COMPUTER ARCHITECTURE PAST PAPERS' SOLUTIONS

19th April 2022

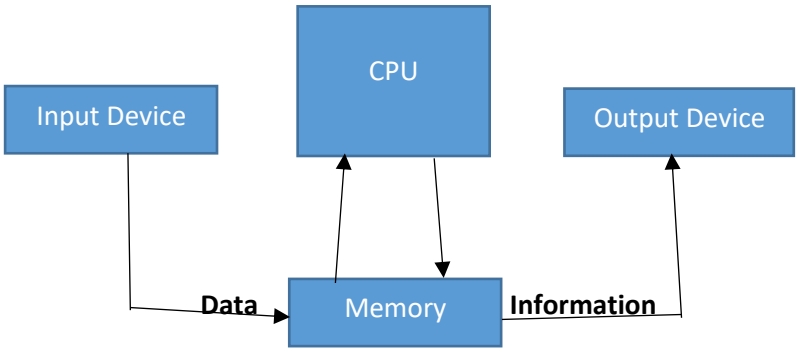
SECTION A

Question One

a) Distinguish between **Computer Architecture** and **Computer Organization.**
Computer Architecture is the structure and behavior of the various functional modules of the computer and how they interact to provide the processing needs of the user while ***Computer Organization*** is the way the hardware components are connected together to form a computer system.

b) Describe how **Data Path** executes and transmits data in a computer.
- The instruction is **fetched** from memory the n loaded to data path. The data path **decodes** the instruction stored in instruction register. The data path is read by the memory address register and data bus to access the data.
- **Execution** by the ALU takes place with the command from the control unit to perform the desired operation on the data.
- The results of the operation are then **stored** by the data path to a specific register or memory location. The data is then **transmitted** to different components of the system.
- The cycle is repeated until all the operations are complete.

c) With illustration, explain how the CPU manages **Memory Input** and **Output.**
- The CPU interacts with both system memory (RAM) and I/O devices using memory addresses. The memory map is a representation of the address space, showing how it is divided between system memory and various I/O devices.
- The CPU can perform memory operations such as read (load) and write (store) using memory addresses. When the CPU wants to read data from memory, it sends a read command along with the memory address to the memory controller. That is to say. When the CPU wants to read data from memory, it sends a read command along with the memory address to the memory controller. When the CPU wants to write data to memory, it sends a write command along with the memory address and the data to be written to the memory controller.
- Similarly, when the CPU wants to communicate with I/O devices, it uses specific memory addresses reserved for those devices. The CPU sends read or write commands to the I/O devices by accessing the corresponding addresses in the I/O address space.
- The CPU sends read or write commands to the I/O devices by accessing the corresponding addresses in the I/O address space.
- The CPU can respond to interrupts by pausing its current task and handling the I/O operation.



Question Two

A student input data in his Computer System by use of keyboard. The input unit converted data to 10110 binary number and was stored in RAM as a set of instructions with their addressing modes specified.

a) Convert the Binary Number to an Octal Number system
By grouping 10110
= 010 110
= 2 6
= $\mathbf{26_8}$

b) Explain **three** addressing modes used for accessing data in memory.
Direct addressing. This is the type of addressing where the address field contains address of the operand.
Indirect addressing. This is the type of addressing where the memory cell pointed to by the address field contains the address of the operand.
Immediate addressing. This is the type of addressing where the operand is part of the instruction.
Register addressing. This is the type of addressing where the operand is held in the register named in the address field.
Stack addressing. Here, the operand is implicitly on top of the stack.
NOTE
Addressing mode is the manner in which this target address or effective address is identified with in the

c) Describe **four** instruction set cycle operations carried out by the processor.
Fetch - The processor fetches the instruction value from the memory location provided by the program counter.
Decode - Once the instruction has been fetched, it needs to be decoded. Decoding means understanding what the instruction requires.
Execute – The program is then put in the Arithmetic Logic Unit for execution
Store – after execution the results are stored in the memory.

Question Three

a) State the functional advantage of Direct Memory Access (DMA).
It is faster to directly access the memory therefore, it results in faster processing. This is because the processor is not included in this operation. It also reduces the waiting time.

b) Explain **two** methods for performing data transfer using DMA.
Burst Mode: Here, once the DMA controller gains the charge of the system bus, then it releases the system bus only after **completion** of data transfer. Till then, the CPU has to wait for the system buses.

Cycle Stealing Mode: In this mode, the DMA controller forces the CPU to stop its operation and relinquish the control over the bus for a short term to DMA controller. After the transfer of every byte, the DMA controller releases the bus and then again requests for the system bus. In this way, the DMA controller steals the clock cycle for transferring every byte.

Transparent Mode: Here, the DMA controller takes the charge of the system bus only if the processor does not require the system bus.

c) Describe **five** steps involved in DMA transfer procedure.
The device wishing to perform DMA asserts the processor's bus request signal.
The processor completes the current bus cycle and then asserts the bus grant signal to the device.
The device then asserts the bus grant acknowledgement signal.
The DMA device performs the transfer from the source to destination address.
Once the DMA operations have been completed, the device releases the bus by asserting the bus release signal.
The processor acknowledges the bus release and resumes its bus cycles from the point it left off.

SECTION B

Question Four

PIVCO Telecom Limited designed a Communication System that implements **De-multiplexer** Technology for connecting a single source to multiple destinations.

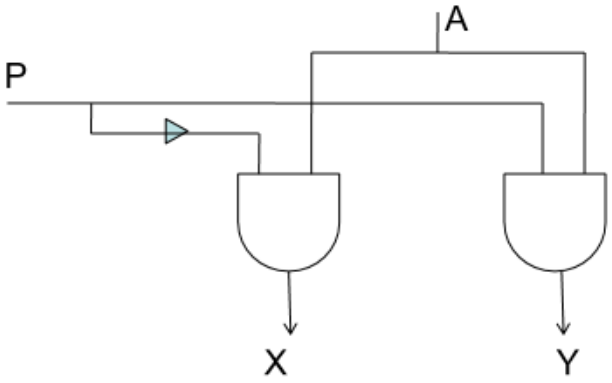
a) Explain the technology used by PIVCO.
A **de-multiplexer** technology has one set of data inputs and two or more sets of outputs and a set of control inputs whose purpose is to select the set of outputs to transmit. It picks a signal from one source and transmits it to different recipients.

b) Draw a **Truth Table** for the above.
Let the data input be A and the control input be P.

P	A	**X**	**Y**
0	0	0	0
0	1	1	0
1	0	0	0
1	1	0	1

c) Construct the **Circuit Diagram** for 4(b).

$X = \bar{P}A;$ $Y = PA$



Question Five

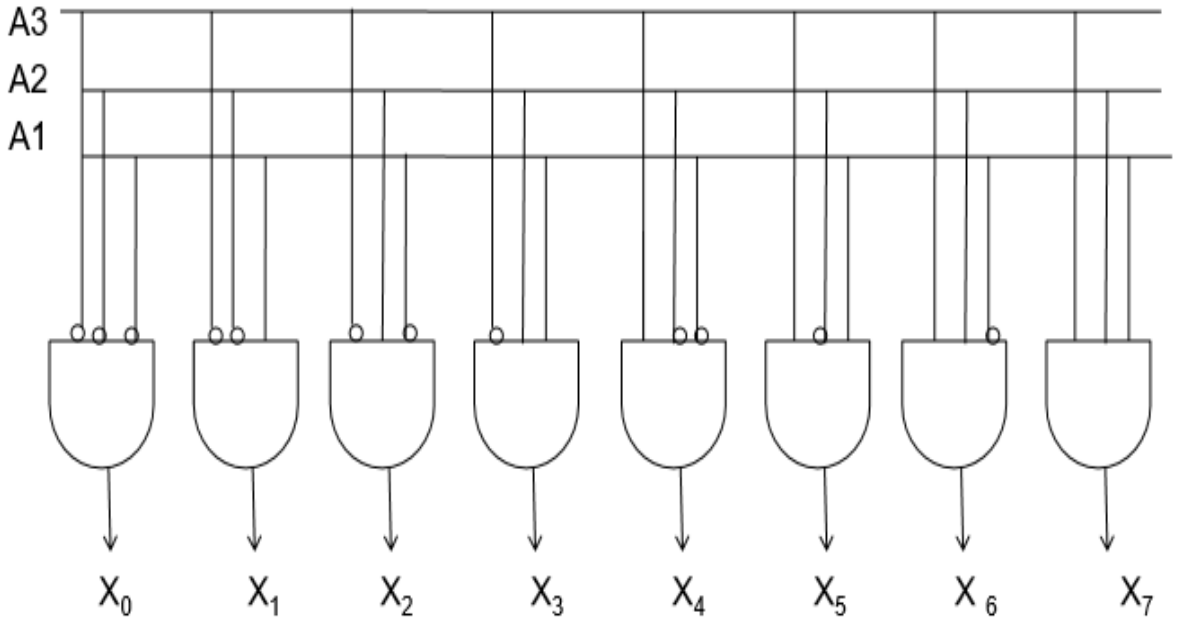
Maxwell bought a **decoder device** which he connected to his Television Set. The device taps signal from the Television antenna and displays it onto the Television Screen.

a) Explain how the device gets data signal and displays it onto the screen.
The device makes sure that exactly one output is displayed at a given time. Thus, the rest of the channels will not be allowed to display. Output of a decoder are mini-terms of the inputs.

b) Demonstrate how it manipulates signal data using a Truth Table.

A_1	A_2	A_3	X_0	X_1	X_2	X_3	X_4	X_5	X_6	X_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

c) Draw a **Circuit Diagram** for 5(b).

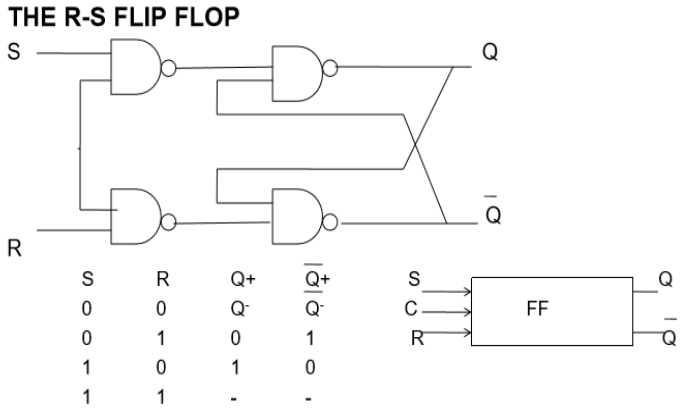


Question Six

a) A Field Programmable Gate Array which implements **Programmable Logic Array (PLA)** technique was used in a system development company to compile, test and edit digital systems in a matter of minutes. Explain the basic operations of the technique mentioned above.
A Programmable Logic Array does not output the mini-terms that will not be needed by the output. It does not necessarily produce all the mini-terms.

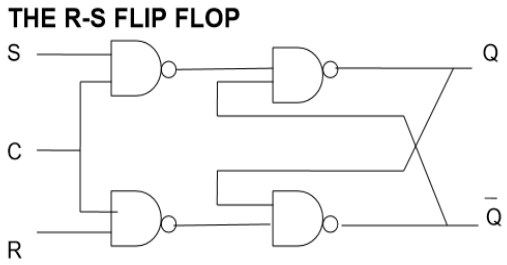
b) With illustration, explain the performance of the following in flip flops.

i) S-R flip flop.



An S-R flip flop has two inputs: Set (S) and Reset (R). It responds immediately to changes in its inputs (S and R). When S is activated, the output Q is set to 1, When R is activated, the output Q is reset to 0.
If both S and R are activated simultaneously, it can lead to undefined behavior or a race condition.

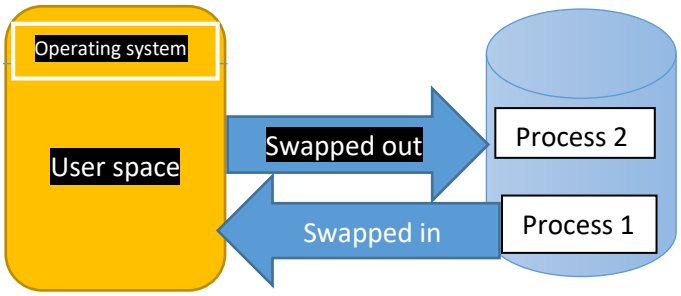
ii) Clocked S-R flip flop.



A clocked S-R flip-flop is also known as an S-R flip-flop with a clock. It responds to changes in its inputs only when a clock signal is active (usually rising or falling edge). The flip-flop has additional inputs: Clock (C or CLK) and sometimes an Enable (E) input. Changes in the S and R inputs are only considered when the clock signal transitions.

Question Seven

a) Illustrate using a well labelled sketch diagram the **schematic view** of swapping in memory management.



Swapping is the process of moving one process out of primary memory to secondary memory to leave space for an incoming process from the secondary memory. The swapped out process is later brought back to memory for continued execution.

b) Describe **three** steps of address binding of instructions.

- **Compile time**: If memory location known a priori, absolute code can be generated; must recompile code if starting location changes.
- **Load time**: Must generate relocatable code if memory location is not known at compile time.
- **Execution time**: Binding delayed until run time if if the process can be moved during its execution from one memory segment to another.

c) Explain **four** drawbacks of Dynamic Random Access Memory (DRAM) refresh.

- It is volatile. It loses data when power is turned off.
- It is slower than Static Random Access Memory (SRAM).
- It requires continuous refreshing
- It has low retention of data.
- Manufacturing is complex
- It has a high power consumption compared to other options.

NOTE

ADVANTAGES

- It can be deleted and refreshed while running the program.
- It is cheaper compared to Static Random Access Memory (SRAM).
- It is smaller in size.
- It has higher storage capacity. Hence it is used to create larger RAM space system.
- It is simple in structure than SRAM.

COMPUTER ARCHITECTURE PAST PAPERS' SOLUTIONS

16th December 2022

SECTION A

Question One

A computer system has five core functions that it must perform for it to be fully appreciated as such a system.

a) Define the meaning of the system stated above.
A **computer system** is a system that accepts input as data through the input units, it processes the input data and produces results at the output units and also stores them in the memory. It also controls all the above operations.

b) Explain **five** core functions of the system stated above.
- **Inputting**. A computer system accepts input through the input devices.
- **Processing**. The computer system processes the input data in the central processing unit by the Arithmetic Logic Unit.
- **Storing**. The system stores the results of processing in the memory. This may be permanent in ROM or temporary in RAM.
- **Outputting**. The system provides output of the results after processing through the output devices.
- **Controlling**. The system coordinates and controls all the above operations.

c) For each of the stated function in (b), mention an example of a computer in the system that is responsible for that functionality.
- **Input** – Keyboard, mouse, microphone, scanner, digital camera, scanner, webcam etc.
- **Processing** – Microprocessor (Arithmetic Logic Unit)
- **Storing** – CD-ROM, compact disks, flash disks etc.
- **Outputting** – Monitor, projector, printer etc.

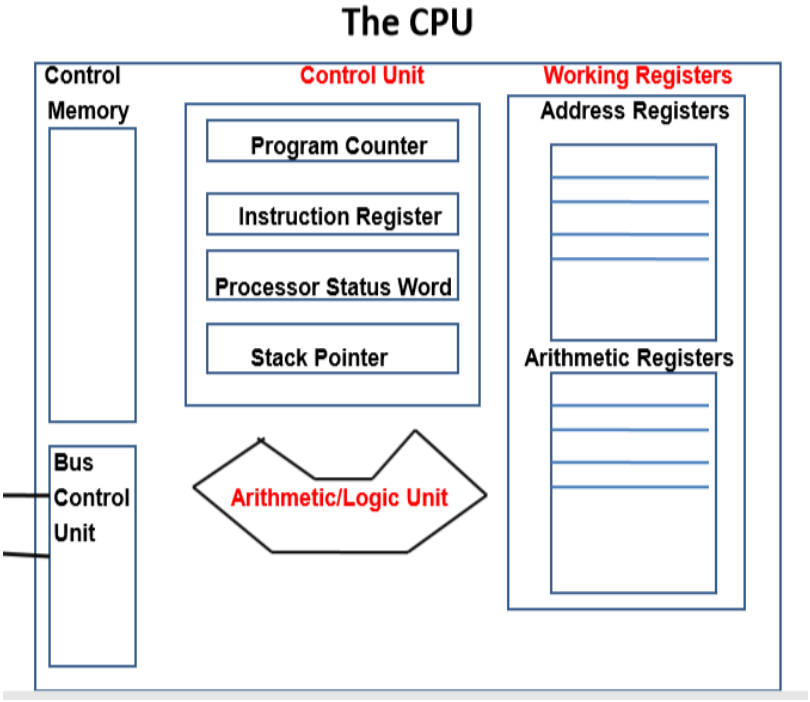
d) Give the purpose of each of the component mentioned in 1(c) above to the system.
- **Keyboard** – It is used for inputting textual data (numbers, characters and symbols) into the computer system.
- **Microprocessor** – It is decodes and executes instructions given to the computer system.
- **CD-ROM** – It is used for storing large amounts of data permanently.
- **Monitor** – It is used to display results of processing activities.

Question Two

a) Differentiate between **registers** and **system buses** as used in computing.
Registers are high speed memory locations developed directly into the Arithmetic Logic Unit that stores data and instructions that are currently being used by Central Processing Unit while

system buses are sets of connectors that connect the Central processing unit to the memory and the input and output devices.

b) Using a well labelled illustration of the top level computer components, explain the functionality of each of the sub-components that make up the CPU.



The working registers are the Address registers and the arithmetic registers.
Arithmetic registers temporarily hold operands and results of arithmetic operations.
Address registers are used for addressing data and instructions in main memory. If a register can be used for both arithmetic operations and addressing, it is called a **general purpose register.**

The arithmetic logic unit is used for arithmetic operations like addition, subtraction, division and multiplication.
It is also used for logic operations of comparisons like >, <, =

The control unit is used to regulate and control all activities carried out in the CPU. It is made up of the program counter, the instruction register, the processor status word and the stack pointer.

The program counter holds the address in the main memory from where the next instruction is to be fetched.
The instruction register receives an instruction when it is brought from the memory and holds it while it gets decoded and executed
The processor status word contains condition flags that indicate the current status of the CPU and important characteristics of the result of the previous instruction.
The stack pointer hold the address at the top of the memory stack.

Question Three

a) Distinguish between **binary-coded-decimal codes** and **alphanumeric codes** as used in computer architecture.

Binary-coded-decimal codes are used for representing only numeric data while alphanumeric codes are used to represent both numeric and character data.

b) Construct a table showing the binary representation, hexadecimal representation and the binary-coded-decimal representation of all decimal numbers from 0 to 15.

decimal	**hexadecimal**	**binary**	**binary-coded-decimal**
0	0	0	0000
1	1	1	0001
2	2	10	0010
3	3	11	0011
4	4	100	0100
5	5	101	0101
6	6	110	0110
7	7	111	0111
8	8	1000	1000
9	9	1001	1001
10	A	1010	0001 0000
11	B	1011	0001 0001
12	C	1100	0001 0010
13	D	1101	0001 0011
14	E	1110	0001 0100
15	F	1111	0001 0101

SECTION B

Question Four

Analyze the table below and answer the questions that follow:

Table: 1 Truth Table on Four-Input Circuit

A	B	C	D	X
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	1
0	1	0	1	0
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

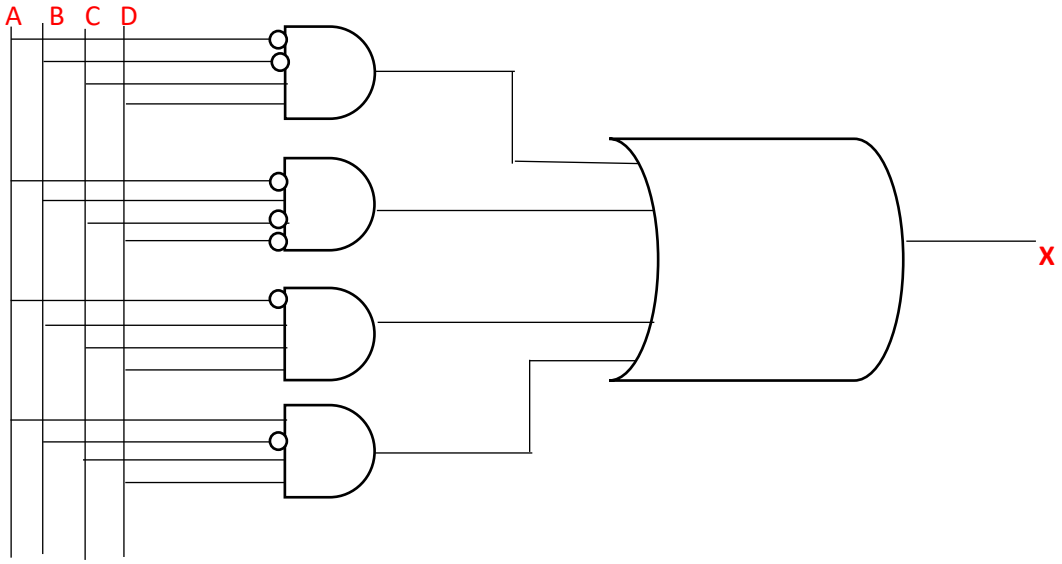
a) State the output of the input circuit above when all inputs except B are 1.
1011
X = 1

b) State the output for the input conditions: **A = 1, B = 0, C = 1, D = 0.**
1010
X = 0

c) Write the Boolean expression that will be realized from the table above assuming the inputs were added together to give the output (x).

$X = \bar{A}\bar{B}CD + \bar{A}B\bar{C}\bar{D} + \bar{A}BCD + A\bar{B}CD$

d) Draw the circuit diagram representation for the Boolean expression in 4(c).



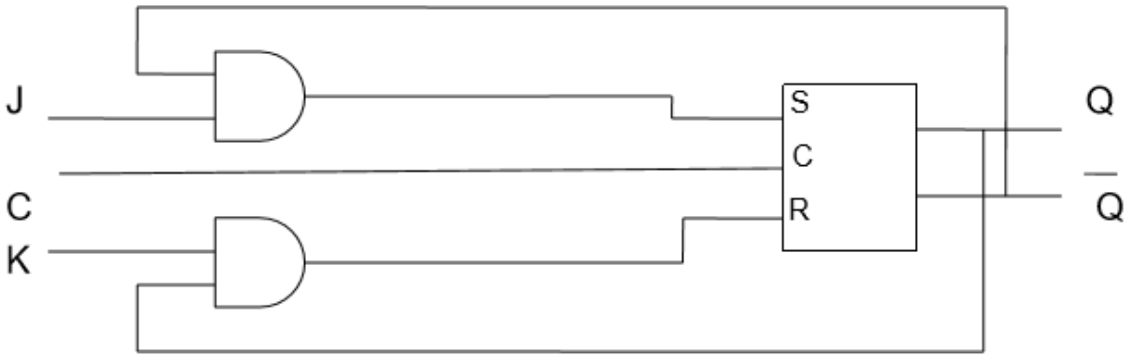
Question Five

a) Distinguish between the terms **Flip-Flop** and **shift register** as used in computer architecture.

- Flip-flops are bi-stable devices that are used in sequential networks while shift registers are sequential logic circuits that are capable of shifting their bits either to the left or to the right. They have a tendency of rearranging their contents.

b) Draw the circuit diagram and the graphic symbol of the J-K Flip-Flop.

Circuit diagram



Graphic symbol of a J-K flip-flop

c) In a tabular form, show the JK Flip-Flop characteristic table.

J	K	Q^+	$\overline{Q}^+$
0	0	Q^-	$\overline{Q}^-$
0	1	0	1
1	0	1	0
1	1	$\overline{Q}^-$	Q^-

Question Six

a) Explain the functionality of each of the following in a computer system.

i) Motherboard.

This is a circuitry that holds other parts of the computer for example the memory chips, processors.

ii) Central processing unit

The **central processing unit** is the center of all processing of the computer where execution of instructions takes place. It also controls all the operations of the computer system.

iii) CMOS battery

A **CMOS battery** is used for powering the computer BIOS during booting. It powers the firmware of the computer.

iv) North bridge

The **North bridge** is connects the CPU to the memory. It provides a communication channel between the CPU and the memory and other circuitry in the computer.

v) Cache memory

It store frequently used instructions. This means that the processor does not need to go to the main memory to fetch those instructions. This results in faster processing.

b) Mention **five** ports that are found on a computer system, stating their purpose on the system.

- **Power port**. It is used for connecting power supply into the computer system.
- **VGA port**. It is used to connect devices like projectors to the computer system.
- **HDMI port**. It is used to transfer video content from devices like decoders to monitors or screens.
- **Ethernet port.** It is used to share internet connection to the computer system.
- **Universal serial bus**. It is used to connect several devices to the computer system to transfer information between them and the computer system.
- **Microphone port**. It is used to microphones to transfer sound signals to the computer system

Question Seven

a) Differentiate between a **read-only memory** (ROM) and a **programmable logic device** (PLD) as used in computer architecture.
Read-only memory (ROM) includes all the possible mini-terms of the decoder while a **programmable logic device** (PLD) outputs only the mini-terms that will be followed by the decoder, it does not output all the mini-terms

b) Explain three types of programmable logic devices (PLD's) that are normally used when drawing the architecture of a computer.
GATES: These are combinatorial circuits with only one output. Example are; AND gate whose input is 1 if all the inputs are 1s, OR gate whose output is 0 if all the inputs are 0s, the NOT gate whose output is 1 if the input is a 0 and vice versa.

MULTIPLEXERS. These are circuits that are capable of selecting a single set of inputs from a set of inputs and passes the selected inputs to the outputs.

DEMULTIPLEXERS: These are circuits which have one set of data inputs and two or more sets of outputs.

c) Define the term **code converter** as used in computer architecture.
Code converter is a circuit that converts data from one format to another. It takes in data in one format and provides output in another format.

d) Design a code converter (use a tabular format) that converts a decimal digit from the 8, 4, -2, -1 code to BCD.

Decimal	BCD
8	1000
4	0100
-2	0010 **1101**
-1	0001 **1101**

COMPUTER ARCHITECTURE PAST PAPERS' SOLUTIONS

6th May 2022

SECTION A

Question One

Among the major components of a computer system unit is a microprocessor.

a) Describe its functions.
- Controlling all other parts of the machine and sending timing signals.
- Transferring data between memory and I/O devices.
- Fetching data and instructions from the memory.
- Decoding instructions
- Performing arithmetical and logical operations.
- Executing programs stored in memory.

b) Explain **three** roles of a system Bus as one of the features.
- It carries information/data from the CPU to the output devices. (data lines/buses)
- It carries information/data from the input devices to the CPU. (data lines)
- It carries address in the memory location from where the instruction is to be fetched or stored. (address buses)
- Control buses regulate activities on the system bus.

Question Two

a) Define the term **interrupt.**
An interrupt is a signal from a device attached to a computer or from a program within a computer that requires the operating system to stop and figure out what to do next.

b) Explain **two** types of interrupts.
Hardware interrupts – This is an interrupt signal generated from external devices. Hardware interrupts are classified into two types which are as follows.
i. **Maskable interrupt –** This is a hardware interrupt that can be delayed when highest priority interrupt has occurred to the processor.
ii. **Non Maskable interrupt –** This is a hardware interrupt that cannot be delayed and immediately serviced by the processor.

Software interrupts - This is an interrupt signal generated from internal devices and software programs which are in need to access any system call. Software interrupts are divided into two types. They are as follows.
iii. **Normal interrupts –** These are interrupts caused by software instructions.
iv. **Exception –** These are unplanned interruptions. For example division by zero.

c) Explain **four** effects of an interrupt to the computer system operation.

- Interrupts decreases waiting time therefore stops wastage of the instruction cycle.
- Interrupts enables multi-tasking by allowing the CPU to quickly switch between different processes.
- Interrupts simplifies input/output operations by allowing devices to communicate directly with the CPU.
- Interrupts provide device independence.
- Interrupts provide concurrency and provide a way to respond to external events.

Question Three

a) Explain the following terms as used in computer architecture;

i) Address.
An **address** is a word location in the memory. It is where each byte in the memory is located.

ii) Memory write.
This is the process of adding information into the memory.

iii) Memory access time.
This the total time spent while using the memory.

iv) Capacity
Capacity is how much a memory or computer can store.

v) DRAM (Dynamic RAM)
DRAM is a type of RAM that stores each bit of data on a separate capacitor.

b) During a practical exercise carried out on maintenance of memory, it was established that addressing modes are methods used to locate and fetch data from CPU register. Describe the **five** modes.

- **Direct addressing**. This is the type of addressing where the address field contains address of the operand.
- **Indirect addressing**. This is the type of addressing where the memory cell pointed to by the address field contains the address of the operand.
- **Immediate addressing**. This is the type of addressing where the operand is part of the instruction.
- **Register addressing**. This is the type of addressing where the operand is held in the register named in the address field.
- **Stack addressing**. Here, the operand is implicitly on top of the stack.

- **Implied addressing.** This is the mode of addressing in which the operands are specified implicitly in definition of the instruction

SECTION B

Question Four

a) Define the term **computer architecture.**

Computer Architecture is the structure and behavior of the various functional modules of the computer and how they interact to provide the processing needs of the user.

b) State **three** functions of the microprocessor unit.

- Controlling all other parts of the machine and sending timing signals.
- Transferring data between memory and I/O devices.
- Fetching data and instructions from the memory.
- Decoding instructions
- Performing arithmetical and logical operations.
- Executing programs stored in memory.

c) List **three** types of lines found in the system bus.

- Data lines
- Address lines
- Control lines

d) In a microprocessor composition, explain the purpose of the following;

i) Program counter

It holds address in the main memory from where the next instruction is to be fetched.

ii) Instruction register.

It receives instructions as they are brought from the main memory and holds them as they get decoded and executed.

iii) Processor status word.

It contains condition flags that indicate the current status of the CPU and important characteristics of the result of the previous arithmetic operation.

Question Five

A current account has three signatories. It is desired that when at least two signatories of that account have signed a cheque, the bank should honor that cheque;

a) Write the Boolean function which describes the above process.

Let A, B, C represent the three signatories

Let X represent the result of the bank honoring the cheque

$X = \bar{A}BC + A\bar{B}C + AB\bar{C} + ABC$

b) Design a truth table for the function in 5(a)

A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Question Six

a) Work out the following in binary coded decimal (BCD)

i) $146_{10} + 259_{10}$

146	0001	0100	0110
259	0010	0101	1001
405	0100	1010	1111
		0110	0110
	0100	0000	0101

ii) $52_{10} + 199_{10}$

52		0101	0010
199	0001	1001	1001
251	010	1111	1011
		0110	0110
	0010	0101	0001

b) Explain **five** differences between the central processing unit and a microprocessor.

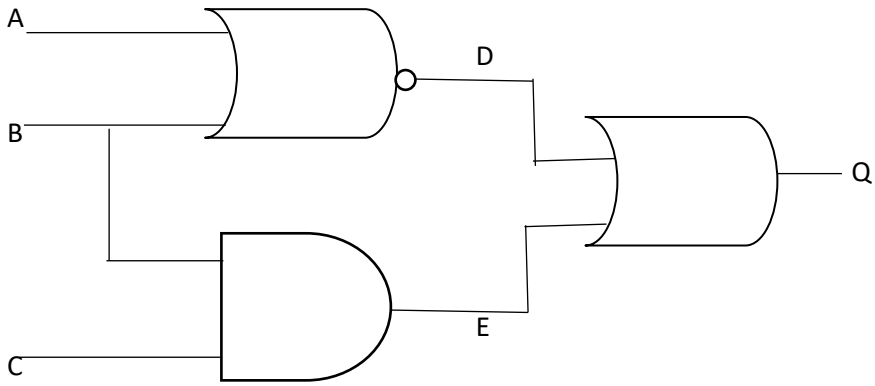
- A CPU is a processor tasked with a variety of tasks while a microprocessor is generally tasked with one specific task.
- A CPU is a component inside the computer while the microprocessor is inside the CPU.
- A CPU is a chip that functions as the brains of the computer while microprocessors are circuitry that surround the CPU.
- A CPU is the central processing unit of a computer while a microprocessor is a smaller, more specialized type of CPU used in embedded systems and other devices.
- A CPU is typically found in desktop and laptop computers while microprocessors are in various devices, including smartphones, cars and medical equipment.
- Microprocessors have simpler architecture than the CPU because they are only made to do small number of jobs.

- A CPU carries out all arithmetic and computing functions of a computer while the microprocessor houses the CPU, BIOS and memory access circuits.

Question Seven

a) The circuit diagram shown below was extracted from the communication system of Electronics Club Telecommunication Company limited.
Draw the truth table for the circuit.

A	B	C	D	E	Q
0	0	0	1	0	1
0	0	1	1	0	1
0	1	0	0	0	0
0	1	1	0	1	1
1	0	0	0	0	0
1	0	1	0	0	0
1	1	0	0	0	0
1	1	1	0	1	1



b) Design the truth tables to show how the following logical gates are implemented.

i) **AND**

For inputs B and C and taking the output as E,

B	C	E
0	0	0
0	1	0
1	0	0
1	1	1

ii) **NOR**

For inputs A and B and taking the output as D,

A	B	D
0	0	1
0	1	0
1	0	0
1	1	0

6th May 2023

SECTION A

Question One

a) Explain the following as used in circuit design of the circuit board;

i) Half adder

A **half adder** is a circuit that implements addition of 2, 1 bit quantities. It has only one carry.

ii) Full adder

A **full adders** is a circuit that implements addition of binary numbers and includes a carry from the lower order bit.

b) Identify **five** reasons for using arithmetic circuits in designing combinatorial circuits.

- Arithmetic circuits form a building block of any functional unit
- They help in performing arithmetic operations of addition, subtraction, multiplication and division.
- Arithmetic circuits form the building block of any functional unit of a computer.
- Arithmetic circuits simplify complex systems.

Note

*An **Arithmetic Circuit*** is a set of gates with a separate set of inputs for number that has to be processed. The gates are connected so as to carry out an arithmetic action and the outputs of the gate circuit are the digits of the result. (Addition, subtraction, multiplication and division).

c) Determine the functions of the following registers;

i) Status register.

It contain flags that indicate the status of the result of the previous arithmetic operation. For example, the Z bit may be set if the result of the operation is zero and cleared if it is non zero.

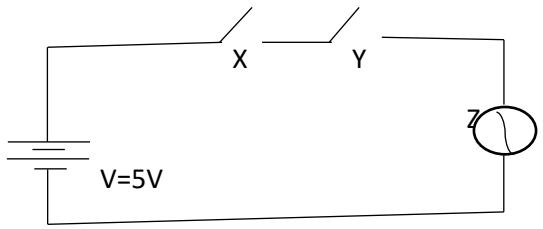
ii) Control register.

It controls the general behavior of the CPU or other services in the system. Common tasks performed by control registers are; interrupt control, switching the addressing mode, paging control and coprocessor control.
This register also specifies the mode of transfer of data in the computer.

iii) Data register.
It holds data that will be stored or fetched from the computer memory. It stores everything that can be copied from the computer memory and used by the processor for subsequent tasks.

Question Two

A computer circuit that operates using an AND gate is fabricated using two switches X and Y. The computer is powered on only if both switches are closed. Using the illustration below.



a) Show on a Truth table the output Z when these switches X and Y are **opened** and **closed.**

X	Y	Z
Opened	Opened	Off
Opened	Closed	Off
Closed	Opened	Off
Closed	Closed	On

b) Show on the Truth table the output using 1 and 0.

X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

c) Identify the Boolean output at Z.
Z = XY

Question Three

Minimize the following expression by use of Boolean rules.

a) $X = ABC + \bar{A}B + AB\bar{C}$
$X = ABC + AB\bar{C} + \bar{A}B$
$= AB(C+\bar{C}) + \bar{A}B$
$= AB + \bar{A}B$
$= B(A + \bar{A})$
$= B$

b) $X = \bar{A}B\bar{C} + A\overline{BC} + \overline{ABC} + \overline{ABC}$

$X = \bar{A}B\bar{C} + A\overline{BC} + \overline{ABC}$

$X = \bar{A}B\bar{C} + A(\bar{B}+\bar{C}) + \bar{A} + \bar{B} + \bar{C}$

$X = \bar{A}B\bar{C} + A\bar{B} + A\bar{C} + \bar{A} + \bar{B} + \bar{C}$

$X = \bar{A}B\bar{C} + \bar{A} + A\bar{B} + \bar{B} + A\bar{C} + \bar{C}$

$X = \bar{A}(B\bar{C}+1) + \bar{B}(A+1) + \bar{C}(A+1)$

$X = \bar{A}(1) + \bar{B}(1) + \bar{C}(1)$

$X = \bar{A} + \bar{B} + \bar{C}$

$X = \overline{ABC}$

SECTION B

Question Four

A colleague has bought a brand new Dell desktop computer and has invited you to orient him on his newly bought device.

a) State **five** internal components that his device possesses.

- Central Processing Unit
- Memory
- Input devices
- Output devices
- System buses
- interfaces

b) Give **four** ports that are found on his device.

- Universal Serial Bus port
- Power port
- VGA port
- HDMI port
- Ethernet port

c) Explain **two** factors that will determine the speed of machine's system bus while communicating with external peripheral devices.

- **Primary memory** (**RAM**). This stores data and instructions temporarily or permanently. More RAM results in faster processing.
- **Cache memory**. This memory stores frequently used instructions. Reuse of such instructions does not need to go back to the main memory. This reduces CPU load times.
- **Bus width.** This is how wide a system bus is. A wider bus carries more information hence resulting in faster processing.
- **Registers**. These are memory locations that store data and instructions that are currently being used by the CPU. They are developed directly into the ALU.

d) Determine **three** types of buses on his device's main board.

- Data buses
- Address buses
- Control buses

Question Five

Paul uses a Pentium four laptop computer in his computer center for doing secretarial and internet services. However, of recent, the performance of his computer is slowing down.

a) State **six** components that Paul's laptop should have in order to meet his business needs.
- Central Processing Unit
- Memory
- Input devices
- Output devices
- System buses
- Interfaces

b) Explain **four** reasons that could have caused the slow performance of Paul's computer.
Insufficient RAM (Random Access Memory). If the computer has too little RAM, it may struggle to handle multiple tasks simultaneously. Running several applications or having numerous browser tabs open can lead to high memory usage
High CPU usage. Intensive tasks or processes that demand a lot of computational power can cause high CPU usage, slowing down the overall system performance.
Disk fragmentation. Fragmented files on the hard drive and low disk space can contribute to slow performance. Fragmentation occurs when files are split into different physical locations on the disk, making it take longer to access them
Malware. Malicious software or unwanted applications running in the background can consume system resources, leading to slow performance. Malware can be particularly harmful and may perform tasks without the user's knowledge.
Outdated hardware. Aging or outdated hardware, such as a slow processor, an old graphics card, or an outdated hard drive, can limit the overall performance of the computer.
Overheating. Overheating can lead to thermal throttling, where the computer's components reduce their performance to prevent damage. Dust accumulation on fans and inadequate cooling can contribute to overheating.

c) Discuss **three** factors Paul would have considered before purchasing the laptop.
- **Storage capacity**. This is the measure of how much information a laptop can store.
- **Amount of RAM**. This stores data and instructions that are currently being used by the CPU. More RAM results in faster laptop.

- **Processor speed**. This is the measure of how fast the CPU can execute instructions. High processor speed results in a faster laptop.

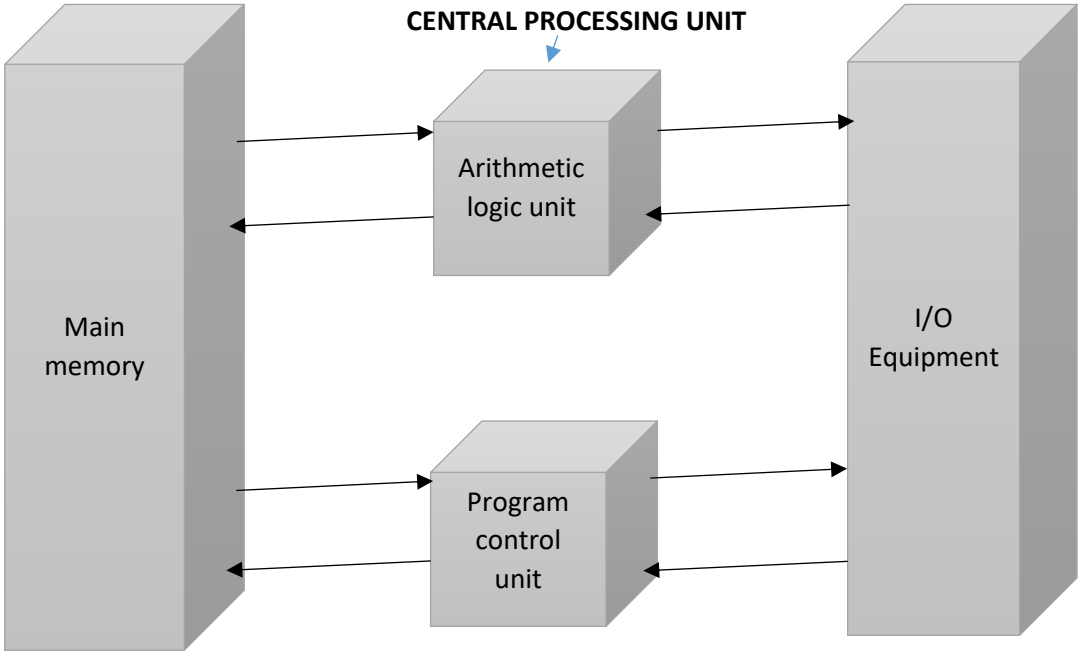
Others

- Generation of the laptop
- Price of the laptop
- Mechanical condition of the laptop
- Model of the laptop

Question Six

Your institute uses computers at the computer lab which are IAS computers for teaching students and for student's research work.

a) With illustration, discuss the general structure of an IAS computer.



The IAS machine is a machine with 4096 words of memory, each 40 bits wide. Each word can hold one 40-bit two's complement integer or two 20-bit machine instructions. A machine instruction consists of an 8-bit opcode followed by a 12-bit operand. The IAS computer has seven registers.
The IAS machine was the first electronic computer built at the ***Institute for Advanced Study*** (IAS) in ***Princeton, New Jersey.*** it is sometimes called the von Neumann machine.

b) Explain **four** registers that the structure in 6(a) possess.

- ✓ **Accumulator –** it stores intermediate arithmetic logic unit results.
- ✓ **Control register (program counter) –** it holds the currently executing instruction.
- ✓ **Function table register –** it holds the current operation code.
- ✓ **Memory address register –** it holds the current address.

- ✓ **Selection register –** it holds the current data value being read from or written to memory.

Others

- ✓ **Arithmetic registers**
- ✓ **Control counter**

Question Seven

a) Explain **four** addressing modes a computer device may perform.

- ✓ **Direct addressing**. This is the type of addressing where the address field contains address of the operand.
- ✓ **Indirect addressing**. This is the type of addressing where the memory cell pointed to by the address field contains the address of the operand.
- ✓ **Immediate addressing**. This is the type of addressing where the operand is part of the instruction.
- ✓ **Register addressing**. This is the type of addressing where the operand is held in the register named in the address field.
- ✓ **Stack addressing**. Here, the operand is implicitly on top of the stack.
- ✓ **Implied addressing.** This is the mode of addressing in which the operands are specified implicitly in definition of the instruction

b) Show how a processor converts the following to decimal.

i) 101_2

$101_2 = (1x2^2) + (1x2^1) + (1x2^0)$

$= 1x2x2 + 1x2 + 1x1$

$= 4 + 2 + 1$

$= \mathbf{5_{10}}$

ii) 1010_2

$1010_2 = (1x2^3) + (0x2^2) + (1x2^1) + (0x2^0)$

$= 1x2x2x2 + 0x2x2 + 1x2 + 0x1$

$= 8 + 0 + 2 + 0$

$= \mathbf{10_{10}}$

iii) 11.011_2

$11.011_2 = (1x2^1) + (1x2^0) + (0x2^{-1}) + (1x2^{-2}) + (1x2^{-3})$

$= 2 + 1 + 0 + 0.25 + 0.125$

$= \mathbf{3.375_{10}}$

August 9, 2023

SECTION A

Question One

a) Differentiate between **memory** and **storage** as applied to computer architecture.

- There is more room in storage than in memory.
- Contents are retained in storage when the computer is turned off, whereas programs or the data in memory disappear when you shut down the computer.
- Storage devices operate much slower than memory chips, but storage is much cheaper than memory.

b) A user attaches an external removable drive to a computer to transfer 20 files.

(i) State **three** memory devices that the CPU will use during the execution of the file transfer.

Random Access Memory
Cache Memory
Registers

(ii) Explain the function of each memory device in 1(b) (i).

Random Access Memory stores data and instructions that are currently being used by the processor (CPU).
The Cache Memory stores data and instructions that are frequently used by the processor (CPU).
Registers are high speed memory devices that store data and instructions that are currently being used by the processor (CPU).

c) Outline the steps that the processor will undertake to perform the following operations;

(i) Write the files to the external drive.

- **Connection.** The user physically connects the external drive.
- **Device Recognition.** The operating system detects the connection of the external drive.
- **Finder Access.** The user opens File Explorer to navigate through the files on their computer.
- The user selects the 20 files they want to transfer.
- The user copies or moves the selected files from their computer to the external drive.
- Once copying is complete, the user safely ejects the external drive. And also disconnect physically.

(ii) Read the files from the external drive.

- Plug the external drive into an available USB port on your computer.
- The operating system should recognize the external drive and assign it a drive letter.
- On Windows, open File Explorer, and on mac OS, open Finder.
- Navigate to the external drive.
- View the files on the list and open the files of interest and read them.

- Then close the files explorer and eject the external drive.

Question Two

A client needs a high performance laptop computer for video editing and rendering as well as playing the latest video games. He owns a modern 32 inch LED TV screen at home which he intends to interface with the laptop.

a) State **two** ports that will provide capability of interfacing the client's LED TV to the laptop.
High Definition Multimedia Interface (HDMI).
Display Port

b) Explain **four** features to consider in order to acquire a computer that meets the demands.
- **Processor**. Choose a processor that suits your needs.
- **Random Access Memory**. Ensure the computer has sufficient RAM for your tasks.
- **Cost**. Establish a realistic budget. Computers come in a wide price range, and knowing your budget helps narrow down the options.
- **Computer Model.** Decide the model of the computer of your choice.
- **Storage Type and Capacity.** Decide between HDD (Hard Disk Drive) or SSD (Solid State Drive) storage. SSDs are faster and more reliable but may be more expensive.

c) Outline the procedures required for the client to perform the following;
(i) Interface with the LED TV to one of the ports in 2(a).
Using the HDMI port
Connect one end of the HDMI cable into its port on the laptop.
Connect the other end to the Television.
On the Television, select HDMI input

Using the display port
Connect the display port cable to the laptop and the other end of the cable to Television.
Select the correct input on the Television.
Configure the display settings if needed.

(ii) Interface with a wireless mouse to the laptop if acquired.
Ensure the wireless is powered.
If the mouse has a USB receiver, plug the USB receiver into the available USB port on the laptop.
Check mouse functionality.

Question Three

a) Describe the operation of the following storage elements;

(i) JK flip-flop.

A J-K flip flop is an R-S flip flop that has been modified by feeding back the outputs and ANDYING them with the inputs. It is constructed from an edge triggered R-S flip flop.

(ii) D latch.

It has two inputs. The clock input and an input labeled D. D latches are often used in applications where a single-bit storage element is needed. They are the building blocks for more complex sequential elements like flip-flops and registers. It's important to note that a D latch is different from a D flip-flop. While a D latch is transparent and samples the input continuously as long as the clock is enabled, a D flip-flop only samples and updates the output on the rising or falling edge of the clock.

b) Design a combined circuit with three inputs and one output that operates as follows;
The output is high when the binary value of the inputs is less than 3 and low when the binary value of the inputs is more than 3.

The truth table

A	B	C	X
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0

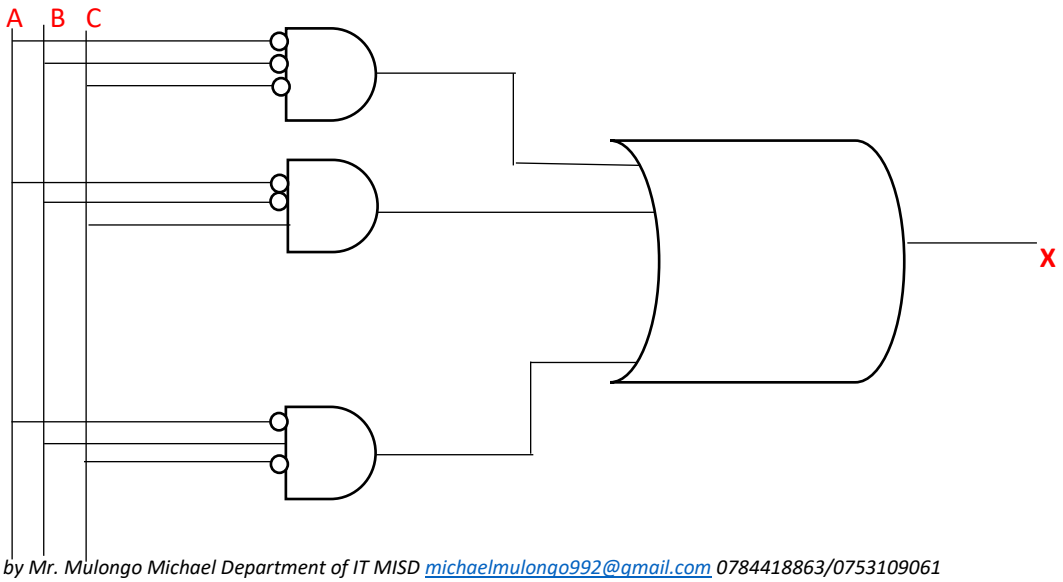
The Boolean expression

From the table

Using Sum of Products

$X = \overline{A}\overline{B}\overline{C} + \overline{A}\overline{B}C + \overline{A}B\overline{C}$

The Circuit diagram



SECTION B

Question Four

a) Construct a truth table showing the binary, hexadecimal and BCD representation of all decimal numbers from o to 1.

Decimal	Binary	Hexadecimal	BCD
0	0	0	0000
1	1	1	0001

b) Perform the following conversions.

(i) 1011011_2 to octal.

$1011011_2 = 001 \quad 011 \quad 011$

$= 1 \quad 3 \quad 3$

$= 133_8$

(ii) 247_8 to hexadecimal.

$247_8 = 010 \quad 100 \quad 111$

$= 0000 \quad 1010 \quad 0111$

$= 0A7$

$= A7_{16}$

(iii) 24.75_{10} to binary.

$24_{10} = 11000_2$

	Divisor	Remainder
2	24	
2	12	0
2	6	0
2	3	0
	1	1

For .75

.75 x 2 = 1.5

.5 x 2 = 1

.75 = 11

$24.75_{10} = 11000.11_2$

(iv) 48_{10} to BCD.

$48_{10} = 0100 \quad 1000$

c) Numbers are entered into a micro-controller based system in BCD, but stored in straight binary format. With reference to this, determine the number of;

(i) Bytes for storage if the system takes a 4-digit decimal entry.

1 digit = 4 bits

The total number of bits required for a 4-digit BCD entry is

4 digits × 4 bits

= 16 bits

Since 1 byte is equal to 8 bits, the storage requirement for a 4-digit BCD entry in straight binary format is

16 bits / 8 bits

= 2 bytes

(ii) Bits for storage if the system takes a 2-digit decimal entry.

1 digit = 4 bits

BCD entry is 2 digits × 4 bits

= 8 bits

Question Five

a) Differentiate between a **decoder** and an **encoder** with reference to combinatorial logic.

A decoder converts a binary code to a set of mutually exclusive outputs while an encoder converts multiple input lines into a binary code.

b) Explain how decoders are used in the memory system of a computer.

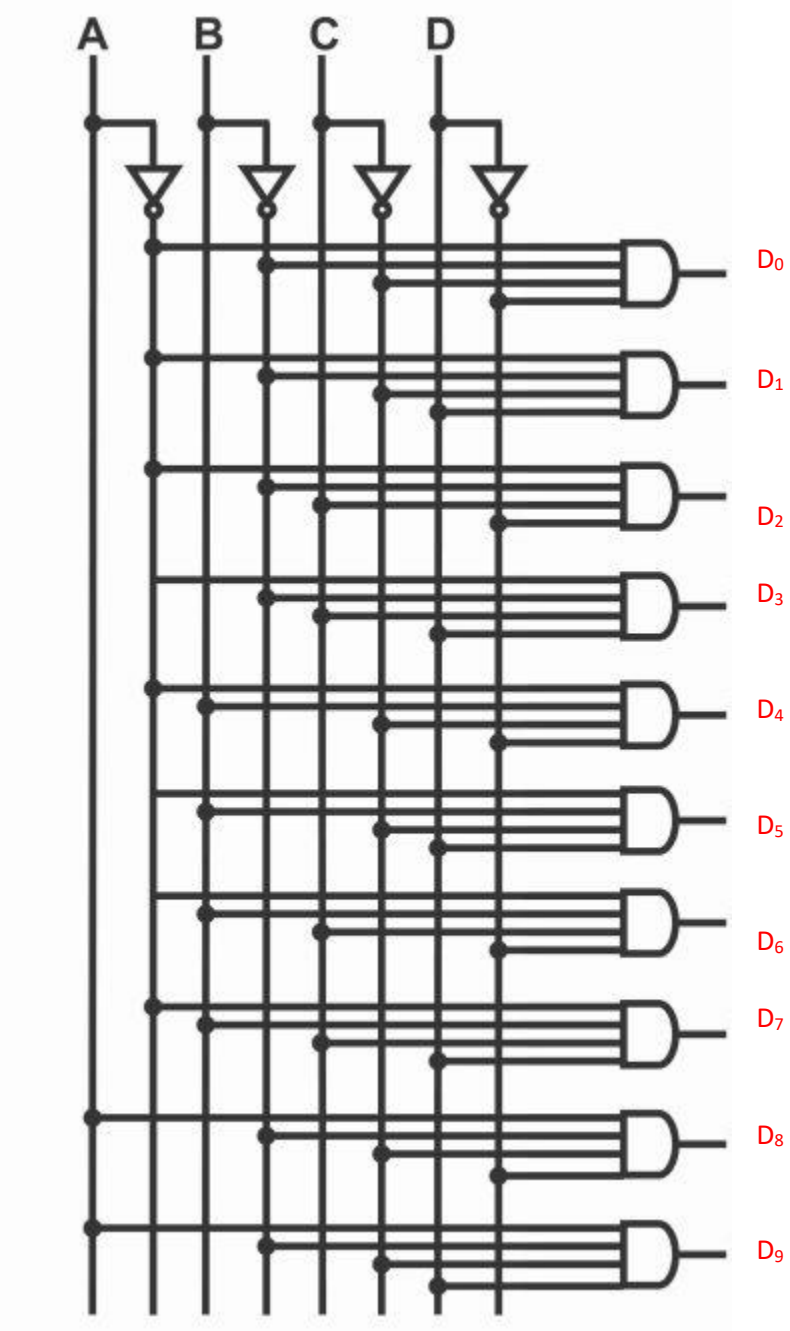
- They are used in memory addressing. In a computer memory system, each byte or word in memory is assigned a unique address.
- They are used in memory decoding. Decoders are used to convert the binary address provided by the CPU into the specific memory location to be accessed. The binary address from the address bus is fed into the input of the decoder.
- Decoders generate enable signals that activate specific memory cells or modules based on the provided address. These enable signals ensure that data is read from or written to the correct location in memory.

c) Use a truth table and logic gates to design a BCD to decimal decoder.

Since it is to decimal, we use all the decimal numbers 0-9.

Truth table

A	B	C	D	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
0	0	0	0	1	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	1	0	0	0	0	0	0	0
0	0	1	1	0	0	0	1	0	0	0	0	0	0
0	1	0	0	0	0	0	0	1	0	0	0	0	0
0	1	0	1	0	0	0	0	0	1	0	0	0	0
0	1	1	0	0	0	0	0	0	0	1	0	0	0
0	1	1	1	0	0	0	0	0	0	0	1	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0
1	0	0	1	0	0	0	0	0	0	0	0	0	1

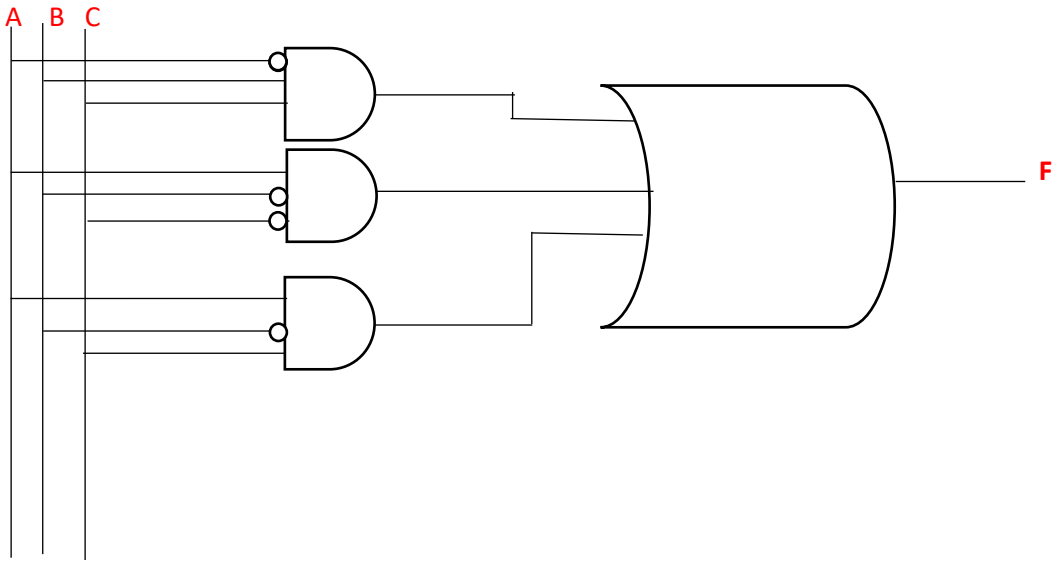


Question Six

You are provided with the following Boolean function, use it to answer the questions that follow;

F (A,B,C) = A'BC + AB'C' + AB'C

a) Draw the circuit diagram for the Boolean function.



b) Use a truth table to determine the output F as a function of inputs A, B, C.

A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

c) Use K-maps to minimize the function and implement the logic circuit for the minimized expression. **From the K-map, F = A'BC + AB'**

C	AB 00	01	11	
0	0	0	0	1
1	0	1	0	1

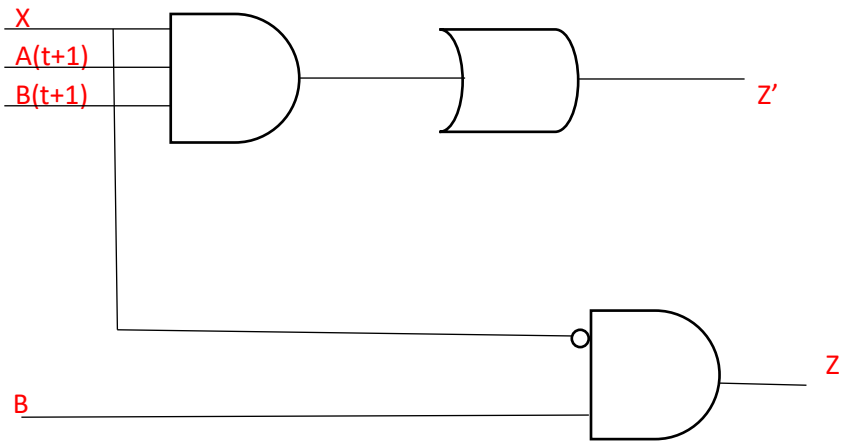
A'BC AB'

Question Seven

A sequential circuit with two **D flip-flops** A and B has one input as X and one output is specified by the following next state output equations:

A(t+1) = AX + BX
B(t+1) = AX + B'X
Z = X'B

a) Draw the logic diagram of the circuit.



b) Derive the state table of the sequential circuit.

A	B	X	A(t+1)	B(t+1)	Z
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	1	0	0
1	0	0	1	1	0
1	0	1	1	1	0
1	1	0	1	0	1
1	1	1	1	1	0

c) Draw the corresponding state diagram.