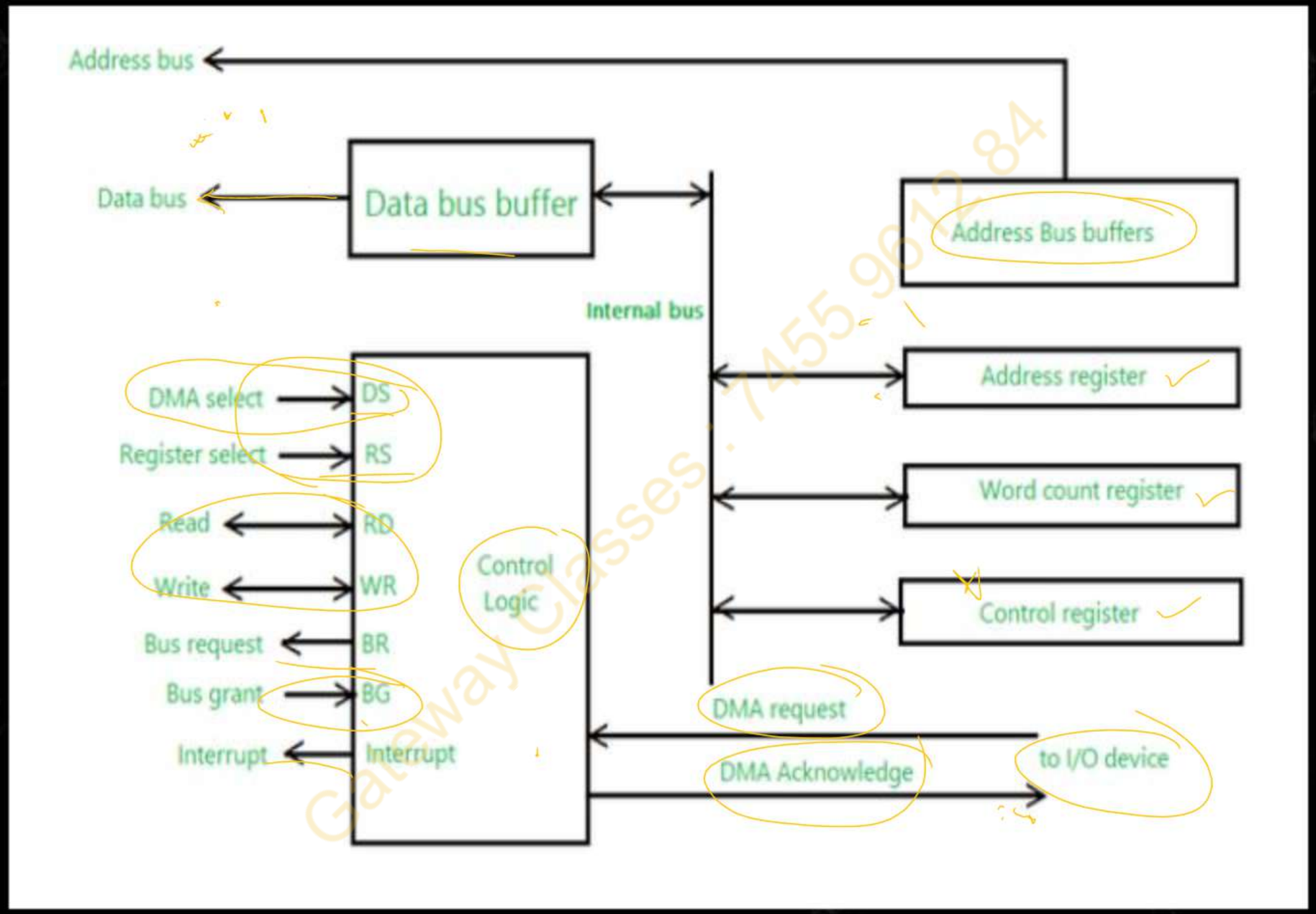
- There are four popular types of DMA.
  - Single-Ended DMA
  - Dual-Ended DMA
  - Arbitrated-Ended DMA
  - Interleaved DMA
- Single-Ended DMA: Single-Ended DMA Controllers operate by reading and writing from a single memory address. They are the simplest DMA.
- Dual-Ended DMA: Dual-Ended DMA controllers can read and write from two memory addresses. Dual-ended DMA is more advanced than single-ended DMA.
- Arbitrated-Ended DMA: Arbitrated-Ended DMA works by reading and writing to several memory addresses. It is more advanced than Dual-Ended DMA.
- Interleaved DMA: Interleaved DMA are those DMA that read from one memory address and write from another memory address.

Gateway Classes : 7455 9612 84

Working of DMA Controller

- The DMA controller registers have three registers as follows.
- Address register – It contains the address to specify the desired location in memory.
- Word count register – It contains the number of words to be transferred.
- Control register – It specifies the transfer mode.
- All registers in the DMA appear to the CPU as I/O interface registers. Therefore, the CPU can both read and write into the DMA registers under program control via the data bus.
- The unit communicates with the CPU through the data bus and control lines.
- Through the use of the address bus and allowing the DMA and RS register to select inputs, the register within the DMA is chosen by the CPU.
- RD and WR are two-way inputs.
- When BG (bus grant) input is 0, the CPU can communicate with DMA registers.
- When BG (bus grant) input is 1, the CPU has relinquished the buses and DMA can communicate directly with the memory.

Gateway Classes : 7455 9612 84



Gateway Classes : 7455 961 284

Explanation

- The CPU initializes the DMA by sending the given information through the data bus.
- The starting address of the memory block where the data is available (to read) or where data are to be stored (to write) is sent by CPU.
- It also sends word count which is the number of words in the memory block to be read or written.
- Control to define the mode of transfer such as read or write.
- A control to begin the DMA transfer

Gateway Classes : 7455 9612 84

Modes of Data Transfer in DMA

- There are 3 modes of data transfer in DMA that are described below.
- Burst Mode: In Burst Mode, buses are handed over to the CPU by the DMA if the whole data is completely transferred, not before that.
- Cycle Stealing Mode: In Cycle Stealing Mode, buses are handed over to the CPU by the DMA after the transfer of each byte. Continuous request for bus control is generated by this Data Transfer Mode. It works more easily for higher-priority tasks.
- Transparent Mode: Transparent Mode in DMA does not require any bus in the transfer of the data as it works when the CPU is executing the transaction.

Gateway Classes : 7455 961284

8237 DMA Controller

- 8237 DMA Controller is a type of DMA Controller which has a flexible number of channels but generally works on 4 Input-Output channels.
- In these present channels, the channel has to be given the highest priority to be decided by the Priority Encoder.
- Each channel in the 8237 DMA Controller has to be programmed separately.

8257 DMA Controller

- 8257 DMA Controller is a type of DMA Controller, that when a single Intel 8212 I/O device is paired with it, becomes 4 channel DMA Controller.
- In 8257 DMA Controller, the highest priority channel is acknowledged.
- It contains two 16-bit registers, one is DMA Address Register and the other one is Terminal Count Register.

Gateway Classes: 7455961284

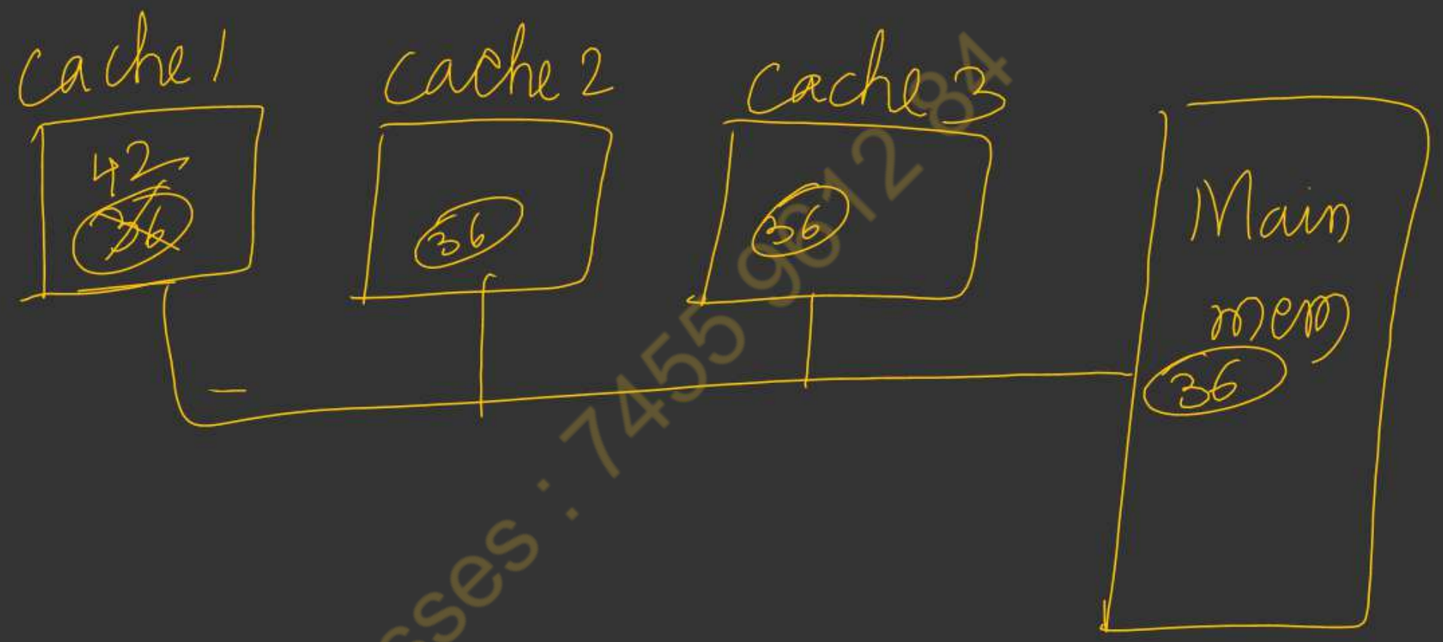
Advantages of DMA Controller

- Data Memory Access speeds up memory operations and data transfer.
- CPU is not involved while transferring data.
- DMA requires very few clock cycles while transferring data.
- DMA distributes workload very appropriately.
- DMA helps the CPU in decreasing its load.

Disadvantages of DMA Controller

- Direct Memory Access is a costly operation because of additional operations.
- DMA suffers from Cache-Coherence Problems.
- DMA Controller increases the overall cost of the system.
- DMA Controller increases the complexity of the software.

Gateway Classes : 7455 9612 84



Gateway Classes : 7455 961284

UNIT 5 : Input / Output
Lec 4

Today's Target

- I/O Channels and its types
- Input-Output Processor
- Features, Applications of an Input-Output Processor
- Advantages, Disadvantages of an Input-Output Processor

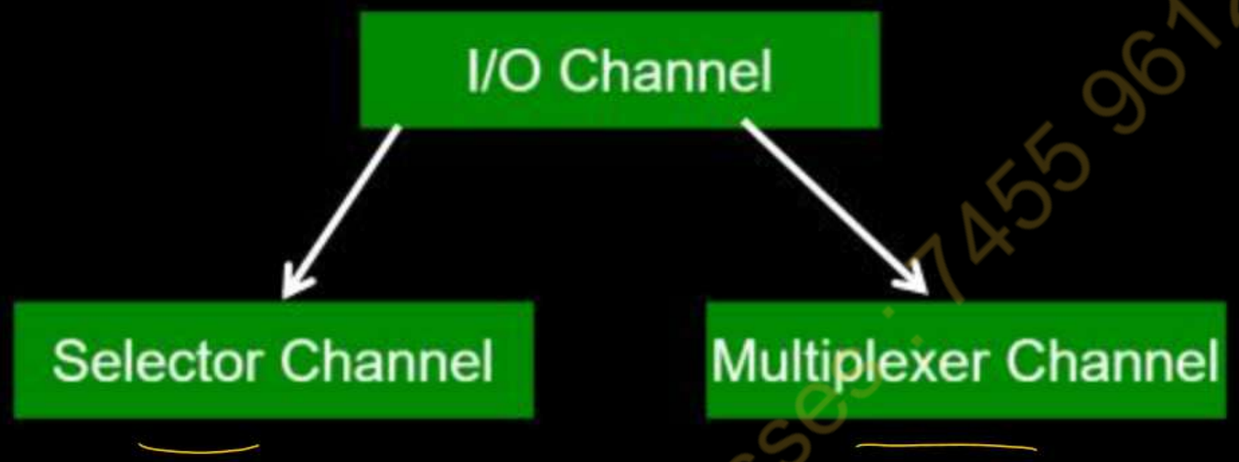
Gateway Classes : 7455 9612 84

I/O Channels

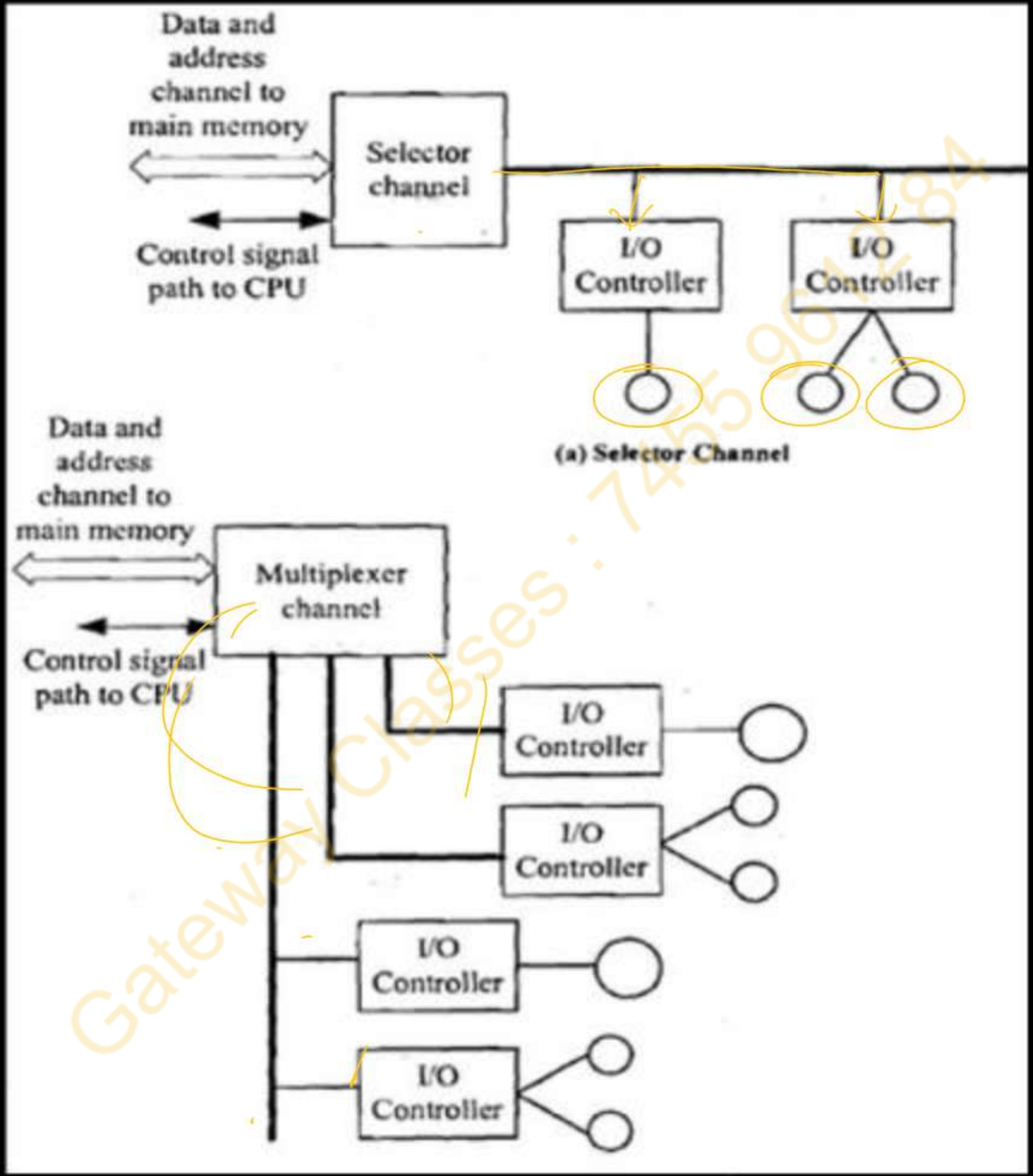
- I/O Channel is an extension of the DMA concept.
- It has ability to execute I/O instructions using special-purpose processor on I/O channel and complete control over I/O operations.
- Processor does not execute I/O instructions itself.
- Processor initiates I/O transfer by instructing the I/O channel to execute a program in memory.
- Program specifies – Device or devices, Area or areas of memory, Priority, and Error condition actions

Gateway Classes : 7455 962 84

Types of I/O Channels :



Gateway Classes: 7455 9612 84



Gateway Classes : 7465 961 484

1. Selector Channel :

- The selector channel controls multiple high-speed devices.
- It is dedicated to the transfer of data with one of the devices.
- In the selector channel, each device is handled by a controller or I/O module.
- It controls the I/O controllers shown in the figure.

2. Multiplexer Channel :

- Multiplexer channel is a DMA controller that can handle multiple devices at the same time.
- It can do block transfers for several devices at once.
- Two types of multiplexers are used in this channel:
- Byte Multiplexer –

It is used for low-speed devices. It transmits or accepts characters. Interleaves bytes from several devices.

- Block Multiplexer –

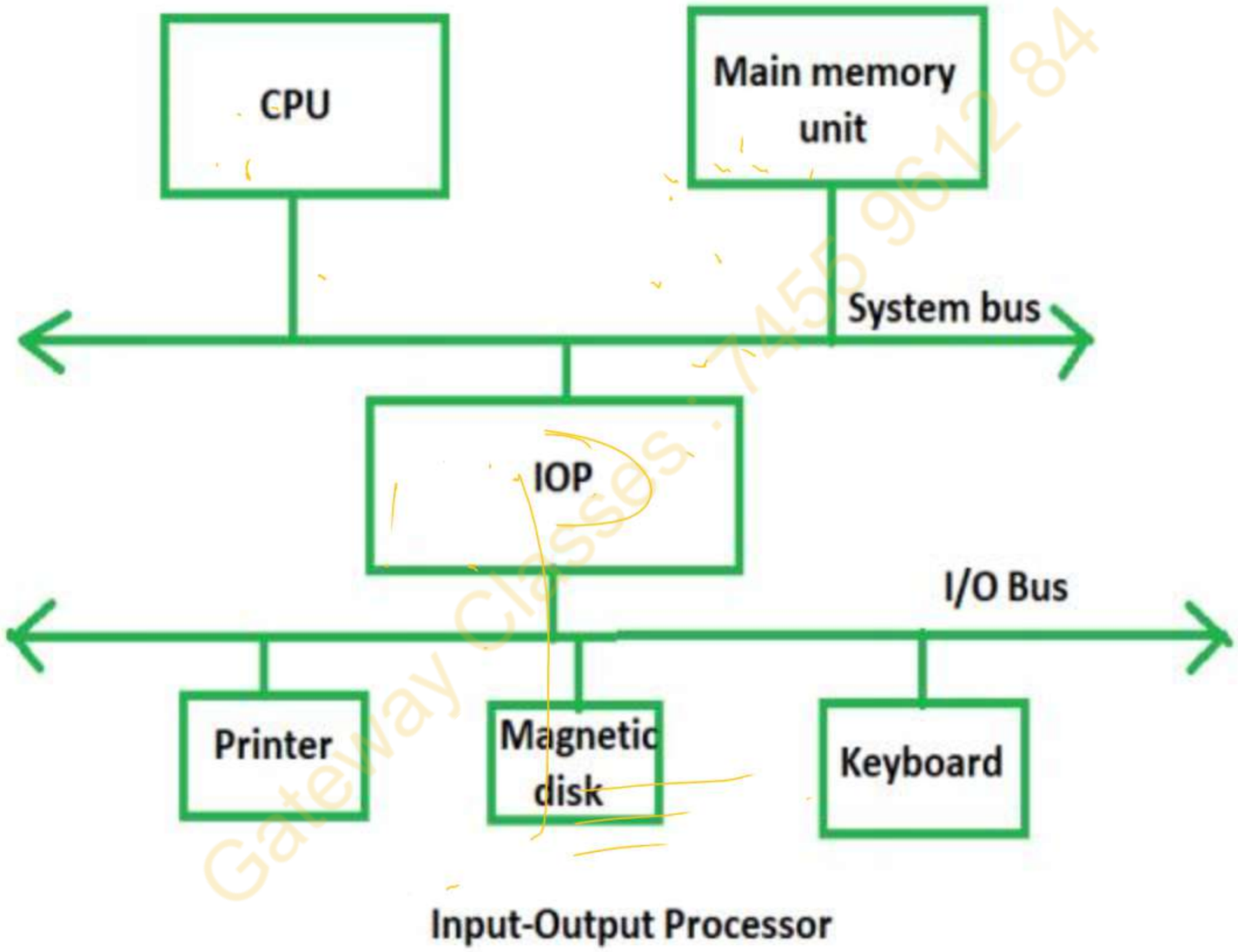
It accepts or transmits block of characters. Interleaves blocks of bytes from several devices. Used for high-speed devices.

Gateway Classes 7455 962 84

Introduction of Input-Output Processor

- The concept of DMA operation can be extended to relieve the CPU further from getting involved with the execution of I/O operations.
- This gives rise to the development of special purpose processors called **Input-Output Processor (IOP) or IO channels**.
- The Input-Output Processor (IOP) is just like a CPU that handles the details of I/O operations.
- It is more equipped with facilities than those available in a typical DMA controller.
- The IOP can fetch and execute its own instructions that are specifically designed to characterize I/O transfers.
- In addition to the I/O-related tasks, it can perform other processing tasks like arithmetic, logic, branching, and code translation.
- The main memory unit takes a pivotal role. It communicates with the processor by means of DMA.
- The Input-Output Processor is a specialized processor which loads and stores data in memory along with the execution of I/O instructions.
- It acts as an interface between the system and devices.
- It involves a sequence of events to execute I/O operations and then store the results in memory.

Gateway Classes : 745 96 12 84



Input-Output Processor

Gateway Classes : 7455 961 284

Features of an Input-Output Processor

- **Specialized Hardware:** An IOP is equipped with specialized hardware that is optimized for handling input/output operations. This hardware includes input/output ports, DMA controllers, and interrupt controllers.
- **DMA Capability:** An IOP has the capability to perform Direct Memory Access (DMA) operations. DMA allows data to be transferred directly between peripheral devices and memory without going through the CPU, thereby freeing up the CPU for other tasks.
- **Interrupt Handling:** An IOP can handle interrupts from peripheral devices and manage them independently of the CPU. This allows the CPU to focus on executing application programs while the IOP handles interrupts from peripheral devices.
- **Protocol Handling:** An IOP can handle communication protocols for different types of devices such as Ethernet, USB, and SCSI. This allows the IOP to interface with a wide range of devices without requiring additional software support from the CPU.
- **Buffering:** An IOP can buffer data between the CPU and peripheral devices. This allows the IOP to handle large amounts of data without overloading the CPU or the peripheral devices.
- **Command Processing:** An IOP can process commands from peripheral devices independently of the CPU. This allows the CPU to focus on executing application programs while the IOP handles peripheral device commands.
- **Parallel Processing:** An IOP can perform input/output operations in parallel with the CPU. This allows the system to handle multiple tasks simultaneously and improve overall system performance.

Gateway Classes: 7455 962 284

Applications of I/O Processors

- **Data Acquisition Systems:** I/O processors can be used in data acquisition systems to acquire and process data from various sensors and input devices. The I/O processor can handle high-speed data transfer and perform real-time processing of the acquired data.
- **Industrial Control Systems:** I/O processors can be used in industrial control systems to interface with various control devices and sensors. The I/O processor can provide precise timing and control signals, and can also perform local processing of the input data.
- **Multimedia Applications:** I/O processors can be used in multimedia applications to handle the input and output of multimedia data, such as audio and video. The I/O processor can perform real-time processing of multimedia data, including decoding, encoding, and compression.
- **Network Communication Systems:** I/O processors can be used in network communication systems to handle the input and output of data packets. The I/O processor can perform packet routing, filtering, and processing, and can also perform encryption and decryption of the data.
- **Storage Systems:** I/O processors can be used in storage systems to handle the input and output of data to and from storage devices. The I/O processor can handle high-speed data transfer and perform data caching and prefetching operations.

Gateway Classes, 7455061284

Advantages of Input-Output Processor

- The I/O devices can directly access the main memory without the intervention of the processor in I/O processor-based systems.
- It is used to address the problems that arise in the Direct memory access method.
- **Reduced Processor Workload:** With an I/O processor, the main processor doesn't have to deal with I/O operations, allowing it to focus on other tasks. This results in more efficient use of the processor's resources and can lead to faster overall system performance.
- **Improved Data Transfer Rates:** Since the I/O processor can access memory directly, data transfers between I/O devices and memory can be faster and more efficient than with other methods.
- **Increased System Reliability:** By offloading I/O tasks to a dedicated processor, the system can be made more fault-tolerant. For example, if an I/O operation fails, it won't affect other system processes.
- **Scalability:** I/O processor-based systems can be designed to scale easily, allowing for additional I/O processors to be added as needed. This can be particularly useful in large-scale data centres or other environments where the number of I/O devices is constantly changing.
- **Flexibility:** I/O processor-based systems can be designed to handle a wide range of I/O devices and interfaces, providing more flexibility in system design and allowing for better customization to meet specific requirements.

Gateway Classes : 7455 DC12 84

Disadvantages of Input-Output Processor

- **Cost:** I/O processors can add significant costs to a system due to the additional hardware and complexity required. This can be a barrier to adoption, especially for smaller systems.
- **Increased Complexity:** The addition of an I/O processor can increase the overall complexity of a system, making it more difficult to design, build, and maintain. This can also make it harder to diagnose and troubleshoot issues.
- **Limited Performance Gains:** While I/O processors can improve system performance by offloading I/O tasks from the main processor, the gains may not be significant in all cases. In some cases, the additional overhead of the I/O processor may actually slow down the system.
- **Synchronization Issues:** With multiple processors accessing the same memory, synchronization issues can arise, leading to potential data corruption or other errors.
- **Lack of Standardization:** There are many different I/O processor architectures and interfaces available, which can make it difficult to develop standardized software and hardware solutions. This can limit interoperability and make it harder for vendors to develop compatible products.

Gateway Classes: 7455061284

UNIT 5: Input / Output

Lec 5

Today's Target

- Serial Communication
- Synchronous Communication
- Asynchronous Communication
- Transmission Modes in Serial Communication
- Advantages of Serial communication

Gateway Classes : 7455961284

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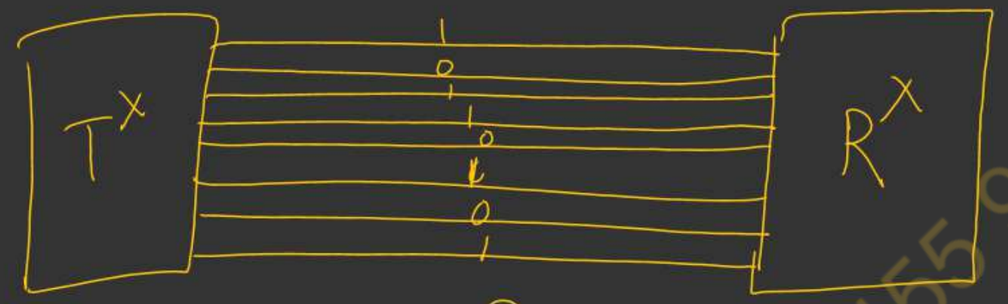
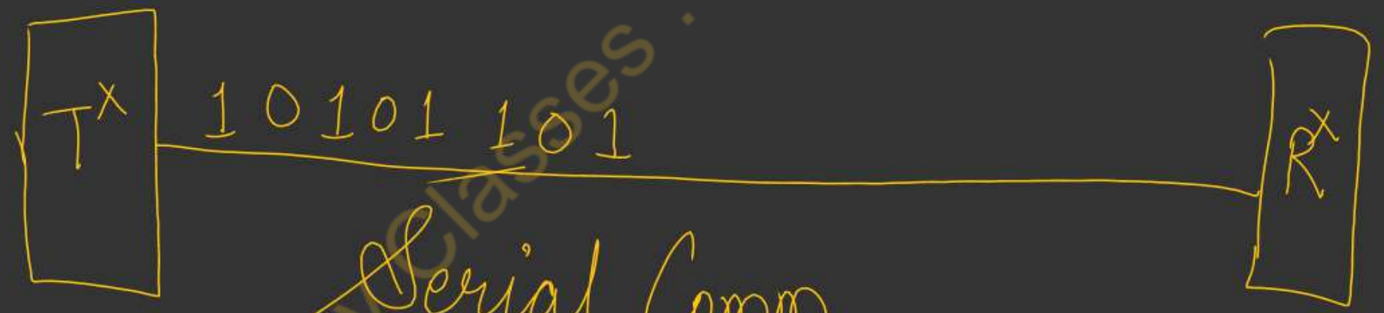


— Parallel Comm.



Serial Comm.

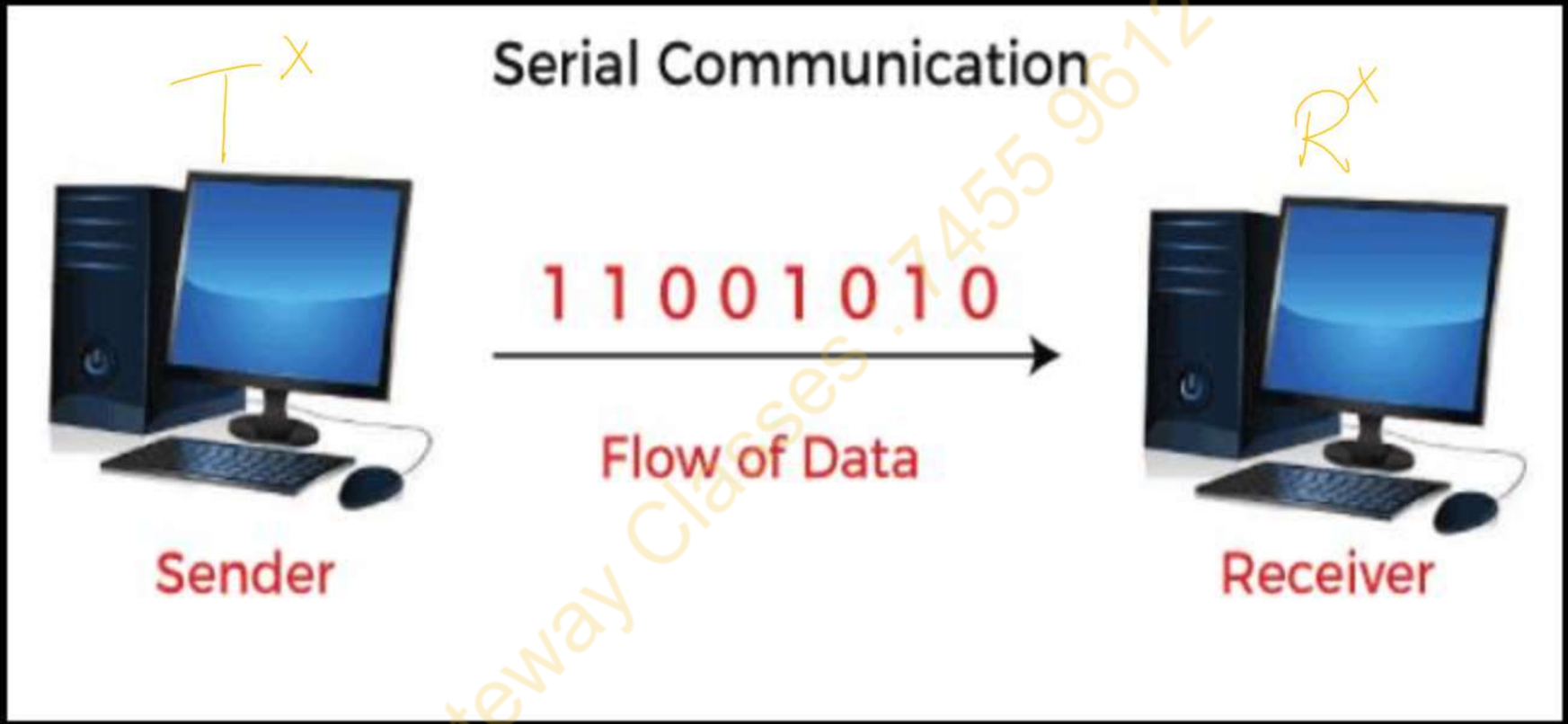
Gateway Classes : 7455 9612 84

Serial Communication

- Serial communication is the process of sequentially transferring the information/bits on the same channel.
- Due to this, the cost of wire will be reduced, but it slows the transmission speed.
- The serial protocol is run on every device that can be our mobile, personal computers, and many more with the help of following some protocols.
- The protocol is a type of reliable and secure form of communication that contains a set of rules addressed with the help of a source host and a destination host.
- In serial communication, binary pulses are used to show the data.
- Binary contains the two numbers 0 and 1. 0 is used to show the LOW or 0 Volts, and 1 is used to show the HIGH or 5 Volts.
- The serial communication can either be asynchronous or synchronous.

Gateway Classes : 7455961284

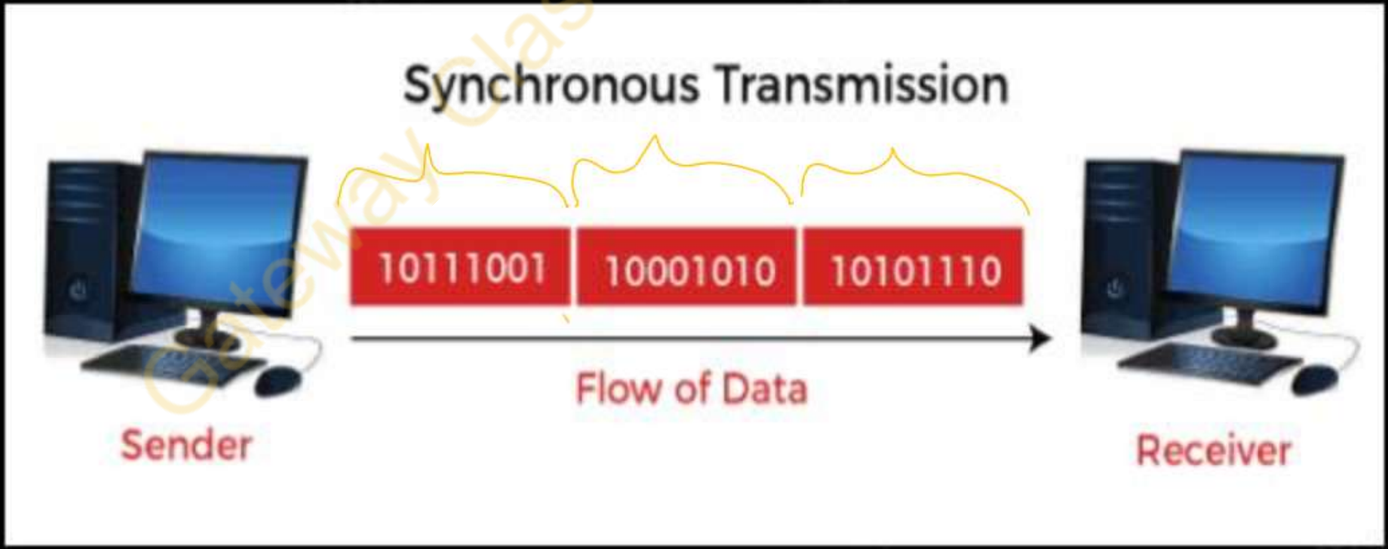
Serial Communication:



Gateway Classes 7455 96 12 84

Synchronous Communication

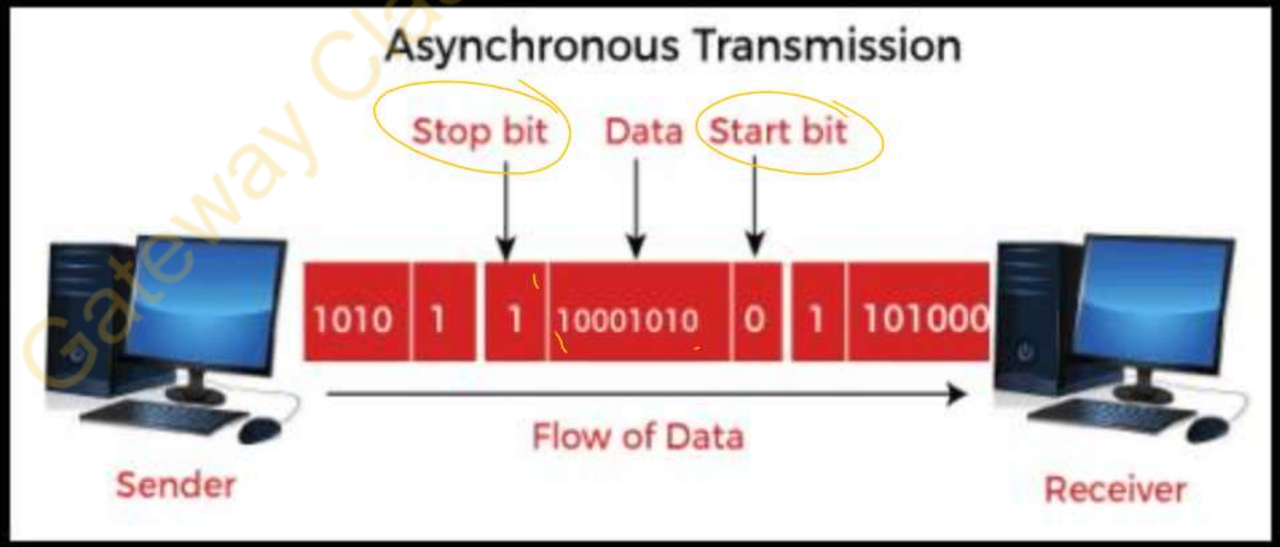
- In synchronous communication, the frames or data will be constructed with the help of combining the groups of bits.
- Those frames will be continuously sent in time with a master clock.
- It uses a synchronized clock frequency to operate the data of the sender or receiver.
- In synchronous communication, there is no need to use the gaps, start bits, and stop bits.
- The time taken by the sender and receiver is synced that's why the frequency of timing errors will be less, and the data will move faster.
- Based on the timing being synced correctly between the sender and receiver devices, the data accuracy is dependent.
- The synchronous serial transmission is more expensive as compared to asynchronous serial transmission.



Gateway Classes : 7455962 84

Asynchronous Communication

- In asynchronous communication, the groups of bits will be treated as an independent unit, and these data bits will be sent at any point in time.
- In order to make synchronization between sender and receiver, the stop bits and start bits are used between the data bytes. These bits are useful to ensure that the data is correctly sent.
- The time taken by data bits of sender and receiver is not constant, and the time between transmissions will be provided by the gaps.
- In asynchronous communication, we don't require synchronization between the sender and receiver devices, which is the main advantage of asynchronous communication.
- This method is also cost-effective.
- In this method, there can be a case when data transmission is slow, but it is not compulsory, and it is the main disadvantage of the asynchronous method.



Gateway Classes : 7455 960 284

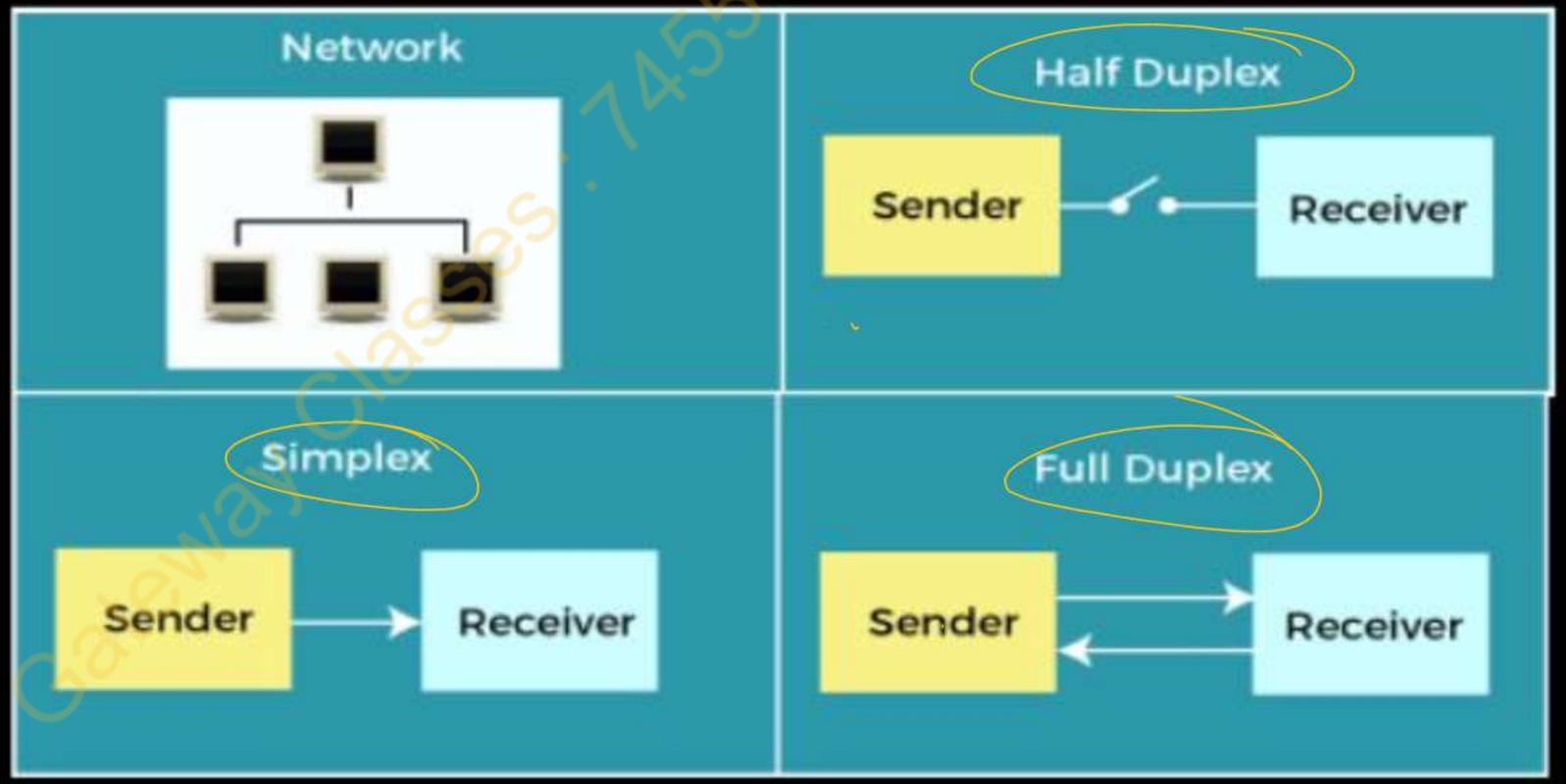
Difference between Serial communication and Parallel communication

Parameter	Serial	Parallel
Speed	Typically slower for short distances than parallel communication.	Typically faster as multiple bits are sent at once
Complexity	Simple for long distances	Simple for short distances
Cost	Typically cheaper for long distances	Typically more expensive for long connections
Reliability	Reliable over long distances	May suffer signal degradation over long distances
Interference	Less prone to crosstalk	More prone to crosstalk in longer connections
Synchronization	Complex at very high speeds	Easier to synchronize at short distances
Scalability	High-speed scalability can be challenging	Can be easily scaled for short distances
Wiring	Requires fewer wires, reducing bulk	Requires more wires, increasing bulk
Bandwidth	Bandwidth limited by channel characteristics	High bandwidth potential

GatewayClasses : 7455961284

Transmission Modes in Serial Communication

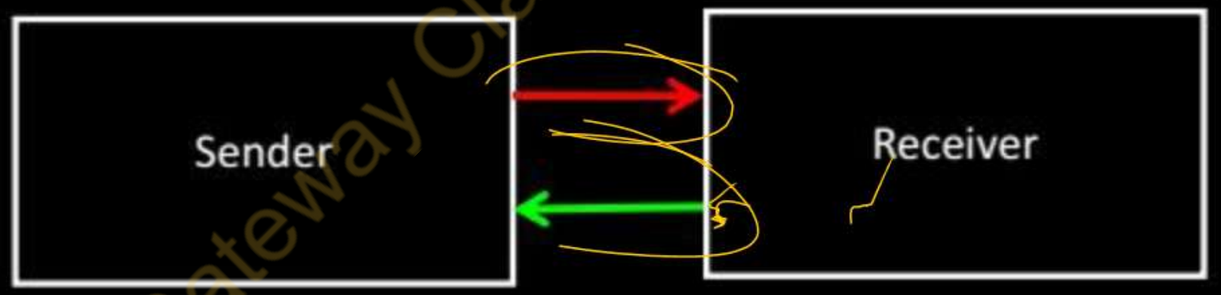
- On the basis of the data transfer rate and the type of transmission mode, serial communication will take many forms.
- The transmission mode can be classified into simplex, half-duplex, and full-duplex.
- Each transmission mode contains the source, also known as sender or transmitter, and destination, also known as the receiver.



Gateway Classes : 7455 9612 84

Simplex

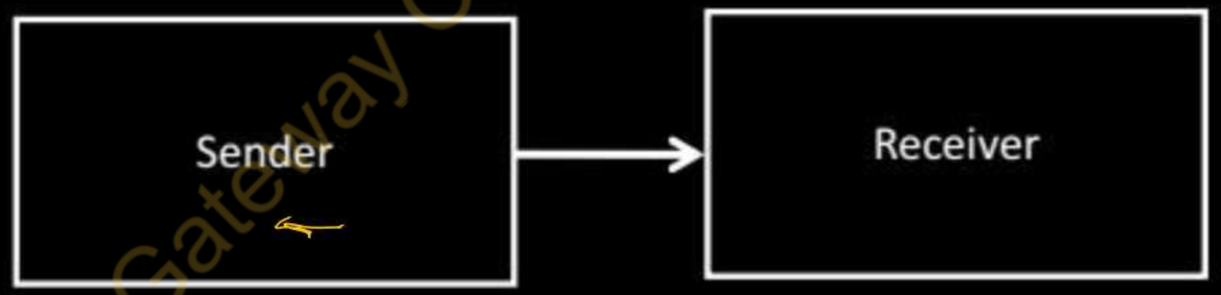
- In the simplex method, the data transmission can be performed only in one direction.
- At a time, only one client (either sender or receiver) can be active. That means among the two devices, one device can only transmit a link while the other device can only receive it.
- A sender can only transmit the data, and the receiver can only accept that data. The receiver cannot reply back to the sender.
- In another case, if the receiver sends the data, the sender will only accept it. The sender cannot reply back to the receiver.
- Examples of the simplex: Keyboard and CPU , Printers and computers , Teletext , One-way road



Gateway Classes : 7455 6619 84

Half Duplex

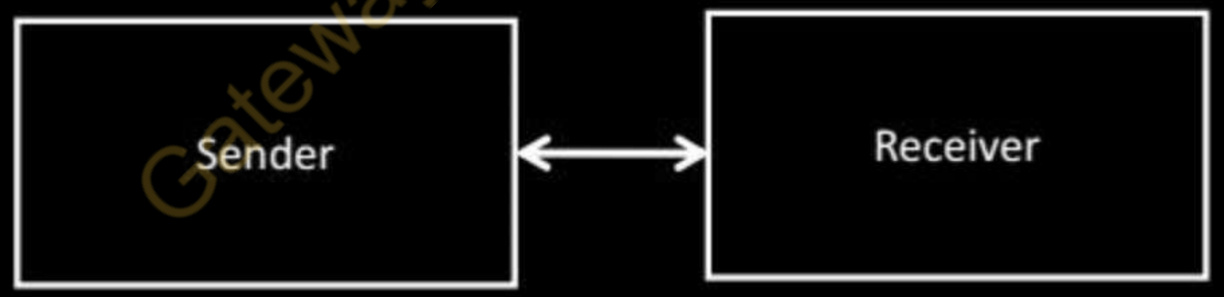
- In the half-duplex, the sender and receiver can communicate in both directions, but not at the same time.
- If a sender sends some data, the receiver is able to accept it, but at that time, the receiver cannot send anything to the receiver.
- Same as if the receiver sends data to the sender, the sender cannot send.
- If there is a case where we don't need to communicate at a time in both the direction, we can use the half-duplex.
- For example, the internet, One lane bridge, Walkie-talkie, Railroads, printer is a good example of half-duplex.



Gateway Classes : 7455961284

Full Duplex

- In the full-duplex, the sender and the receiver are able to send and receive at the same time.
- The communication mode of full-duplex is widely used in the world.
- In this mode, signals travelling in one direction are able to share the capacity of links with signals travelling in the opposite directions. There are two ways in which sharing can occur, which is described as follow:
- Either capacity of the link is divided into the signals going in both directions.
- Or the links have two physically separated transmission parts. Where one part can be used for sending, and another part can be used for receiving.
- If we need communication in both directions constantly, in this case, we will use the full-duplex mode.
- Examples: Telephone Network, ordinary two-lane highway, Audio calling or Video calling



Gateway Classes: 7455959294

Advantages of Serial communication over Parallel communication

- No Clock Required: If there is a case of the asynchronous and unclocked type of serial communication, the problem related to the clock skew between channels will not exist.
- Need less Space: At the time of configuration of serial communication, it needs less amount of space because the serial connection needs less amount of cable. Hence because of this feature, we will have an additional space, which can be used to provide better isolation of data lanes/channels from the components of neighboring communication.
- No Cross Talks: The serial communication contains fewer amounts of conductors in the nearby space. That's why the possibility of cross-talk is rare.
- Low cost: The serial communication contains the serial link. The cost of this link is less than the parallel link.

Gateway Classes : 7455961284

UNIT 5 : Input / Output
Lec 6

Gateway Classes: 7455 96 12 84

Today's Target

- STANDARD COMMUNICATION INTERFACE
- Role of the Communication Interface
- Peripheral Component Interconnect
- **Small Computer System Interface (SCSI)**
- **Universal Serial Bus (USB)**
- University Questions

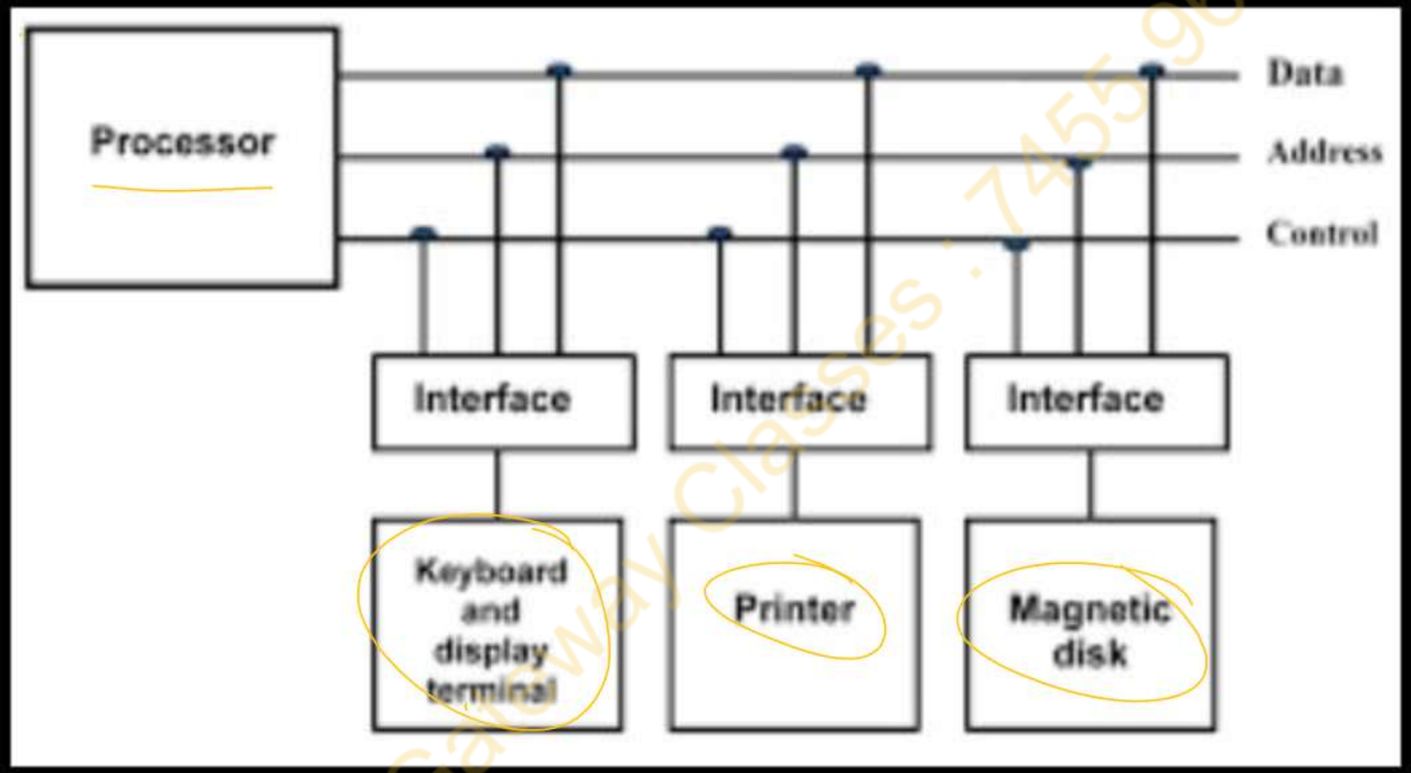
UNIVERSITY QUESTIONS

YEAR	QUESTIONS	MARKS
22-23	Discuss the design of a typical input or output interface.	10 Marks

Gateway Classes : 7455 9612 84

STANDARD COMMUNICATION INTERFACE

- A communication interface is an interface used for data transfer and communication between devices.
-



Gateway Classes · 7455 961284

Role of the Communication Interface

The main roles of the communication interface is a bridge between communication devices include the following:

Transmission of Signals: Converts digital signals from the sender into signals suitable for the transmission medium and sends them to the receiver.

Protocol Conversion: to realize the conversion of communication protocols between different communication devices, so as to meet the needs of various applications.

Level Matching: Match the signal levels according to the electrical characteristics between different communication devices to ensure the correct transmission of information.

Enhanced Data Security: Provides encryption, authentication and other functions to ensure the security and integrity of communication data.

Simplified Connection: Simplifies the connection between devices and improves interoperability through a common standard communication interface specification.

Gateway Classes : 7455 9612 84

Introduction:

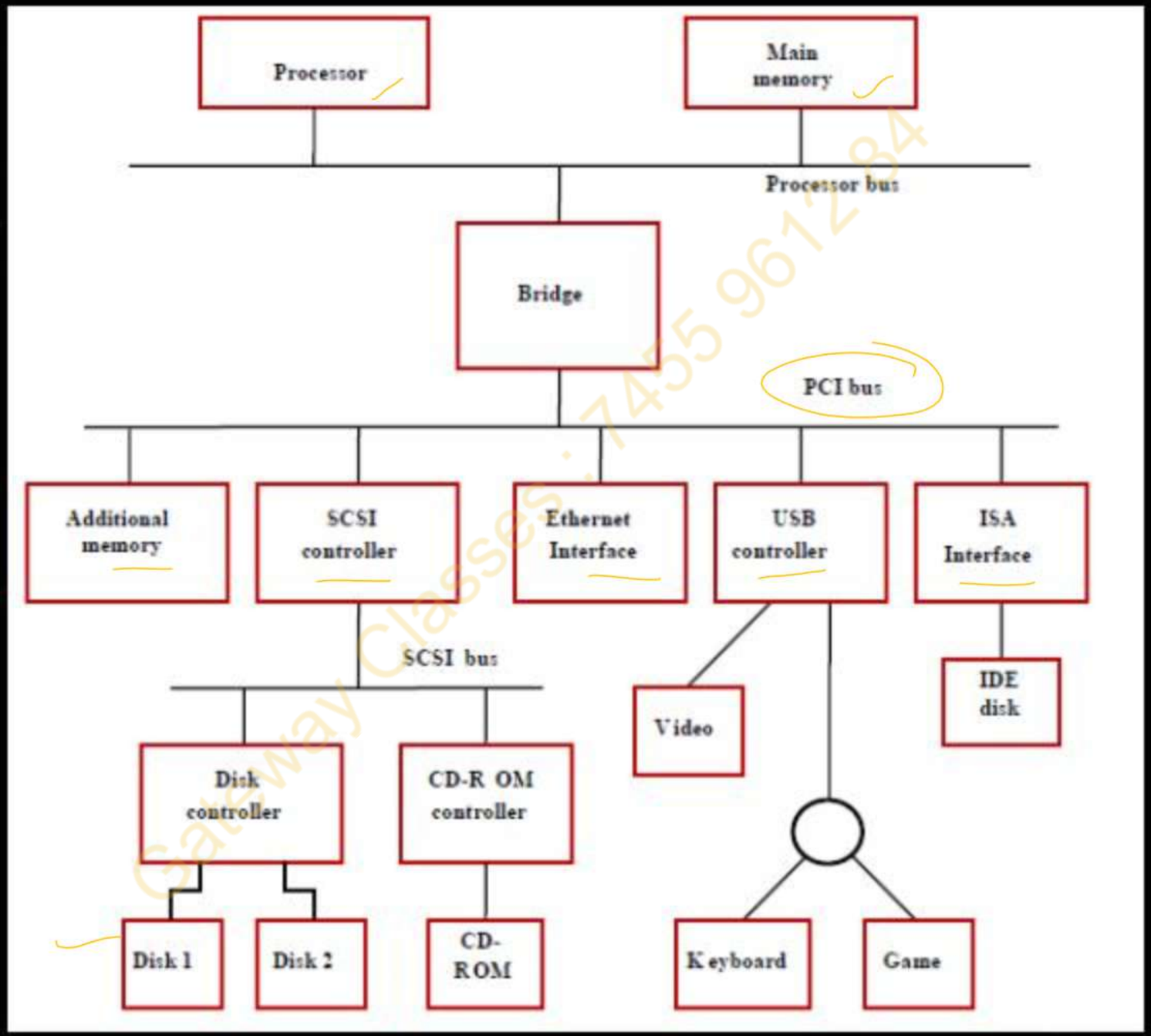
- A number of standards have been developed for I/O Interface.
- IBM developed a standard called ISA (Industry Standard Architecture) for their personal computer known at the time as PC AT leading to other manufacturers producing ISA -compatible interfaces.
- Organizations such as the IEEE (Institute of Electrical and Electronics Engineers), ANSI (American Nationa1 Standards Institute), or international bodies such as ISO (International Standards Organization) have blessed these standards and given them an official status.
- There are three widely used bus standards,

➢ PCI (Peripheral Component Interconnect),

➢ SCSI (Small Computer System Interface), and

➢ USB (Universal Serial Bus).

Gateway Classes : 7455961284

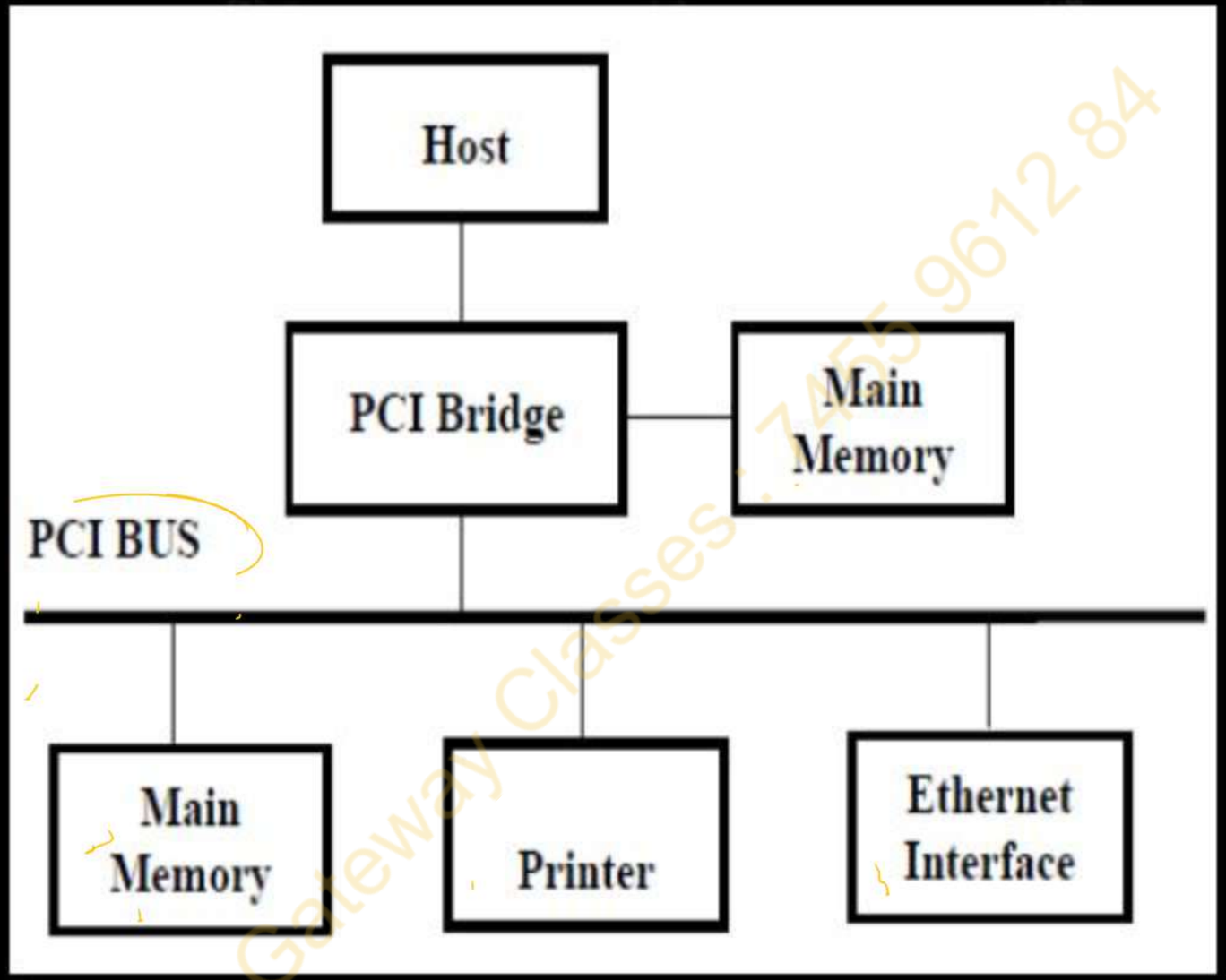


Gateway Classes : 7455 961284

Peripheral Component Interconnect (PCI)

- PCI) is a local computer bus for attaching hardware devices in a computer and is part of the PCI Local Bus standard.
- The PCI bus supports the functions found on a processor bus but in a standardized format that is independent of any given processor's native bus.
- PCI defines the electrical characteristics and signal protocols used for devices to communicate over a computer's central bus.
- PCI was traditionally used as the computer bus interface for network adapters add-in cards including both Ethernet and Wi-Fi adapters for desktop PCs.
- The figure shows an interface circuit that enables devices compatible with the earlier ISA standard, such as the popular IDE (Integrated Device Electronics) disk, to be connected.
- It also shows a connection to an Ethernet.
- The Ethernet is a widely used local area network, providing a high-speed connection among computers in a building or a university campus.
- A given computer may use more than one bus standard.

Gateway Classes : 7255942 84



Gateway Classes, 7455 9612 84

Features of an Input-Output Processor

- A typical Pentium computer has both a PCI bus and an ISA bus, thus providing the user with a wide range of devices to choose from.
- Devices connected to the PCI bus appear to the processor as if they were connected directly to the processor bus.
- An important feature that the PCI pioneered is a plug-and-play capability for connecting I/O devices.
- Most memory transfers involve a burst of data rather than just one word. The reason is that modem processors include a cache memory.
- The PCI is designed primarily to support this mode of operation.
- A read or a write operation involving a single word is simply treated as a burst of length one.
- The bus supports three independent address spaces: memory, I/O, and configuration. The I/O address space is intended for use with processors, such as Pentium, that have a separate I/O address space.

Gateway Classes 7455 96 12 84

Use of a PCI bus in a computer system

- At any given time, one device is the bus master. It has the right to initiate data transfers by issuing read and write commands.
- A master is called an initiator in PCI terminology. This is either a processor or a DMA controller.
- The addressed device that responds to read and write commands is called a target.
- The main bus signals used for transferring data are Clock, duration of transaction, address/data lines, command/byte enable, Initiator/Target Ready signal, Device select, etc
- The main difference between the PCI protocol with others is that in addition to a Target-ready signal, PCI also uses an Initiator read signal, IRDY.

Gateway Classes: 7435 9612 84

Small Computer System Interface (SCSI)

- It provides a high level of versatility and efficiency in data transfer.
- SCSI is a set of American National Standards Institute (ANSI) standard electronic interfaces used for computers.
- Allows communication with peripheral hardware such as disk drives, tape drives, CD-ROM drives, printers, and scanners.
- Faster and more flexible than previous parallel data transfer interfaces.

Gateway Classes: 7455 96 12 84

SCSI Host Adapter

- A SCSI host adapter is a device used to connect one or more SCSI devices to a computer bus.
- A SCSI host adapter is commonly referred to as a SCSI controller, which is not entirely accurate, as any component that understands the SCSI protocol can be called a controller.
- In this notion, all SCSI devices have a SCSI controller integrated, while host adapters are responsible for transferring data between the computer's input/output bus and the SCSI bus.

SCSI Devices

- SCSI Devices encompass a wide range of peripherals, including hard drives, CD/DVD drives, tape recording drives, scanners, and printers.
- These devices are designed to connect to a SCSI machine and communicate with the host computer through the SCSI host appendage.
- A SCSI machine is the physical connection through which SCSI bias are connected to the SCSI host appendage.
- It can be either internal or external, depending on the configuration of the computer and the bias.

Gateway Classes : 7455961984

SCSI Components

- **Initiator:** An initiator issues requests for service by SCSI devices and receives responses. Initiators come in various forms and may be integrated into the server's system board or exist within the host bus adapter. SCSI connectivity typically uses a software-based initiator.
- **Target:** The SCSI target is typically a physical storage device (although software-based SCSI targets also exist). The target can be a single hard disk or an entire storage array. It is also possible for non-storage hardware to act as a SCSI target. Although rare today, it was once common to connect an optical scanner to a computer via a SCSI bus and act as a SCSI target.
- **Service Delivery Subsystem:** The mechanism that allows communication between the initiator and the target. This usually takes the form of cabling.
- **Expander:** Used only with serial-attached SCSI (SAS). Allows multiple SAS devices to share a single initiator port.

Gateway Classes : 0105 96 10 24

Universal Serial Bus (USB)

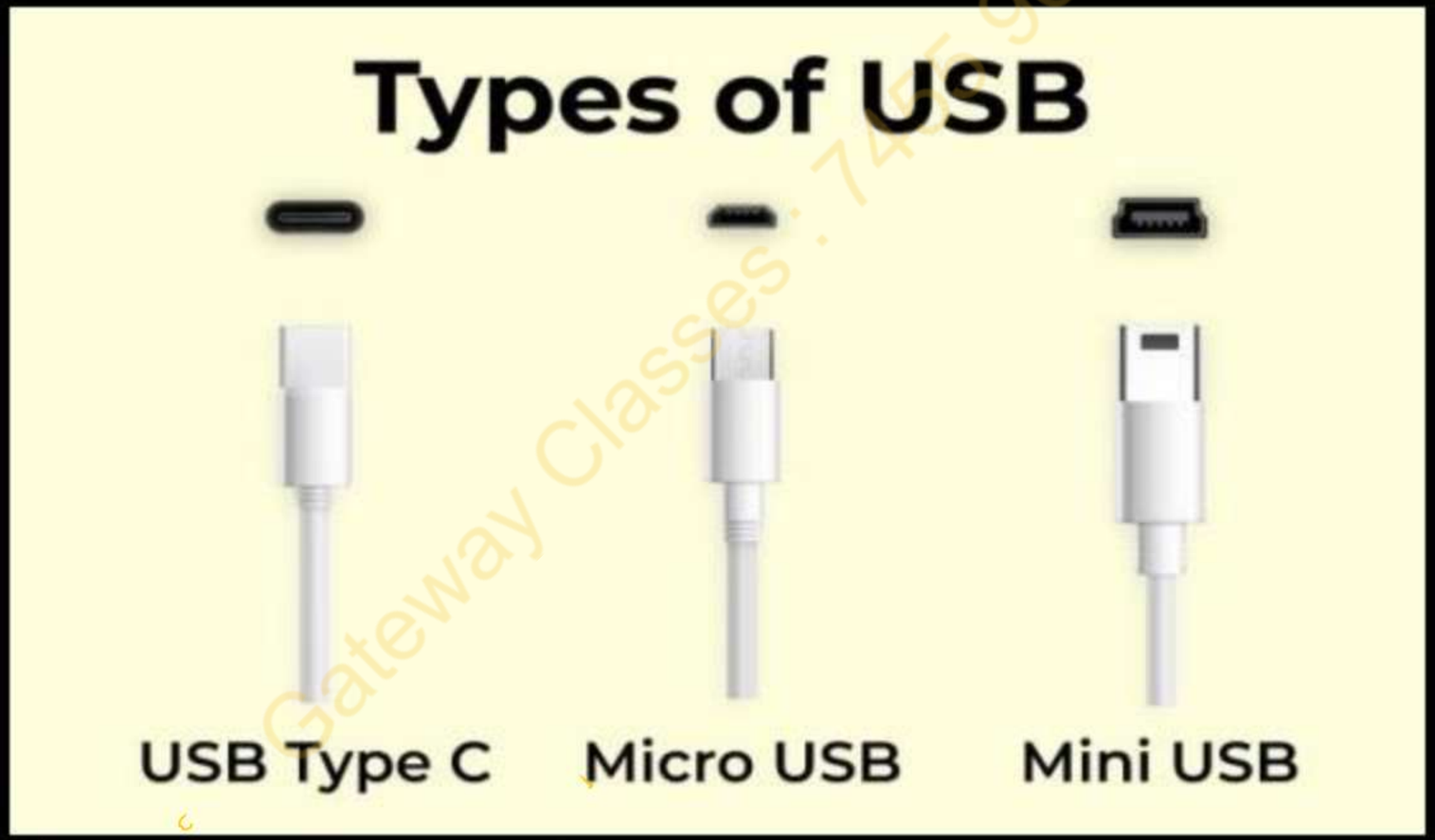
- USB was designed to standardize the connection of peripherals like pointing devices, keyboards, digital still, and video cameras.
- Devices such as printers, portable media players, disk drives, and network adaptors to personal computers used USB to communicate and to supply electric power.
- It is common place to many devices and has largely replaced interfaces such as serial ports and parallel ports.
- USB connectors have replaced other types of battery chargers for portable devices with themselves.
- Universal Serial Bus (USB) is an industry standard that establishes specifications for connectors, cables, and protocols for communication, connection, and power supply between personal computers and their peripheral devices.
- There have been 3 generations of USB specifications:

➢ USB 1.x
➢ USB 2.0
➢ USB 3.x

Gateway Classes : 7455 9212 84

USB Connector Types

- USB connectors have different shapes and sizes.
- Most of the USB connectors are the standard USB, Mini-USB, and Micro-USB, which have two or more variations of connectors.



Gateway Classes : 74 96 961284

Mini USB

- Mini USB is available in three different types A type, B type, and AB type.
- It is used with computer peripherals and digital cameras.
- The most common kind of interface is referred to as mini B.
- Micro USB and USB-C cables basically take the place of mini USB on the latest devices.
- It uses coaxial cable to transmit data and power between two devices which applies to mobile hard drives, digital cameras, and MP3 players.
- One end of a micro USB cable has a much smaller quadrilateral hub, and the other end has a regular USB hub with a flat head.
- It can be easily plugged into mobile devices.
- The tiny USB can also be used to transfer data between computers having at least one USB port for charging device.

Gateway Classes: 7455 912 84

Micro USB

- Micro-USB was created for connecting small and mobile devices including digital cameras, smartphones, GPS components, MP3 players, and photo printers.
- It was first announced in 2007 as a replacement for mini USB.
- The three different types of Micro-USB are Micro A, Micro B, and Micro USB 3.
- The connector size for the type Micro-A and Micro-B is 6.85 x 1.8 mm, while the Micro-A connector has a larger maximum overmild size.
- Because it has more pins on the side for twice as many wires than micro B, USB 3 micro is more comparable to micro B yet has faster speed.
- Micro USB and normal USB versions are both plug-and-play and hot-swappable is still widely used with electronic devices.

Gateway Classes : 7455 961 284

USB Type-C

- A USB Type-C port is a relatively new type of connector that may be found on the majority of contemporary newer Android smartphones and other USB-connected devices.
- Data and power are delivered to computing machines using it.
- In contrast to traditional USB connections, USB-C cables can be connected into devices in either direction, including upside down.

Gateway Classes : 7455 5612 04

USB Transfer Speeds

- Since it is an external bus standard, USB 1.0 can accommodate up to 127 peripheral devices and data transfer rates of 12 Mbps.
- The USB 2.0 standard, commonly referred to as high-speed USB which support a transfer rate of 60 megabytes per second or more up to 480 Mbps.
- USB 3.0, generally known as Super Speed. The enhanced functionality and speed of USB 3.0 contributed to advancements in power management, improved bandwidth capacity.
- Up to 5.0 gigabits per second (Gbps), or 640 megabytes per second, can be supported.
- USB 3.1 can support transfer rates of up to 10 Gbps.

Gateway Classes : 7455 962 84

Advantages of USB

- The Universal Serial Bus was designed to simplify and improve the interface between personal computers and peripheral devices when compared with previously existing standard or ad-hoc proprietary interfaces.
- The USB interface is self-configuring. This means that the user need not adjust settings on the device and interface for speed or data format, or configure interrupts, input/output addresses, or direct memory access channels.
- USB connectors are standardized at the host, so any peripheral can use any available receptacle. USB takes full advantage of the additional processing power that can be economically put into peripheral devices so that they can manage themselves. USB devices mostly do not have user-adjustable interface settings.
- The USB interface is hot pluggable or plug and plays, meaning devices can be exchanged without rebooting the host computer. Small devices can be powered directly from the USB interface thus removing extra power supply cables.
- The USB interface defines protocols for improving reliability over previous interfaces and recovery from common errors.
- Installation of a device relying on the USB standard minimal operator action is required.

Gateway Classes: 7455 9642 84

Disadvantages of USB

- USB cables are limited in length.
- USB has a strict tree topology and master-slave protocol for addressing peripheral devices. Peripheral devices cannot interact with one another except via the host, and two hosts cannot communicate over their USB ports directly.
- Some very high-speed peripheral devices require sustained speeds not available in the USB standard.
- For a product developer, the use of USB requires the implementation of a complex protocol and implies an intelligent controller in the peripheral device.
- Use of the USB logos on the product requires annual fees and membership in the organization.

Gateway Classes: 7455 962 84

Comparison of USB 1.x, USB 2.0, and USB 3.x

Specification	USB 1.x	USB 2.0	USB 3.x
Release Year	1996	2000	2008
Data Transfer Rate	Low Speed: 1.5 Mbps, Full Speed: 12 Mbps	High Speed: 480 Mbps	SuperSpeed: 5 Gbps, SuperSpeed+ (SS+): 10 Gbps
Power Delivery	5V, 500mA (2.5W)	5V, 500mA (2.5W) for USB 2.0, 5V, 900mA (4.5W) for USB 3.x	5V, 900mA (4.5W) for USB 3.x, 20V, 5A (100W) for USB 3.1
Connector Types	Type A, Type B, Mini-USB, Micro-USB	Same as USB 1.x, plus Type C	Same as USB 2.0
Cable Length Limit	5 meters (16.4 feet)	Same as USB 1.x	Same as USB 2.0
Backward Compatibility	Yes	Yes	Yes

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