Computer Organization and Architecture

Exercise & Exam-Oriented Questions and Answers

SET 2

Chapter 1: Basics of Computer System

Contents

(A fresh set of questions, different from Set 1, for further practice.)

Section A — Very Short Answer Type Questions (1 Mark Each)

Q1. Give the full form of ALU.

Ans. Arithmetic Logic Unit.

Q2. Which register holds the instruction currently being decoded or executed?

Ans. The Instruction Register (IR).

Q3. Give one example of a secondary storage device.

Ans. Hard disk (or SSD, optical disk, magnetic tape).

Q4. What is the function of the Accumulator register?

Ans. It is a general-purpose register used to temporarily store the intermediate results of ALU operations.

Q5. Name any two input devices.

Ans. Keyboard and mouse (scanner, joystick, microphone are also acceptable).

Q6. Name any two output devices.

Ans. Monitor and printer (speaker is also acceptable).

Q7. Which generation of computers used transistor technology?

Ans. The Second Generation of computers (1956–1963).

Q8. Expand the term VLSI.

Ans. Very Large Scale Integration.

Q9. Expand the term ULSI.

Ans. Ultra Large Scale Integration.

Q10. Define a Personal Computer (PC) in one line.

Ans. A Personal Computer is an inexpensive, general-purpose, single-user computer used for everyday individual computing tasks.

Q11. What is the primary purpose of a Server?

Ans. To manage, store and deliver resources, data or services to multiple client computers over a network.

Q12. Name the technology on which the Fifth Generation of computers is based.

Ans. Artificial Intelligence and ULSI (Ultra Large Scale Integration).

Section B — Short Answer Type Questions (2–3 Marks Each)

Q1. Explain the term 'bus' in a computer system. What are its three types? *[3 Marks]*

Ans. A bus is a set of parallel wires or pathways used to transfer data, addresses and control signals between the CPU, memory and I/O devices. There are three types of buses: the Address Bus, which carries the address of the memory location or device to be accessed; the Data Bus, which carries the actual data being transferred; and the Control Bus, which carries control signals (such as read/write) that coordinate the activities of the system.

Q2. What is the difference between a Workstation and a Personal Computer? *[2 Marks]*

Ans. A Personal Computer is a general-purpose, relatively inexpensive machine meant for everyday tasks, whereas a Workstation is a high-performance, single-user computer with more powerful processors, memory and graphics capability, designed specifically for computation-intensive technical or scientific applications such as CAD and 3D animation.

Q3. Explain the concept of an interrupt in a computer system. *[2 Marks]*

Ans. An interrupt is a signal sent by a hardware device or a program to the CPU, indicating that it requires immediate attention. On receiving an interrupt, the CPU temporarily suspends its current task, services the request, and then resumes the earlier task. This allows the CPU to respond efficiently to devices without having to continuously check (poll) each one for readiness.

Q4. What is the significance of the Accumulator register in a CPU? *[2 Marks]*

Ans. The Accumulator is a special-purpose register used by the ALU to hold intermediate or final results of arithmetic and logical operations during processing. Since many instructions implicitly use the Accumulator as the source and destination of data, it plays a central role in speeding up repetitive calculations within the CPU.

Q5. Differentiate between the First Generation and Fourth Generation of computers. *[3 Marks]*

- Technology: First Generation used vacuum tubes, while Fourth Generation uses microprocessors built with VLSI technology.
- Size and cost: First Generation computers were room-sized and extremely expensive; Fourth Generation computers are compact and affordable, leading to the personal computer.
- Programming: First Generation used machine language, whereas Fourth Generation supports high-level languages, GUIs and networking.

Q6. What is meant by 'volatile' and 'non-volatile' memory? Give one example of each. *[2 Marks]*

Ans. Volatile memory loses its stored data as soon as power is switched off; RAM is an example of volatile memory. Non-volatile memory retains its stored data even without power; ROM (and secondary storage such as a hard disk) is an example of non-volatile memory.

Q7. Explain any three applications of a Super Computer. *[3 Marks]*

- Weather forecasting and climate modelling, which require processing enormous volumes of atmospheric data quickly.

- Nuclear and molecular simulations, used in scientific research where extremely precise, large-scale calculations are needed.
- Large-scale scientific research such as space exploration, genome sequencing and astrophysical modelling.

Q8. What is the role of the system bus in Von Neumann Architecture? *[2 Marks]*

Ans. The system bus is the common pathway that connects the CPU, memory and I/O devices, and carries addresses, data and control signals between them. Because this single bus is shared for both instructions and data, it is directly responsible for the Von Neumann Bottleneck, as only one transfer can take place on it at a time.

Q9. Differentiate between a Laptop and a Workstation. *[2 Marks]*

Ans. A Laptop is a portable, general-purpose computer meant for everyday individual use with an emphasis on mobility, while a Workstation is a high-performance, typically non-portable, single-user computer built for specialised, computation-intensive technical or scientific tasks with far greater processing and graphics capability.

Q10. Explain in brief the concept of time-sharing, introduced in the Third Generation of computers. *[2 Marks]*

Ans. Time-sharing is a technique, made possible by operating systems developed in the Third Generation, in which the CPU's processing time is divided into small slices and rapidly switched between multiple users or programs. This gives each user the impression that they have exclusive, simultaneous access to the computer, even though the CPU is actually serving them one at a time in quick succession.

Section C — Long Answer / Descriptive Questions (5–10 Marks Each)

Q1. Differentiate between Von Neumann Architecture and Harvard Architecture. *[8 Marks]*

The Von Neumann Architecture, as discussed earlier, uses a single, unified memory to store both instructions and data, and a common bus to access them. While this design is simple and cost-effective, it suffers from the Von Neumann Bottleneck, since instructions and data cannot be fetched at the same time.

The Harvard Architecture was developed to overcome this limitation. It uses two separate memories — one dedicated to storing instructions and another dedicated to storing data — along with separate buses for each. This allows the CPU to fetch an instruction and access data simultaneously, improving overall processing speed.

Basis	Von Neumann Architecture	Harvard Architecture
Memory	Single, shared memory for instructions and data	Separate memories for instructions and data
Bus	Single common bus	Separate buses for instructions and data
Speed	Slower due to the Von Neumann Bottleneck	Faster, since fetch and data access can overlap
Complexity/Cost	Simpler and cheaper to design	More complex and costlier to implement
Typical use	General-purpose computers (PCs, laptops)	Specialised systems such as microcontrollers and DSPs

Q2. Describe the various types of registers used in a CPU and explain the function of each. *[8 Marks]*

- Program Counter (PC): Holds the address of the next instruction to be fetched from memory; it is automatically incremented after every fetch so the CPU always knows where to find the next instruction.
- Instruction Register (IR): Holds the instruction that is currently being decoded or executed by the Control Unit.
- Memory Address Register (MAR): Holds the address of the memory location that the CPU wants to read from or write to.
- Memory Data Register (MDR) / Memory Buffer Register (MBR): Holds the actual data or instruction that is being transferred to or from the memory location addressed by the MAR.
- Accumulator (ACC): A general-purpose register used to store the intermediate or final results produced by the ALU during arithmetic or logical operations.
- General-Purpose Registers: A set of additional registers used to temporarily hold operands and results during program execution, reducing the need for frequent, slower memory access.

Together, these registers allow the CPU to keep track of program flow, hold instructions and data temporarily, and carry out the fetch-decode-execute cycle efficiently without constantly having to access the comparatively slower main memory.

Q3. Explain RAM and ROM in detail, including their common types. *[8 Marks]*

RAM (Random Access Memory) is the primary working memory of a computer. It is volatile, meaning its contents are lost when power is switched off, and it temporarily holds the programs and data that are currently being used by the CPU. RAM is mainly of two types:

- SRAM (Static RAM): Faster and more expensive; retains data as long as power is supplied, without needing to be refreshed; commonly used for cache memory.
- DRAM (Dynamic RAM): Slower and cheaper than SRAM; needs to be refreshed periodically to retain data; commonly used as the computer's main memory.

ROM (Read Only Memory) is non-volatile memory that retains its contents even without power, and is mainly used to store permanent instructions such as the system's bootstrap loader. Common types of ROM include:

- PROM (Programmable ROM): Can be programmed once by the user after manufacture, but cannot be changed afterward.
- EPROM (Erasable Programmable ROM): Can be erased using ultraviolet light and reprogrammed multiple times.
- EEPROM (Electrically Erasable Programmable ROM): Can be erased and reprogrammed electrically, without removing it from the system, and is widely used in modern devices for firmware storage.

Q4. Explain the functioning of Input and Output devices with suitable examples. *[6 Marks]*

Input devices are hardware components that allow a user to enter data, commands or signals into the computer; they convert human-understandable information into binary form that the computer can process. Common examples include the keyboard, which is used to enter text and commands; the mouse, used for pointing, clicking and navigation; the scanner, used to digitise printed documents or images; and the microphone, used to input audio.

Output devices, in contrast, take the processed data from the computer, which exists in binary form, and convert it into a form that is understandable to the user. Common examples include the monitor, which displays visual output; the printer, which produces a physical, paper copy of output; and the speaker, which produces audio output. Together, input and output devices form the I/O unit, which enables the two-way communication that makes a computer usable in practice.

Q5. "Each generation of computers is defined by a change in the underlying hardware technology." Justify this statement with reference to all five generations. *[10 Marks]*

The classification of computers into generations is based primarily on the core electronic technology used to build their processing hardware, and each shift in technology brought about major changes in size, speed, reliability, power consumption and usability, supporting the given statement:

- First Generation (Vacuum Tubes, 1940–1956): The earliest computers relied on bulky, fragile vacuum tubes, resulting in huge size, very high power consumption and heat generation, and low reliability.
- Second Generation (Transistors, 1956–1963): The replacement of vacuum tubes with transistors made computers significantly smaller, faster, more reliable and cheaper to run, directly because of this hardware change.

- Third Generation (Integrated Circuits, 1964–1971): Packing multiple transistors onto a single IC chip further miniaturised computers and boosted speed and reliability, while also enabling the software advances of operating systems and time-sharing.
- Fourth Generation (Microprocessor/VLSI, 1971–Present): Placing an entire CPU on a single chip using VLSI technology made computers small and affordable enough to become personal computers, a change driven directly by this hardware breakthrough.
- Fifth Generation (AI/ULSI, Present and Beyond): The use of ULSI technology and a focus on Artificial Intelligence hardware and algorithms is now enabling machines capable of learning and natural interaction, once again showing technology as the defining factor.

In every case, it is a specific advance in the underlying hardware technology — from vacuum tubes to transistors, to ICs, to microprocessors, and now to AI-oriented ULSI chips — that marks the boundary between one generation and the next, confirming that hardware technology is indeed the defining basis of computer generations.

Q6. Explain the concept of Personal Computer and Laptop in detail, highlighting their similarities and differences. *[6 Marks]*

A Personal Computer (PC) is a general-purpose, single-user computer built around a single microprocessor, typically configured as a desktop system with a separate system unit, monitor, keyboard and mouse. It is designed for everyday tasks such as document preparation, browsing, entertainment and small-scale computing, and is relatively inexpensive compared to specialised machines.

A Laptop is essentially a portable version of the personal computer: it integrates the display, keyboard, pointing device (touchpad) and all processing hardware into a single compact, foldable, battery-powered unit. Both PCs and laptops serve the same general-purpose, single-user role and run similar operating systems and software. However, they differ mainly in portability and, often, in performance and upgradability — laptops trade some raw performance and ease of upgrading for the convenience of mobility, while desktop PCs typically offer better performance and easier hardware upgrades for a similar price.

Q7. Explain the concept of a Server and describe its common types. *[6 Marks]*

A Server is a powerful computer, or a program running on such a computer, designed to manage, store and deliver resources, data or services to other computers, known as clients, over a network. Unlike a personal computer, a server is built for reliability, continuous uptime and the ability to handle numerous simultaneous requests, and it typically runs a specialised server operating system with strong security and fault-tolerance features.

- File Server: Stores and manages files centrally, allowing multiple users on a network to access and share them.
- Web Server: Hosts websites and delivers web pages to client browsers in response to requests, typically over HTTP/HTTPS.
- Database Server: Stores and manages databases, and processes queries and data requests sent by client applications.
- Mail Server: Handles the sending, receiving and storage of email messages for an organisation's users.

Q8. Discuss the role of interrupts and DMA in improving I/O efficiency. *[6 Marks]*

Because peripheral devices operate at speeds far slower than the CPU, a computer system uses special techniques to avoid wasting CPU time while waiting for these devices, thereby improving overall I/O efficiency.

- Interrupts: Instead of the CPU repeatedly checking (polling) whether a device is ready, the device itself sends an interrupt signal to the CPU only when it requires attention (for example, when data is ready to be read). On receiving the interrupt, the CPU temporarily pauses its current task, services the device through an interrupt service routine, and then resumes its earlier work. This allows the CPU to perform other useful processing instead of idly waiting.
- Direct Memory Access (DMA): For large data transfers (such as reading a file from disk), routing every byte through the CPU would be highly inefficient. A DMA controller allows the peripheral device to transfer data directly to or from main memory without CPU involvement in each individual transfer, freeing the CPU to execute other instructions while the transfer proceeds in the background; the CPU is only interrupted once, when the entire transfer is complete.

Together, interrupts and DMA significantly reduce the amount of CPU time wasted on managing slow I/O operations, allowing the processor to be used far more efficiently.

Q9. Explain why the Von Neumann Architecture is called the 'stored-program architecture'. Discuss its advantages and limitations. *[8 Marks]*

The Von Neumann Architecture is called the stored-program architecture because it stores the program's instructions in the same read/write memory as the data, in binary form, rather than requiring the machine to be physically rewired for every new program. Since instructions are treated as ordinary data that can be read, loaded and even modified by the CPU, a computer built on this model can be reprogrammed simply by loading a different set of instructions into memory.

Advantages:

- Simple and flexible design, since only one memory and one set of access circuitry is needed for both instructions and data.
- Computers can be easily reprogrammed through software alone, without any change in hardware wiring.
- Relatively inexpensive to design and manufacture compared to more complex alternative architectures.

Limitations:

- The Von Neumann Bottleneck: since instructions and data share a single bus, they cannot be accessed simultaneously, which limits processing speed.
- Because instructions and data are stored identically in binary, a program error can accidentally treat data as an instruction (or vice versa), which can lead to system errors.
- Not ideally suited to certain specialised real-time or high-throughput applications, where architectures such as the Harvard Architecture perform better.

Q10. Write short notes on the following: (a) Super Computer (b) Workstation (c) Fetch-Decode-Execute Cycle. *[9 Marks]*

(a) Super Computer:

A Super Computer is among the fastest and most powerful classes of computers, using thousands of interconnected processors working in parallel to perform extremely large numbers of calculations per second.

It is used for tasks demanding massive computational power, such as weather forecasting, nuclear simulations and large-scale scientific research, and is extremely expensive and physically large, requiring specialised cooling; examples include India's PARAM series.

(b) Workstation:

A Workstation is a high-performance, single-user computer built for specialised, computation-intensive technical or scientific tasks such as CAD, 3D animation and engineering simulation. It typically has more powerful processors, larger and faster memory, and high-end graphics capability compared to an ordinary PC, and is often connected to a network to share resources while still being used primarily by one user at a time.

(c) Fetch-Decode-Execute Cycle:

This is the basic operational cycle by which a CPU processes every instruction. In the fetch stage, the instruction at the address held in the Program Counter is retrieved from memory into the Instruction Register, and the Program Counter is incremented. In the decode stage, the Control Unit interprets the instruction to determine the required operation. In the execute stage, the Control Unit generates the necessary signals and the ALU (if required) performs the operation, with the result typically stored in the Accumulator or written back to memory. This cycle repeats continuously for every instruction in a program.