Pariksha Saathi — Computer Knowledge Notes

1 topics • 11 lessons • updated 28 October 2026

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The Computer Knowledge topics in the syllabus of: IBPS PO, SSC CHSL, SBI PO, SBI Clerk, IBPS Clerk, RRB NTPC, Rajasthan Patwari, Haryana CET (Group C). Each topic ends with a link to its free practice questions; full mock tests are free in the Pariksha Saathi app and on the website.

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Computer Knowledge — **Revision sheet**

Computer Knowledge

Computer Knowledge — Fundamentals

This topic covers the core computer-fundamentals areas commonly tested across SSC and banking exams: computer hardware (CPU, memory types, input/output devices), the generations of computers, the distinction between system software and application software, basic networking and internet terms (LAN, WAN, HTTP, URL, IP address), common file formats and keyboard shortcuts, and basic computer-security concepts (malware, antivirus, firewalls). Most questions test stable, well-established definitions and abbreviations rather than fast-changing technical details, so focus on understanding what each term means and how the pieces relate to each other - for example, that RAM is volatile while ROM is not, or that an operating system is system software while a word processor is application software.

A few historical figures are frequently tested as standalone facts: Charles Babbage, who designed the Analytical Engine, is widely called the 'Father of the Computer.' Tim Berners-Lee invented the World Wide Web in 1989. Linus Torvalds created the Linux kernel in 1991. These are distinct people credited with distinct inventions, and mixing them up is a common source of error.

The five generations of computers are defined by their core technology, in order: vacuum tubes (1st generation), transistors (2nd), integrated circuits (3rd), microprocessors (4th), and artificial intelligence/ULSI (5th, ongoing) - each generation made computers smaller, faster, and more reliable than the last.

A compiler is worth understanding as a specific, named concept distinct from an operating system or an application: it translates an entire program written in a high-level language (like C or Java) into machine code before the program runs, which is different from an interpreter, which translates and executes code line-by-line.

Examples

- RAM loses its contents when power is switched off, so it is called volatile memory; ROM retains its contents without power, so it is non-volatile.
- A keyboard sends data into the computer (input), while a monitor displays data from the computer (output) - the same distinction applies to a mouse (input) versus a printer (output).
- HTTPS is HTTP with the added 'S' for Secure, meaning the connection between the browser and the website is encrypted.
- Charles Babbage designed the Analytical Engine and is called the 'Father of the Computer'; Tim Berners-Lee invented the World Wide Web in 1989; Linus Torvalds created the Linux kernel in 1991 - three different people, three different inventions.

- The five generations of computers, in order, are defined by: vacuum tubes (1st), transistors (2nd), integrated circuits (3rd), microprocessors (4th), and AI/ULSI (5th, ongoing).
- A compiler translates an entire high-level-language program into machine code before execution, while an interpreter translates and runs the code line by line - both convert code, but at different times and in different ways.
- A bit (binary digit) is the smallest unit of data, represented as 0 or 1; 8 bits make one byte, the standard unit for measuring file and memory sizes.

> **Quick revision:** Know your abbreviations (CPU, RAM, ROM, USB, URL, HTTP, LAN, WAN, GUI, DBMS, ALU) and the input/output and volatile/non-volatile distinctions; system software (the OS) manages the computer, application software (Word, Excel, a browser) helps the user do a specific task. Key inventors: Babbage (computer concept), Berners-Lee (WWW, 1989), Torvalds (Linux, 1991). Five generations: vacuum tubes → transistors → ICs → microprocessors → AI/ULSI. Compiler translates all-at-once; interpreter translates line-by-line.

Computer Fundamentals: History, Generations and Types of Computers

What a computer is: A computer is an electronic device that accepts data as input, processes it according to a stored set of instructions called a program, stores the data and results, and gives output as useful information. The word comes from the Latin computare, to calculate. Raw facts are data; processed, meaningful data is information. Every computer follows the input-process-output cycle, with storage supporting each step. A computer has no intelligence of its own and does exactly what the program says, so the rule GIGO (garbage in, garbage out) applies: wrong input gives wrong output.

Characteristics: Exams list speed (work is measured in microseconds, nanoseconds and picoseconds), accuracy (errors come from wrong data or programs, not from the machine), diligence (it never tires, so the millionth calculation is as accurate as the first), versatility (the same machine types letters, calculates salaries and plays music), storage (it holds huge amounts of data and recalls it instantly) and automation (a program, once started, runs without human help). Its limitation is that it cannot think, feel or decide on its own.

Before electronics: The abacus, a frame of sliding beads long used in China, is regarded as the earliest calculating device. John Napier devised Napier's Bones in 1617 for multiplication. Blaise Pascal built the Pascaline in 1642, often called the first mechanical adding machine, which could add and subtract; Gottfried Leibniz's machine of the 1670s could also multiply and divide. Joseph Marie Jacquard's loom of the early 1800s used punched cards to control weaving, an idea later used for computer input. Charles Babbage designed the Difference Engine in 1822 and then the Analytical Engine, which had a mill (processor), a store (memory) and punched-card input; this is why he is called the Father of the Computer. Ada Lovelace wrote a method for computing numbers on it in 1843 and is called the first programmer. Herman Hollerith's punched-card tabulator processed the 1890 US Census, and his company later became part of IBM.

The electronic age: Alan Turing described the theoretical Turing machine in 1936. The Harvard Mark I (1944) of Howard Aiken was electromechanical. ENIAC (Electronic Numerical Integrator and Computer), built by J. Presper Eckert and John Mauchly at the University of Pennsylvania and unveiled in 1946, was the first general-purpose electronic digital computer; it used about 18,000 vacuum tubes and weighed about 30 tons. John von Neumann's stored-program concept, keeping the program in memory along with the data, shaped EDVAC and nearly every later computer. UNIVAC I (Universal Automatic Computer), also by Eckert and Mauchly, was delivered to the US Census Bureau in 1951 as the first commercial computer made in the United States.

Five generations: Each generation is named after its main electronic component; books differ slightly on the years, but not on the technology. First (about 1946-1959): vacuum tubes, machine language, magnetic drum memory, great size and heat; ENIAC, EDVAC and UNIVAC I. Second (about 1959-1965): transistors, invented at Bell Labs in 1947; assembly language and the first high-level languages FORTRAN and COBOL; magnetic core memory; the IBM 1401. Third (about 1965-1971): integrated circuits, invented by Jack Kilby in 1958 and independently by Robert Noyce; keyboards, monitors and operating systems; the IBM System/360. Fourth (1971 onwards): the microprocessor, built with LSI and then VLSI chips, starting with the Intel 4004 in 1971; personal computers such as the IBM PC of 1981, graphical interfaces and networks. Fifth (present and future): ULSI, parallel processing and artificial intelligence.

Types of computers: By the data they handle, computers are analog (they measure continuous quantities such as temperature, speed or voltage, like a speedometer), digital (they work on discrete values, ultimately 0 and 1, like a PC or a calculator) and hybrid (both together, like ICU patient monitors or a petrol pump dispenser). By purpose they are general-purpose or special-purpose (embedded in washing machines, ATMs and traffic signals). By size, supercomputers are the fastest, rated in FLOPS (floating-point operations per second) and used for weather forecasting and nuclear simulation; the CRAY-1 (1976) of Seymour Cray, the father of supercomputing, is the classic example. Mainframes serve thousands of users at once in banks and railway reservation. Minicomputers are mid-range multi-user machines. Microcomputers, built around one microprocessor, include desktops, laptops, tablets and smartphones.

India's firsts: India's first digital computer, the HEC-2M, imported from Britain, was installed at the Indian Statistical Institute (ISI), Kolkata, in 1956 (some accounts say 1955). TIFRAC, the first digital computer designed and built in India, was commissioned at the Tata Institute of Fundamental Research, Mumbai, in 1960, and ISIJU, built by ISI with Jadavpur University in the mid-1960s, was the first transistorised computer built in India. After the United States refused to export a Cray supercomputer, the government set up C-DAC (Centre for Development of Advanced Computing) in Pune in 1988; under Vijay Bhatkar it built PARAM 8000, India's first supercomputer, in 1991.

Examples

- Blaise Pascal's Pascaline (1642) is often called the first mechanical adding machine; it could only add and subtract.
- Charles Babbage, the Father of the Computer, designed the Difference Engine (1822) and the Analytical Engine, which had a mill, a store and punched-card input; Ada Lovelace is called the first programmer.
- ENIAC (1946, Eckert and Mauchly, University of Pennsylvania) was the first general-purpose electronic digital computer, with about 18,000 vacuum tubes.
- UNIVAC I (1951) was the first commercial computer made in the US; its first customer was the US Census Bureau.
- Generations by technology: vacuum tubes, transistors, integrated circuits, microprocessors (VLSI), then ULSI and artificial intelligence.
- The Intel 4004 (1971) was the first commercial microprocessor and marks the start of the fourth generation.
- Analog computers measure continuous quantities (speedometer); digital computers work on discrete 0s and 1s; hybrid computers such as ICU monitors combine both.
- Supercomputer speed is measured in FLOPS; Seymour Cray, builder of the CRAY-1 (1976), is called the father of supercomputing.
- HEC-2M at ISI Kolkata (1956) was India's first digital computer; TIFRAC (1960) the first digital computer built in India; PARAM 8000 (1991, C-DAC Pune, Vijay Bhatkar) India's first supercomputer.
- GIGO means garbage in, garbage out: a computer's output is only as good as its input and its program.

> **Quick revision:** Computer: input-process-output, from Latin computare; Pascaline 1642 (add, subtract); Babbage: Difference Engine 1822, Analytical Engine, Father of the Computer; Ada Lovelace first programmer; ENIAC 1946 (about 18,000 vacuum tubes); UNIVAC I 1951 first US commercial computer; generations: vacuum tube, transistor, IC, microprocessor, AI/ULSI; analog, digital, hybrid; super, mainframe, mini, micro; HEC-2M 1956; TIFRAC 1960; PARAM 8000 1991.

CPU and Memory: ALU, Control Unit, RAM, ROM, Cache and Memory Units

The processor: The Central Processing Unit (CPU) is called the brain of the computer because it carries out every instruction of a program. In a modern computer the whole CPU sits on one chip, the microprocessor, mounted on the motherboard, the main circuit board that links the CPU, memory and other parts through buses: the data bus carries data, the address bus carries memory addresses and the control bus carries control signals. The CPU has three parts: the Arithmetic Logic Unit, the Control Unit and the registers.

ALU, control unit and registers: The Arithmetic Logic Unit (ALU) does arithmetic (addition, subtraction, multiplication, division) and logical operations (comparisons such as greater than or equal to, and AND, OR, NOT). The Control Unit (CU) does not process data itself; like a traffic controller, it fetches instructions from memory, decodes them and directs the ALU, memory and input-output devices. Registers are tiny, very fast storage locations

inside the CPU. The Program Counter holds the address of the next instruction, the Instruction Register holds the instruction being executed, the Memory Address Register holds the address to be read or written, the Memory Data Register holds the data moving to or from memory, and the Accumulator holds the intermediate results of the ALU.

The machine cycle: For every instruction the CPU repeats a machine (instruction) cycle of four steps: fetch the instruction from memory, decode it, execute it and store the result. Fetch and decode make up the instruction time (I-time); execute and store make up the execution time (E-time). A clock inside the CPU sends regular pulses that keep these steps in time. Clock speed is measured in hertz, and a 3 GHz processor runs 3 billion clock cycles per second. Processing speed is also expressed in MIPS (million instructions per second). A multi-core processor (dual-core, quad-core) has two or more processing units on one chip, and word size (32-bit or 64-bit) is the number of bits the CPU handles at a time.

Primary memory and RAM: Primary or main memory holds the programs and data the CPU is using right now. RAM (Random Access Memory) can be both read and written, and any location can be reached directly; it is volatile, so its contents are lost when the power goes off. Static RAM (SRAM) stores each bit in a flip-flop circuit, needs no refreshing, is fast and costly, and is used for cache. Dynamic RAM (DRAM) stores each bit as a charge on a tiny capacitor that leaks, so it must be refreshed many times every second; it is cheaper and packs more data, so it is used as main memory. SDRAM and DDR (double data rate) memory are forms of DRAM.

ROM and its types: ROM (Read Only Memory) is non-volatile and holds firmware such as the BIOS (Basic Input/Output System) that starts the computer. Mask ROM is written at the factory. PROM (Programmable ROM) can be written once by the user. EPROM (Erasable PROM) is erased with ultraviolet light and then rewritten, while EEPROM (Electrically Erasable PROM) is erased with electrical signals. Flash memory, used in pen drives, memory cards and SSDs, is a type of EEPROM.

Cache and virtual memory: Cache is a small, very fast SRAM memory placed between the CPU and RAM that keeps the most frequently used data and instructions close at hand; L1 cache is the smallest and fastest, followed by L2 and L3. Virtual memory works the other way: when RAM is full, the operating system uses part of the hard disk (the page file or swap space) as if it were RAM, moving blocks of data called pages between the two. It lets bigger programs run but is much slower than real RAM. The memory hierarchy, from fastest and costliest to slowest and cheapest, is registers, cache, RAM and secondary storage.

Memory units: The bit (binary digit, 0 or 1) is the smallest unit. 4 bits make a nibble and 8 bits a byte, enough for one character. After that each unit is 1024 times the one before: 1 kilobyte (KB) = 1024 bytes, 1 megabyte (MB) = 1024 KB, 1 gigabyte (GB) = 1024 MB, 1 terabyte (TB) = 1024 GB and 1 petabyte (PB) = 1024 TB, followed by the exabyte, zettabyte and yottabyte. Since 1024 is 2 to the power 10, 1 KB = 8192 bits, 1 MB = 1,048,576 bytes and 1 GB = 1,073,741,824 bytes. To convert to a smaller unit multiply by 1024, and to a larger one divide: 4 GB = 4096 MB, and 2048 KB = 2 MB. Disk makers count 1 GB as 1000 million bytes, which is why a drive shows a little less space than its label.

Examples

- ALU performs arithmetic and logical operations; the Control Unit fetches, decodes and directs but does not process data; registers are the fastest storage inside the CPU.
- The Program Counter holds the address of the next instruction; the Accumulator holds intermediate ALU results.
- Machine cycle: fetch, decode, execute, store; fetch plus decode is I-time, execute plus store is E-time.
- Clock speed is measured in hertz (GHz today); processor speed is also given in MIPS and supercomputer speed in FLOPS.
- SRAM (flip-flops, no refresh, fast, used for cache) versus DRAM (capacitors, needs refresh, cheaper, used as main memory).
- ROM types: PROM written once; EPROM erased by ultraviolet light; EEPROM erased electrically; flash memory is a kind of EEPROM.
- Cache sits between the CPU and RAM (L1 is fastest); virtual memory uses hard disk space as an extension of RAM.
- Memory hierarchy, fastest to slowest: registers, cache, RAM, secondary storage (hard disk, optical disc).

- 4 bits = 1 nibble; 8 bits = 1 byte; 1024 bytes = 1 KB; 1024 KB = 1 MB; 1024 MB = 1 GB; 1024 GB = 1 TB; 1024 TB = 1 PB.
- Order of units: bit, nibble, byte, KB, MB, GB, TB, PB, EB, ZB, YB; 1 GB = 2 to the power 30 bytes = 1,073,741,824 bytes.

> **Quick revision:** CPU = ALU + Control Unit + registers (Program Counter, Accumulator); machine cycle fetch-decode-execute-store; clock speed in Hz, speed also in MIPS; RAM volatile (SRAM for cache, DRAM for main memory); ROM non-volatile (PROM, EPROM by UV, EEPROM, flash), holds BIOS; cache L1 fastest; virtual memory uses disk; 1 nibble = 4 bits, 1 byte = 8 bits; KB, MB, GB, TB, PB each 1024 times the last.

Storage Devices, Input Devices and Output Devices

Secondary storage: Primary memory is fast but small and mostly volatile, so data is kept permanently on secondary storage, which is non-volatile, larger, cheaper per byte and slower. It is of three kinds: magnetic (hard disk, magnetic tape, the old floppy disk), optical (CD, DVD, Blu-ray) and solid-state or flash (SSD, pen drive, memory card). Magnetic tape allows only sequential access, reading data in order from the start, so it is used for backups and archives; disks allow direct (random) access.

Hard disk and SSD: A hard disk drive (HDD) stores data magnetically on spinning metal platters, read and written by heads on a moving arm. Each surface is divided into circular tracks and pie-shaped sectors, and the same track on all platters forms a cylinder; formatting a disk creates this structure. Disk speed is given in revolutions per minute, such as 5400 or 7200 rpm. IBM's RAMAC of 1956 was the first computer sold with a hard disk. A solid-state drive (SSD) has no moving parts and stores data in NAND flash chips, so it is faster, quieter and more shock-resistant than an HDD but costs more per gigabyte. The old 3.5-inch floppy disk held 1.44 MB.

Optical and flash storage: Optical discs are read by a laser that detects tiny pits and flat lands on the surface. A CD (Compact Disc) holds about 700 MB, a single-layer DVD (Digital Versatile Disc) 4.7 GB, a dual-layer DVD 8.5 GB and a single-layer Blu-ray disc 25 GB; Blu-ray uses a blue-violet laser of shorter wavelength, which lets it pack data more tightly. ROM discs (CD-ROM) can only be read, R discs can be written once and RW discs can be erased and rewritten. A pen drive is flash memory with a USB (Universal Serial Bus) plug, and memory cards such as SD (Secure Digital) and microSD are used in phones and cameras. Their capacities keep growing, so remember the technology rather than the largest size on sale.

Input devices: The keyboard is the main input device; its standard layout is QWERTY, named after the first six letters on the top row of letter keys, and its keys are grouped into alphanumeric keys, function keys F1 to F12, the numeric keypad, cursor keys and modifier keys (Shift, Ctrl, Alt). The mouse, invented by Douglas Engelbart in the 1960s, is a pointing device; others are the trackball, touchpad, joystick (for games), light pen and stylus. A scanner converts paper pages and photographs into digital images. A touch screen works as both an input and an output device. Microphones, webcams and biometric readers (fingerprint, iris) are also input devices.

Special readers: OMR (Optical Mark Recognition) detects pencil or pen marks in fixed positions and is used to evaluate objective answer sheets. OCR (Optical Character Recognition) turns an image of printed or handwritten text into editable text. MICR (Magnetic Ink Character Recognition) reads characters printed with magnetic iron-oxide ink at the bottom of cheques, which banks use to process cheques quickly; the 9-digit MICR code on an Indian cheque has 3 digits for the city, 3 for the bank and 3 for the branch. A barcode reader scans the black and white bars on products at shop counters, and the QR (Quick Response) code is a two-dimensional barcode developed in Japan in 1994.

Output devices: A monitor or VDU (visual display unit) shows soft copy. Old monitors used a CRT (cathode ray tube); flat screens use LCD (liquid crystal display), LED-backlit LCD or OLED panels. A screen is made of pixels (picture elements); resolution is the number of pixels across and down, and screen size is measured diagonally in inches. Speakers and headphones give sound output, and a projector throws the screen image onto a wall or screen.

Printers and plotters: Printers give hard copy. Impact printers strike an inked ribbon against the paper and can make carbon copies: the dot matrix printer (pins forming dots, speed in characters per second), the daisy wheel

printer (letter quality but slow) and the line printer (a whole line at a time, speed in lines per minute). Non-impact printers do not strike the paper and are quieter: the inkjet sprays tiny ink droplets, the laser printer uses a laser, a charged drum and toner powder (speed in pages per minute), and the thermal printer uses heat-sensitive paper, as in ATM slips and billing receipts. Print quality is measured in dpi (dots per inch). A plotter draws large, precise drawings such as maps, building plans and engineering designs.

Examples

- Magnetic tape allows only sequential access and is used for backup; hard disks, SSDs and optical discs allow direct (random) access.
- HDD: spinning platters divided into tracks and sectors; SSD: NAND flash chips, no moving parts, faster and more shock-resistant.
- Standard capacities: 3.5-inch floppy 1.44 MB; CD about 700 MB; single-layer DVD 4.7 GB; dual-layer DVD 8.5 GB; single-layer Blu-ray 25 GB.
- CD-ROM is read-only, CD-R can be written once, CD-RW can be erased and rewritten.
- OMR reads marked bubbles on answer sheets; OCR converts images of text into editable text; MICR reads magnetic-ink characters on cheques.
- The 9-digit MICR code on an Indian cheque: first 3 digits city, next 3 bank, last 3 branch.
- Douglas Engelbart invented the mouse; the QWERTY keyboard is named after the first six letters of its top letter row.
- A touch screen is both input and output; scanner, microphone, webcam and barcode reader are input; monitor, printer, plotter, speaker and projector are output.
- Impact printers (dot matrix, daisy wheel, line) strike a ribbon and can make carbon copies; non-impact printers (inkjet, laser, thermal) are quieter and faster.
- Dot matrix speed is in characters per second, line printer speed in lines per minute, laser printer speed in pages per minute; print resolution is in dpi.

> **Quick revision:** Secondary storage is non-volatile: magnetic (HDD, tape - sequential access), optical (CD about 700 MB, DVD 4.7 GB, Blu-ray 25 GB), flash (SSD, pen drive, SD card); HDD tracks, sectors, rpm; input: keyboard (QWERTY), mouse (Engelbart), scanner, OMR (answer sheets), OCR (text), MICR (cheques, 9-digit code), barcode, QR code; output: monitor (pixels; CRT, LCD, LED), impact printers (dot matrix, daisy wheel, line), non-impact (inkjet, laser, thermal), plotter.

Software and Operating Systems: Types, Functions, Booting and Files

Software and its kinds: Hardware is the physical part of a computer; software is the set of programs that tells the hardware what to do. System software runs and manages the computer itself: the operating system, device drivers (which let the operating system talk to a printer or graphics card), language translators and utility programs. Application software helps the user do a particular task: word processors, spreadsheets, web browsers, media players, accounting packages and games. It may be general-purpose, sold to everyone, or custom-made for one organisation. Firmware is software stored permanently in ROM or flash chips on the hardware, such as the BIOS or UEFI of a computer, and sits between hardware and software.

Utilities and licences: Utility software maintains and protects the computer: antivirus, disk cleanup, the disk defragmenter (which gathers the scattered pieces of files on a hard disk), backup tools, file compression (ZIP) and disk formatting. By licence, proprietary or closed-source software keeps its source code secret and is used on the owner's terms (Microsoft Windows, MS Office, macOS). Open-source software publishes its source code so anyone can study, change and share it (Linux, LibreOffice, Firefox, Apache). Freeware is free to use but usually closed, and shareware is given on trial and must be paid for later. Richard Stallman started the GNU Project in 1983 and the Free Software Foundation in 1985.

The operating system: An operating system (OS) is the interface between the user and the hardware and the manager of all resources. Its functions are process management (deciding which program gets the CPU and for how long), memory management (allotting RAM and taking it back), file management (creating, naming, storing and protecting files), device management (controlling input-output devices through drivers), security (user accounts and

passwords) and providing a user interface. The core of the OS that stays in memory is the kernel; the shell carries the user's commands to the kernel. The interface may be a CLI (command line interface), where commands are typed as in MS-DOS, or a GUI (graphical user interface) with windows, icons, menus and a pointer.

Types of operating system: A batch OS collects similar jobs into batches and runs them one after another without user interaction, as on early mainframes. A multiprogramming OS keeps several programs in memory so the CPU is never idle. A time-sharing or multitasking OS gives each user or task a short time slice of the CPU in turn, so many users seem to work at once; UNIX is the classic example. A real-time OS (RTOS) must respond within a fixed time and is used in missile guidance, air traffic control, industrial robots and medical equipment. A multi-user OS (UNIX, Linux) lets many users share one computer's resources, while a single-user OS such as MS-DOS serves one. A distributed OS runs a group of networked computers as one system.

Windows, Linux and Android: Microsoft, founded by Bill Gates and Paul Allen in 1975, released MS-DOS, a command-line system, in 1981 and Windows 1.0, a graphical shell, in 1985; Windows 95 introduced the Start button and the taskbar. The Windows desktop has the taskbar, Start menu, icons, File Explorer, Control Panel and the Recycle Bin, which keeps deleted files until they are restored or the bin is emptied; Shift+Delete removes a file without sending it there. UNIX was developed at Bell Labs in 1969 by Ken Thompson and Dennis Ritchie. Linux, a free Unix-like system built on the kernel Linus Torvalds released in 1991, comes in distributions such as Ubuntu, Fedora and Debian, and its mascot is the penguin Tux. Android, a Linux-based mobile OS, was bought by Google in 2005, and the first Android phone came out in 2008; Apple's iOS runs the iPhone.

Booting: Booting is starting a computer and loading the OS from disk into RAM. Cold booting starts a computer from power off; warm booting restarts one that is already on, using Restart (in the DOS era, Ctrl+Alt+Del). On power-up the BIOS runs the POST (power-on self-test) to check the hardware, and then the bootstrap loader finds the OS and loads it.

Files and folders: A file is a named collection of data stored on disk; its name ends in an extension after a dot that shows its type, as in report.docx or photo.jpg. Folders, also called directories, hold files and other folders in a tree. The top level is the root directory, written C:\ in Windows and / in Linux, and the path gives a file's full location. The OS organises a disk with a file system, such as FAT32 or NTFS in Windows and ext4 in Linux.

Examples

- System software (OS, device drivers, translators, utilities) runs the computer; application software (MS Word, browsers, accounting software, games) does the user's tasks.
- Firmware is software stored permanently in ROM or flash, such as the BIOS or UEFI.
- Open source: Linux, LibreOffice, Firefox, Apache; proprietary: Windows, MS Office, macOS; freeware is free of cost, shareware is try first and pay later.
- OS functions: process, memory, file, device and security management plus the user interface; the kernel is the core of the OS, the shell carries user commands to it.
- Real-time OS responds within a fixed time (missiles, air traffic control); time-sharing OS gives each user a slice of CPU time (UNIX); batch OS runs grouped jobs without interaction.
- MS-DOS (1981) used a command line; Windows 1.0 (1985) was a graphical shell; Windows 95 introduced the Start button and taskbar.
- UNIX: Bell Labs, 1969, Ken Thompson and Dennis Ritchie; Linux kernel: Linus Torvalds, 1991; Linux mascot: Tux the penguin.
- Android is a Linux-based mobile OS bought by Google in 2005; the first Android phone came in 2008.
- Cold boot starts from power off, warm boot restarts a running computer; the BIOS runs POST (power-on self-test) at start-up.
- Shift+Delete deletes a file permanently, bypassing the Recycle Bin; the root directory is C:\ in Windows and / in Linux.

> **Quick revision:** Software = system (OS, drivers, translators, utilities) + application (Word, browser); firmware in ROM (BIOS); open source (Linux, Firefox) vs proprietary (Windows, MS Office); OS manages processes, memory, files, devices, security; kernel and shell; CLI vs GUI; batch, time-sharing, real-time, multi-user, distributed OS; MS-DOS 1981, Windows 1.0 1985; UNIX 1969; Linux 1991; Android bought by Google 2005; booting: POST, bootstrap loader; cold vs warm boot.

Programming Languages, Translators, Number Systems and Character Codes

Generations of languages: A computer directly understands only machine language, strings of 0s and 1s; this is the first generation (1GL). It runs fastest and needs no translation, but it is machine-dependent and very hard to write. Assembly language (2GL) uses short mnemonics such as ADD, SUB and MOV in place of binary codes. Machine and assembly languages are called low-level languages. Third-generation (3GL) high-level languages use English-like words and run on many machines: FORTRAN (1957, John Backus at IBM, for science), COBOL (1959, for business), BASIC (1964), Pascal (1970), C (1972, Dennis Ritchie at Bell Labs), C++ (Bjarne Stroustrup), Python (1991, Guido van Rossum) and Java (1995, James Gosling at Sun Microsystems). Fourth-generation languages (4GL) such as SQL state what result is wanted rather than how to get it, and fifth-generation languages (5GL) such as PROLOG are used in artificial intelligence.

Translators: Every program not in machine code must be translated. An assembler converts assembly language into machine code. A compiler translates the whole high-level program (the source code) at once into machine code (the object code) and lists all errors together; the compiled program then runs fast without the compiler, as with C and C++. An interpreter translates and executes one line at a time and stops at the first error, so it is slower but handy for testing; Python and BASIC are usually interpreted. Java is compiled into bytecode, which the Java Virtual Machine runs on any computer. A linker joins object files into one executable program, and a loader places it in memory to run. A mistake in a program is a bug and removing it is debugging. The terms are popularly linked with Grace Hopper, after a moth was found in 1947 stuck in the Harvard Mark II, a computer she worked on; she also built one of the first compilers.

Algorithms and flowcharts: An algorithm is a finite, step-by-step procedure for solving a problem; the word comes from the name of the ninth-century mathematician al-Khwarizmi. A good algorithm has input, output, definiteness (every step is clear), finiteness (it ends) and effectiveness. A flowchart draws an algorithm as a diagram: an oval marks start or end, a parallelogram input or output, a rectangle a process, a diamond a decision with yes and no branches, arrows the flow, and a small circle a connector. Pseudocode writes the same steps in plain, structured English.

Number systems: The base (radix) of a number system is the number of digits it uses. Binary has base 2 (0 and 1), octal base 8 (0 to 7), decimal base 10 (0 to 9) and hexadecimal base 16 (0 to 9 and A to F, where A is 10 and F is 15). Computers work in binary because electronic circuits have two states, on and off. Octal and hexadecimal are short ways of writing binary, since one octal digit stands for 3 bits and one hexadecimal digit for 4 bits.

Worked conversions: To change decimal to binary, divide by 2 again and again and read the remainders from bottom to top; 25 gives remainders 1, 0, 0, 1, 1, so 25 is 11001. To change binary to decimal, multiply each bit by its place value (1, 2, 4, 8, 16, 32 from the right) and add; 101101 is 32 + 8 + 4 + 1 = 45. For binary to octal, group the bits in threes from the right: 101 101 is 55 in octal. For binary to hexadecimal, group them in fours: 0010 1101 is 2D. Hexadecimal 1A is 1 × 16 + 10 = 26, and the largest 8-bit number, 11111111, is 255 in decimal, FF in hexadecimal and 377 in octal. In binary addition, 1 + 1 = 10 (write 0, carry 1).

Character codes: Letters and symbols are stored as numbers using a code. ASCII (American Standard Code for Information Interchange) is a 7-bit code for 128 characters, in which A is 65, a is 97, the digit 0 is 48 and the space is 32; extended ASCII uses 8 bits for 256 characters. EBCDIC (Extended Binary Coded Decimal Interchange Code) is an 8-bit code made by IBM for its mainframes. Unicode gives a unique number to every character of every script, including Devanagari, and is stored in forms such as UTF-8 and UTF-16; its first 128 characters are the same as ASCII. BCD (Binary Coded Decimal) writes each decimal digit as 4 bits.

Bits, nibbles and bytes: A bit is one binary digit, a nibble is 4 bits (one hexadecimal digit), a byte is 8 bits (one ASCII character) and a word is the group of bits the CPU handles at once. With n bits, 2 to the power n different values can be shown, so one byte can hold 256 values, from 0 to 255.

Examples

- 1GL machine language (0s and 1s, no translator); 2GL assembly (mnemonics, assembler); 3GL high-level (FORTRAN, COBOL, C, Java); 4GL (SQL); 5GL (PROLOG, artificial intelligence).
- FORTRAN (1957) was the first widely used high-level language; COBOL (1959) is for business; C (1972) was written by Dennis Ritchie at Bell Labs; Java (1995) by James Gosling.
- A compiler translates the whole program at once and the result runs fast; an interpreter translates line by line and stops at the first error; an assembler translates assembly language.
- Flowchart symbols: oval for start or end, parallelogram for input or output, rectangle for a process, diamond for a decision, small circle for a connector.
- Decimal 25 = binary 11001; binary 101101 = decimal 45 = octal 55 = hexadecimal 2D.
- 255 in decimal = 11111111 in binary = FF in hexadecimal = 377 in octal.
- Bases: binary 2, octal 8, decimal 10, hexadecimal 16 (A = 10 up to F = 15); one octal digit = 3 bits, one hexadecimal digit = 4 bits.
- ASCII is a 7-bit code for 128 characters (A = 65, a = 97); extended ASCII is 8-bit (256); EBCDIC is IBM's 8-bit code; Unicode covers all scripts including Devanagari.
- Nibble = 4 bits, byte = 8 bits; n bits can represent 2 to the power n values, so a byte holds 0 to 255.

> **Quick revision:** Languages: machine (1GL), assembly (2GL), high-level (3GL: FORTRAN 1957, COBOL 1959, C 1972, Python 1991, Java 1995), 4GL (SQL), 5GL (PROLOG); assembler, compiler (whole program), interpreter (line by line); algorithm and flowchart symbols; bases 2, 8, 10, 16; 25 = 11001; 101101 = 45 = octal 55 = hex 2D; ASCII 7-bit, 128 characters, A = 65; EBCDIC 8-bit (IBM); Unicode; nibble 4 bits, byte 8 bits.

MS Word: Formatting, Tables, Mail Merge, Track Changes and Shortcuts

MS Word and its window: Microsoft Word is a word processor, a program to create, edit, format and print documents; it is part of Microsoft Office and was first released in 1983. Since Word 2007 a document is saved as .docx by default (earlier versions used .doc), a template as .dotx and a document with macros as .docm. The window has the title bar, the Quick Access Toolbar, the Ribbon of tabs with grouped commands, the ruler, the document area and the status bar, which shows the page number and word count. The File tab opens the Backstage view with New, Open, Save, Save As, Print and Options.

Where commands live: Exams often ask which tab holds a command. Home has the Clipboard (Cut, Copy, Paste, Format Painter), Font, Paragraph, Styles and Editing (Find, Replace). Insert has Table, Pictures, Shapes, SmartArt, Chart, Hyperlink, Header, Footer, Page Number, Text Box, WordArt, Drop Cap, Symbol and Equation. Design has themes, Watermark, Page Color and Page Borders. Layout (Page Layout in older versions) has Margins, Orientation, Size, Columns, Breaks, indents and spacing. References has Table of Contents, Footnotes, Citations, Captions and Index. Mailings has Mail Merge, Envelopes and Labels. Review has Spelling and Grammar, Thesaurus, Word Count, Comments, Track Changes and Compare. View has the document views, Ruler, Zoom and Macros.

Formatting and styles: Character formatting changes the look of text: font, size, bold, italic, underline, colour, superscript and subscript. Font size is measured in points (72 points make an inch) and can be set from 1 to 1638. Paragraph formatting covers alignment (left, centre, right, justify), line spacing, indentation, bullets and numbering. Page formatting covers margins (the Normal setting is 1 inch on every side), orientation (portrait or landscape), paper size and columns. Format Painter copies formatting from one piece of text to another. A style is a named set of formats, such as Normal, Title or Heading 1; using heading styles lets Word build an automatic table of contents. Word's views are Print Layout (the default), Read Mode, Web Layout, Outline and Draft.

Tables, headers and footers: Insert, Table creates a grid of rows and columns whose boxes are called cells; cells can be merged or split, and pressing Tab in the last cell adds a new row. A Word table can have at most 63 columns. When a table is selected, the Table Design and Layout tabs appear. A header is text repeated at the top of every

page and a footer at the bottom, typically holding the title, page numbers or date; they can be different on the first page or on odd and even pages. A footnote appears at the bottom of its page, while an endnote appears at the end of the document.

Mail merge: Mail merge creates many personalised copies of one document, such as letters, envelopes or labels. It joins a main document with a data source (a list of recipients in Excel, Access or Outlook contacts) through merge fields such as name and address. In the Mailings tab the steps are to choose the document type, select the recipients, insert merge fields, preview the results, and finish and merge.

Track changes and proofing: Track Changes (Review tab, Ctrl+Shift+E) records every insertion, deletion and formatting change so that a reviewer can accept or reject each one, and comments add notes in the margin. Spelling and Grammar runs with F7 and the Thesaurus with Shift+F7. A red wavy underline marks a possible spelling mistake and a blue underline (green in older versions) a possible grammar problem. Zoom ranges from 10 to 500 percent.

Shortcuts exams ask: Ctrl+B bold, Ctrl+I italic, Ctrl+U underline, Ctrl+E centre, Ctrl+L left, Ctrl+R right and Ctrl+J justify. Ctrl+N new, Ctrl+O open, Ctrl+S save, F12 Save As, Ctrl+P print, Ctrl+F find, Ctrl+H replace, Ctrl+G go to, Ctrl+K hyperlink, Ctrl+Z undo and Ctrl+Y redo. Ctrl+Enter inserts a page break and Shift+Enter a line break. Ctrl+1, Ctrl+2 and Ctrl+5 set single, double and 1.5 line spacing. Ctrl+] and Ctrl+[increase and decrease the font size, Ctrl+D opens the Font dialog box, Shift+F3 changes case, Ctrl+= gives subscript and Ctrl+Shift+= superscript. Ctrl+Home and Ctrl+End jump to the start and the end of the document.

Examples

- Default extension: .docx since Word 2007 (.doc earlier); template .dotx; document with macros .docm.
- Mail Merge is in the Mailings tab; Track Changes, Comments, Word Count, Thesaurus and Spelling are in the Review tab.
- Header, Footer, Page Number, Table, WordArt, Drop Cap, Symbol and Hyperlink are on the Insert tab; Watermark and Page Borders on the Design tab.
- Mail merge = main document + data source + merge fields; used for personalised letters, envelopes and labels.
- Font size is in points (72 points = 1 inch) and can be set from 1 to 1638; zoom runs from 10 to 500 percent.
- A Word table can have at most 63 columns; pressing Tab in the last cell adds a new row.
- Footnote: at the bottom of the page; endnote: at the end of the document; both are on the References tab.
- Ctrl+E centre, Ctrl+J justify, Ctrl+L left, Ctrl+R right; Ctrl+Enter page break; Shift+Enter line break.
- F7 spelling and grammar; Shift+F7 thesaurus; F12 Save As; Ctrl+Shift+E track changes; Shift+F3 change case.
- Ctrl+= subscript, Ctrl+Shift+= superscript; Ctrl+1 single, Ctrl+2 double, Ctrl+5 1.5 line spacing.

> **Quick revision:** MS Word (1983): .docx since 2007, .dotx template; Ribbon tabs: Home (font, paragraph, styles, find), Insert (table, header, footer, WordArt, drop cap), Design (watermark), Layout (margins, orientation), References (contents, footnotes), Mailings (mail merge), Review (spelling F7, track changes Ctrl+Shift+E, comments), View; font size 1-1638 points; table up to 63 columns; zoom 10-500 percent; Ctrl+E centre, Ctrl+J justify, Ctrl+Enter page break.

MS Excel: Cell References, Formulas, Functions, Charts and Error Values

Spreadsheets and Excel: A spreadsheet arranges data in rows and columns and recalculates results automatically whenever the data changes. VisiCalc (1979) was the first spreadsheet for personal computers and Lotus 1-2-3 followed in 1983; Microsoft Excel was released in 1985. An Excel file is a workbook, saved as .xlsx since Excel 2007 (.xls earlier, .xlsm with macros, .xltx as a template), and a workbook contains worksheets shown as tabs at the bottom. Excel 2010 and earlier versions opened a new workbook with three sheets; later versions open it with one.

Rows, columns and cells: Since Excel 2007 a worksheet has 1,048,576 rows numbered from 1 and 16,384 columns lettered from A to XFD; the older .xls format had 65,536 rows and 256 columns (A to IV). A cell is where a row and a column meet and is named by its column letter and row number, such as C5. The selected cell is the active cell; the Name Box shows its address and the Formula Bar shows its contents. A range of cells is written with a colon, as in A1:D10. By default text is aligned to the left of a cell and numbers to the right.

Formulas and references: A formula always begins with an equals sign, as in =A1+B1. The arithmetic operators are + - * / and ^ for power, worked out in the order brackets, power, multiplication and division, then addition and subtraction; & joins text and <> means not equal to. A relative reference (A1) changes when the formula is copied: =A1*B1 copied one row down becomes =A2*B2. An absolute reference (A1) stays fixed, which is useful for a constant such as a tax rate kept in one cell. A mixed reference fixes only the column ($A1) or only the row (A$1). Pressing F4 while editing a formula cycles a reference through these four forms.

Common functions: SUM adds a range, AVERAGE gives the mean, and MAX and MIN give the largest and smallest values. COUNT counts cells that contain numbers, COUNTA counts non-empty cells, COUNTBLANK counts empty cells, and COUNTIF and SUMIF count or add only the cells that meet a condition. IF tests a condition and returns one value if it is true and another if it is false, as in =IF(B2>=40,"Pass","Fail"). AND, OR and NOT combine conditions. VLOOKUP(lookup value, table, column number, FALSE) searches the first column of a table from top to bottom and returns the value from the given column of the matching row; FALSE asks for an exact match, and HLOOKUP does the same across the first row. Others often asked are ROUND, ABS, SQRT, MOD, LEN, UPPER, LOWER, CONCATENATE, TODAY (the current date) and NOW (the date and time). AutoSum (Alt+=) inserts SUM at once.

Charts, sorting and filtering: Charts are on the Insert tab. A column or bar chart compares values, a line chart shows a trend over time, a pie chart shows the parts of one whole (a single data series), and a scatter chart shows the relation between two sets of numbers. F11 creates a chart on a separate chart sheet and Alt+F1 an embedded chart on the same sheet. Sort (Data tab) arranges rows in ascending or descending order, and Filter (Ctrl+Shift+L) shows only the rows that meet a condition while hiding the rest, without deleting them. Freeze Panes (View tab) keeps headings visible while scrolling, Conditional Formatting (Home tab) colours cells by rules, and a PivotTable (Insert tab) summarises a large table. Goal Seek, under What-If Analysis on the Data tab, finds the input needed to reach a desired result.

Error values: #DIV/0! means division by zero. #N/A means a value is not available, as when VLOOKUP finds no match. #NAME? means Excel does not recognise text in the formula, such as a misspelt function name. #REF! means an invalid cell reference, often after cells have been deleted. #VALUE! means the wrong type of argument, such as adding text to a number. #NUM! means an invalid number and #NULL! a wrong range operator. A cell filled with ##### is not an error: the column is simply too narrow to show the number.

Shortcuts: F2 edits the active cell, Alt+Enter starts a new line inside a cell, Ctrl+; enters today's date and Ctrl+Shift+; the current time. Ctrl+Home goes to cell A1, Ctrl with an arrow key jumps to the edge of the data, and Ctrl+Page Down and Ctrl+Page Up move between sheets, while Shift+F11 inserts a new worksheet. Ctrl+1 opens Format Cells, Ctrl+D fills down and Ctrl+R fills right. Ctrl+Space selects a whole column, Shift+Space a whole row, and Ctrl+9 hides the selected rows.

Examples

- Excel 2007 onward: 1,048,576 rows and 16,384 columns (A to XFD); the older .xls format: 65,536 rows and 256 columns (A to IV).
- Relative A1 changes when copied; absolute A1 stays fixed; mixed $A1 or A$1 fixes one part; F4 cycles through them.
- Every formula starts with =; ^ is the power operator, & joins text and <> means not equal to.
- COUNT counts numeric cells, COUNTA counts non-empty cells, COUNTBLANK counts empty cells and COUNTIF counts cells that meet a condition.
- =IF(B2>=40,"Pass","Fail") returns Pass when B2 is 40 or more, otherwise Fail.
- VLOOKUP searches the first column of a table vertically and returns a value from a chosen column; HLOOKUP searches the first row horizontally; #N/A means no match was found.
- #DIV/0! division by zero; #NAME? unrecognised name; #REF! invalid reference; #VALUE! wrong data type; ##### column too narrow.
- A pie chart shows the parts of one whole; a line chart shows a trend; F11 makes a chart on a new sheet and Alt+F1 an embedded chart.
- Filter (Ctrl+Shift+L) hides the rows that do not match but does not delete them; Freeze Panes keeps headings in view.

- F2 edit cell; Alt+Enter new line in a cell; Ctrl+; today's date; Alt+= AutoSum; Shift+F11 new worksheet.

> **Quick revision:** Excel (1985): workbook .xlsx with worksheets; 1,048,576 rows and 16,384 columns (A to XFD); cell address C5, range A1:D10; formulas start with =; relative A1, absolute A1, mixed $A1 or A$1, F4 toggles; SUM, AVERAGE, COUNT, COUNTA, IF, VLOOKUP, HLOOKUP, COUNTIF; pie chart = parts of a whole; F11 chart sheet; Filter hides rows; errors #DIV/0!, #N/A, #NAME?, #REF!, #VALUE!; ##### = column too narrow.

MS PowerPoint, Access, Outlook, Common Shortcuts and File Extensions

PowerPoint basics: Microsoft PowerPoint is presentation software. It was created by Robert Gaskins and Dennis Austin at Forethought Inc., released in 1987 and bought by Microsoft the same year. A presentation is a set of slides, saved as .pptx since PowerPoint 2007 (.ppt earlier); a .ppsx file opens straight into a slide show and .potx is a template. Each slide follows a layout such as Title Slide (the default first slide), Title and Content, Section Header, Two Content, Comparison, Title Only or Blank, and the dotted boxes in a layout that hold text, pictures or charts are called placeholders. A theme (Design tab) gives all slides matching colours, fonts and backgrounds, and the Slide Master (View tab) controls the common formatting of every slide from one place.

Transitions, animations and views: A transition is the effect as one slide gives way to the next and is set on the Transitions tab. An animation is an effect on an object within a slide, set on the Animations tab, in four kinds: entrance, emphasis, exit and motion paths. The Animation Pane lists the order of the effects, and Rehearse Timings records how long each slide is shown. PowerPoint's views are Normal (the default editing view, with slide thumbnails and a notes pane), Outline View, Slide Sorter (all slides as thumbnails, easy to rearrange), Notes Page, Reading View and Slide Show; the master views are Slide Master, Handout Master and Notes Master. F5 starts the show from the first slide and Shift+F5 from the current slide, Esc ends it, and during a show B turns the screen black and W white. Ctrl+M adds a new slide and Ctrl+D duplicates the selected one. Speaker notes are seen by the presenter but not by the audience.

Access and Outlook: Microsoft Access is the database program of Office; its files are .accdb (.mdb earlier), and its objects are tables (which store data), queries (which find and filter it), forms (for entering it), reports (for printing it), macros and modules. Microsoft Outlook is an email client and personal information manager with mail, calendar, contacts and tasks; its folders include the Inbox, Drafts (unfinished messages), Outbox (messages waiting to be sent), Sent Items, Deleted Items and Junk Email. OneNote is the digital notebook of Office.

General Windows shortcuts: Ctrl+C copy, Ctrl+X cut, Ctrl+V paste, Ctrl+Z undo, Ctrl+Y redo, Ctrl+A select all, Ctrl+S save, Ctrl+P print, Ctrl+N new and Ctrl+O open work in almost every program. Alt+F4 closes the active window or program and Alt+Tab switches between open programs. F1 opens Help, F2 renames a selected file and F5 refreshes. The Windows key opens the Start menu (as does Ctrl+Esc), Windows+D shows the desktop, Windows+E opens File Explorer, Windows+L locks the computer and Windows+R opens the Run box. Ctrl+Shift+Esc opens Task Manager directly, and Ctrl+Alt+Delete opens the security screen. Delete sends a file to the Recycle Bin and Shift+Delete removes it permanently. Print Screen copies the whole screen to the clipboard (in Windows 11 it may open the Snipping Tool instead) and Alt+Print Screen only the active window.

Browser shortcuts: In most web browsers, Ctrl+T opens a new tab, Ctrl+W closes the current tab, Ctrl+Shift+T reopens the last closed tab, Ctrl+H shows the history, Ctrl+J shows downloads, Ctrl+D bookmarks the page, F5 reloads it and F11 switches to full screen.

File extensions: An extension tells the type of a file. Documents: .docx and .doc (Word), .txt (plain text, as in Notepad), .rtf (Rich Text Format), .pdf (Portable Document Format, created by Adobe), .xlsx, .pptx and .csv (comma-separated values). Images: .jpg or .jpeg (Joint Photographic Experts Group, compressed with some loss of quality), .png (Portable Network Graphics, lossless, supports transparency), .gif (Graphics Interchange Format, supports simple animation), .bmp (bitmap) and .tif. Audio: .mp3 (compressed), .wav (uncompressed) and .aac. Video: .mp4, .avi, .mov, .mkv and .wmv. Compressed archives: .zip, .rar and .7z. Programs and system files: .exe (executable), .bat (batch file), .dll (dynamic link library), .msi (Windows installer) and .apk (Android app package). Web pages and code: .html or .htm, .css, .js, .xml, .c, .java and .py.

Examples

- PowerPoint: .pptx since 2007; .ppsx opens straight into a slide show; .potx is a template.
- Transition = effect between slides (Transitions tab); animation = effect on an object within a slide (Animations tab): entrance, emphasis, exit, motion paths.
- Normal view is PowerPoint's default; Slide Sorter shows all slides as thumbnails for rearranging; the Slide Master sets formatting for all slides.
- F5 starts a slide show from the beginning, Shift+F5 from the current slide; Ctrl+M inserts a new slide; B turns the screen black during a show.
- Access objects: tables, queries, forms, reports, macros, modules; Access file extension .accdb.
- Outlook: the Outbox holds messages waiting to be sent; Drafts holds unfinished messages.
- Alt+F4 closes the active program; Alt+Tab switches programs; Ctrl+Shift+Esc opens Task Manager; Windows+L locks the PC; Windows+D shows the desktop.
- F2 renames a file; F5 refreshes; Shift+Delete deletes permanently, skipping the Recycle Bin.
- Image formats: .jpg (lossy), .png (lossless, transparency), .gif (animation), .bmp (bitmap); audio .mp3 and .wav; video .mp4, .avi, .mov.
- .exe executable, .bat batch file, .dll dynamic link library, .apk Android package, .zip and .rar compressed archives, .pdf Portable Document Format.

> **Quick revision:** PowerPoint (1987, Forethought, bought by Microsoft): .pptx, .ppsx show, .potx template; layouts, placeholders, themes, Slide Master; transitions between slides, animations on objects (entrance, emphasis, exit, motion path); Normal view default, Slide Sorter; F5 show, Shift+F5 from current slide, Ctrl+M new slide; Access .accdb (tables, queries, forms, reports); Outlook Outbox; Alt+F4, Alt+Tab, Windows+D, Windows+L, Ctrl+Shift+Esc; .exe, .dll, .jpg, .png, .gif, .mp3, .mp4, .zip, .pdf.

Computer Networks, the OSI Model, Internet Protocols and Email

Networks and their sizes: A computer network is two or more computers connected to share data, printers and an internet connection. A PAN (Personal Area Network) covers a few metres around one person, as when a phone links to earphones over Bluetooth. A LAN (Local Area Network) covers a room, building or campus, is fast and privately owned, and uses Ethernet cables (the IEEE 802.3 standard) or Wi-Fi (IEEE 802.11). A MAN (Metropolitan Area Network) covers a city, like a cable TV network. A WAN (Wide Area Network) spans countries and continents through leased lines and satellites; the internet is the largest WAN. An intranet is a private network inside an organisation built with internet technology, and an extranet opens part of it to outside partners.

Topologies and media: Topology is the layout of a network. In a bus all computers share one backbone cable, so a break in it stops the network. In a star every computer connects to a central hub or switch; it is the most common LAN layout and easy to extend, but everything stops if the centre fails. In a ring each computer connects to two neighbours and data travels round in one direction. In a mesh every device connects to every other, which is the most reliable and the costliest; a full mesh of n devices needs n(n-1)/2 links. Data travels over twisted-pair cable (RJ-45 connectors for Ethernet), coaxial cable (cable TV), optical fibre (light pulses, the fastest and least affected by interference) or wireless links. Transmission is simplex (one way, like radio broadcast), half-duplex (both ways in turn, like a walkie-talkie) or full-duplex (both ways at once, like a telephone call).

Network devices: A NIC (network interface card) connects a computer to a network and carries its MAC address. A repeater regenerates a weak signal. A hub sends incoming data out of all its ports, while a switch sends it only to the port of the destination computer, using MAC addresses. A bridge joins two LAN segments. A router connects different networks and forwards packets along the best path using IP addresses. A modem (modulator-demodulator) converts digital signals to analog for telephone lines and back again. A gateway connects networks that use different protocols, acting as a protocol converter.

The OSI model: The OSI (Open Systems Interconnection) reference model, published by the International Organization for Standardization (ISO) in 1984, divides network communication into seven layers. From the bottom they are 1 Physical (bits, cables, hubs, repeaters), 2 Data Link (frames, MAC addresses, switches, bridges), 3

Network (packets, IP addresses, routing, routers), 4 Transport (end-to-end delivery and error control, TCP and UDP), 5 Session (opening, managing and closing sessions), 6 Presentation (translation, encryption, compression) and 7 Application (user services such as HTTP, FTP, SMTP and DNS). The internet itself runs on the simpler four-layer TCP/IP model.

Protocols and addresses: A protocol is a set of rules for communication. TCP (Transmission Control Protocol) delivers data reliably and in order, UDP sends it faster without that guarantee, and IP (Internet Protocol) addresses and routes packets; TCP/IP was designed by Vint Cerf and Bob Kahn, and ARPANET switched to it on 1 January 1983. HTTP (HyperText Transfer Protocol, port 80) carries web pages, and HTTPS (port 443) carries them encrypted with SSL/TLS. FTP (port 21) transfers files. SMTP (port 25) sends email, POP3 (port 110) downloads mail to one device, usually removing it from the server, and IMAP (port 143) keeps mail on the server and keeps every device in sync. An IPv4 address is 32 bits written as four numbers from 0 to 255, such as 192.168.1.1, and an IPv6 address is 128 bits written in hexadecimal. A MAC address is a 48-bit physical address fixed in the network card. DNS (Domain Name System, port 53) translates domain names into IP addresses.

The web, browsers and search: The World Wide Web, proposed by Tim Berners-Lee at CERN in 1989, is a system of linked pages written in HTML. A URL (Uniform Resource Locator) such as https://www.example.com/index.html has a protocol, a domain name and a path; domains end in suffixes such as .com, .org, .edu, .gov and the country code .in. A web browser such as Chrome, Firefox, Edge or Safari displays pages; Mosaic (1993) was the first popular graphical browser. A search engine indexes pages so they can be found; Archie (1990), which indexed FTP files, is regarded as the first internet search engine, and Google was founded in 1998.

Email and internet history: Ray Tomlinson sent the first network email in 1971 and chose the @ sign, so addresses read user@domain. The To field holds the main recipients, CC (carbon copy) sends copies that every recipient can see, and BCC (blind carbon copy) sends copies whose recipients are hidden from the others. The internet grew from ARPANET, built by the Advanced Research Projects Agency of the US Defense Department; its first message went from UCLA to the Stanford Research Institute on 29 October 1969. In India, ERNET linked education and research institutions from 1986, and VSNL opened public internet service on 15 August 1995.

Examples

- PAN (Bluetooth, a few metres), LAN (building, Ethernet, Wi-Fi), MAN (city), WAN (countries); the internet is the largest WAN.
- Star topology uses a central hub or switch; bus uses one backbone cable; in a ring data goes one way; mesh is the most reliable and needs n(n-1)/2 links.
- A hub broadcasts to all ports; a switch sends to one port using MAC addresses; a router links different networks using IP addresses; a gateway joins networks with different protocols.
- OSI layers from bottom to top: Physical, Data Link, Network, Transport, Session, Presentation, Application (mnemonic: Please Do Not Throw Sausage Pizza Away).
- The router works at the Network layer, the switch and bridge at the Data Link layer, and the hub and repeater at the Physical layer.
- Ports: HTTP 80, HTTPS 443, FTP 21, SMTP 25, POP3 110, IMAP 143, DNS 53.
- SMTP sends mail; POP3 downloads it to one device; IMAP keeps it on the server and syncs it across devices.
- IPv4: 32 bits, four numbers from 0 to 255 (192.168.1.1); IPv6: 128 bits in hexadecimal; MAC address: 48 bits, fixed in the network card.
- CC recipients are visible to everyone; BCC recipients are hidden from all the other recipients.
- ARPANET's first message: 29 October 1969, UCLA to Stanford Research Institute; Ray Tomlinson's email and the @ sign: 1971; public internet in India by VSNL: 15 August 1995.

> **Quick revision:** PAN, LAN (Ethernet 802.3, Wi-Fi 802.11), MAN, WAN; bus, star, ring, mesh (n(n-1)/2 links); hub, switch (MAC), router (IP), modem, gateway; OSI (ISO, 1984) 7 layers: physical, data link, network, transport, session, presentation, application; TCP/IP (Cerf, Kahn); HTTP 80, HTTPS 443, SMTP 25, POP3 110, IMAP 143; IPv4 32-bit, IPv6 128-bit, MAC 48-bit; DNS; ARPANET 1969; email 1971; VSNL 1995; CC visible, BCC hidden.

Cyber Security, the IT Act 2000 and Database (DBMS and SQL) Basics

Malware: Malware is any software written to harm a computer or its user. A virus attaches itself to a program or file and spreads when that file is run or shared; Brain, written in Pakistan in 1986, is called the first virus for IBM PCs. A worm is a standalone program that copies itself across networks without any user action; the Morris worm of 1988 was one of the first on the internet. A Trojan horse, named after the wooden horse of Greek legend, looks like useful software but secretly does harm, such as opening a backdoor, and unlike a virus it does not replicate. Ransomware encrypts the victim's files and demands payment for the key, as WannaCry did in 2017. Spyware secretly collects information, a keylogger records keystrokes to steal passwords, adware shows unwanted advertisements, and a botnet is a group of infected computers (zombies) controlled remotely by an attacker.

Attacks: Phishing uses fake emails or websites that imitate a bank or other trusted body to trick people into revealing passwords, card numbers or OTPs; by phone call it is vishing and by SMS smishing. Spoofing is faking an identity, such as a forged email sender, caller ID or IP address. Pharming redirects users from a real website to a fake one, and a denial-of-service (DoS) attack floods a server with requests until it stops working; a DDoS attack does this from many computers, often a botnet. Others are the man-in-the-middle attack (secretly intercepting communication), the brute-force attack (trying every possible password) and social engineering (manipulating people rather than machines).

Defences: A firewall is hardware or software that monitors traffic between a trusted network and the internet and blocks whatever its rules do not allow. Antivirus software detects and removes malware by matching known signatures and watching for suspicious behaviour, so it must be updated regularly. Encryption turns readable plaintext into unreadable ciphertext with a key. Symmetric encryption (such as AES) uses one shared key, while asymmetric or public-key encryption (such as RSA, 1977) uses a public key to encrypt and a private key to decrypt. A digital signature is made with the sender's private key and checked with the sender's public key, proving who sent a message and that it was not altered. Two-factor authentication asks for two different kinds of proof out of three: something you know (password or PIN), something you have (a phone receiving an OTP, or a card) and something you are (fingerprint or face).

The IT Act 2000: The Information Technology Act, 2000, India's main law on cybercrime and electronic commerce, came into force on 17 October 2000. Based on the UNCITRAL Model Law on Electronic Commerce, it gives legal recognition to electronic records and digital signatures, and Certifying Authorities licensed by the Controller of Certifying Authorities issue Digital Signature Certificates. Section 43 provides compensation for damage to computer systems, Section 65 punishes tampering with computer source code and Section 66 covers computer-related offences such as hacking. The 2008 amendment added offences such as identity theft (66C), cheating by personation (66D), violation of privacy (66E) and cyber terrorism (66F, punishable with imprisonment up to life), and gave CERT-In a legal role as the national agency for cyber security incidents. Section 66A, on offensive online messages, was struck down by the Supreme Court in Shreya Singhal v. Union of India in 2015.

Databases and DBMS: A database is an organised collection of related data, and a DBMS (Database Management System) is the software that creates, stores, updates and retrieves it while reducing duplication, keeping data consistent and controlling access; MySQL, Oracle, PostgreSQL and MS Access are examples. In the relational model, proposed by E. F. Codd of IBM in 1970, data is kept in tables called relations. A row is a record or tuple, a column is a field or attribute, the number of columns is the degree and the number of rows is the cardinality.

Keys: A primary key uniquely identifies each record in a table and can be neither empty (NULL) nor repeated, like a roll number. Every field, or set of fields, that could serve as the primary key is a candidate key, and the candidates not chosen are alternate keys. A composite key is made of two or more columns together. A foreign key is a field in one table that refers to the primary key of another table; it links the two tables and keeps their references valid, which is called referential integrity.

SQL in outline: SQL (Structured Query Language) was developed at IBM in the 1970s and became an ANSI standard in 1986. DDL (Data Definition Language) defines structure with CREATE, ALTER, DROP and TRUNCATE. DML (Data Manipulation Language) changes data with INSERT, UPDATE and DELETE, and SELECT queries it, as in SELECT name FROM students WHERE marks > 60. DCL (Data Control Language) gives and takes away rights with

GRANT and REVOKE. TCL (Transaction Control Language) manages transactions with COMMIT, ROLLBACK and SAVEPOINT. DROP removes a whole table, TRUNCATE removes all its rows but keeps the structure, and DELETE removes only the rows chosen.

Examples

- A virus needs a host file and user action to spread; a worm spreads by itself over networks; a Trojan disguises itself as useful software and does not replicate.
- Ransomware encrypts files and demands payment (WannaCry, 2017); spyware secretly gathers data; a keylogger records keystrokes.
- Phishing: fake email or website; vishing: by voice call; smishing: by SMS; spoofing: faking a sender's identity.
- A firewall filters network traffic by rules; antivirus detects malware by signatures and must be kept updated.
- Symmetric encryption uses one key (AES); asymmetric uses a public and a private key (RSA); a digital signature is made with the sender's private key.
- Two-factor authentication combines two of: something you know (PIN), something you have (phone for OTP, card) and something you are (fingerprint).
- IT Act 2000 came into force on 17 October 2000, based on the UNCITRAL Model Law; amended in 2008; Section 66A struck down in the Shreya Singhal case (2015).
- Section 66C identity theft, 66D cheating by personation, 66E violation of privacy, 66F cyber terrorism (up to life imprisonment).
- Primary key: unique and never NULL; foreign key: refers to another table's primary key; candidate keys not chosen become alternate keys.
- SQL groups: DDL (CREATE, ALTER, DROP, TRUNCATE), DML (INSERT, UPDATE, DELETE, SELECT), DCL (GRANT, REVOKE), TCL (COMMIT, ROLLBACK, SAVEPOINT).

> **Quick revision:** Virus (needs a host), worm (spreads itself), Trojan (disguised, does not replicate), ransomware (WannaCry 2017), spyware, keylogger, botnet; phishing, vishing, smishing, spoofing, pharming, DoS/DDoS; firewall, antivirus, encryption (AES symmetric, RSA public-key), digital signature, two-factor authentication; IT Act 2000 in force 17 October 2000, amended 2008, 66A struck down 2015; DBMS, relational model (Codd 1970); primary, candidate, foreign keys; SQL DDL, DML, DCL, TCL.

Free practice questions: parikshasaathi.com/q/computer-knowledge/

Revision sheet

Every lesson's quick-revision box in one place, for the last read before the exam.

Computer Knowledge — Fundamentals	Know your abbreviations (CPU, RAM, ROM, USB, URL, HTTP, LAN, WAN, GUI, DBMS, ALU) and the input/output and volatile/non-volatile distinctions; system software (the OS) manages the computer, application software (Word, Excel, a browser) helps the user do a specific task. Key inventors: Babbage (computer concept), Berners-Lee (WWW, 1989), Torvalds (Linux, 1991). Five generations: vacuum tubes → transistors → ICs → microprocessors → AI/ULSI. Compiler translates all-at-once; interpreter translates line-by-line.
Computer Fundamentals: History, Generations and Types of Computers	Computer: input-process-output, from Latin computare; Pascaline 1642 (add, subtract); Babbage: Difference Engine 1822, Analytical Engine, Father of the Computer; Ada Lovelace first programmer; ENIAC 1946 (about 18,000 vacuum tubes); UNIVAC I 1951 first US commercial computer; generations: vacuum tube, transistor, IC, microprocessor, AI/ULSI; analog, digital, hybrid; super, mainframe, mini, micro; HEC-2M 1956; TIFRAC 1960; PARAM 8000 1991.
CPU and Memory: ALU, Control Unit, RAM, ROM, Cache and Memory Units	CPU = ALU + Control Unit + registers (Program Counter, Accumulator); machine cycle fetch-decode-execute-store; clock speed in Hz, speed also in MIPS; RAM volatile (SRAM for cache, DRAM for main memory); ROM non-volatile (PROM, EPROM by UV, EEPROM, flash), holds BIOS; cache L1 fastest; virtual memory uses disk; 1 nibble = 4 bits, 1 byte = 8 bits; KB, MB, GB, TB, PB each 1024 times the last.
Storage Devices, Input Devices and Output Devices	Secondary storage is non-volatile: magnetic (HDD, tape - sequential access), optical (CD about 700 MB, DVD 4.7 GB, Blu-ray 25 GB), flash (SSD, pen drive, SD card); HDD tracks, sectors, rpm; input: keyboard (QWERTY), mouse (Engelbart), scanner, OMR (answer sheets), OCR (text), MICR (cheques, 9-digit code), barcode, QR code; output: monitor (pixels; CRT, LCD, LED), impact printers (dot matrix, daisy wheel, line), non-impact (inkjet, laser, thermal), plotter.
Software and Operating Systems: Types, Functions, Booting and Files	Software = system (OS, drivers, translators, utilities) + application (Word, browser); firmware in ROM (BIOS); open source (Linux, Firefox) vs proprietary (Windows, MS Office); OS manages processes, memory, files, devices, security; kernel and shell; CLI vs GUI; batch, time-sharing, real-time, multi-user, distributed OS; MS-DOS 1981, Windows 1.0 1985; UNIX 1969; Linux 1991; Android bought by Google 2005; booting: POST, bootstrap loader; cold vs warm boot.
Programming Languages, Translators, Number Systems and Character Codes	Languages: machine (1GL), assembly (2GL), high-level (3GL: FORTRAN 1957, COBOL 1959, C 1972, Python 1991, Java 1995), 4GL (SQL), 5GL (PROLOG); assembler, compiler (whole program), interpreter (line by line); algorithm and flowchart symbols; bases 2, 8, 10, 16; 25 = 11001; 101101 = 45 = octal 55 = hex 2D; ASCII 7-bit, 128 characters, A = 65; EBCDIC 8-bit (IBM); Unicode; nibble 4 bits, byte 8 bits.
MS Word: Formatting, Tables, Mail Merge, Track Changes and Shortcuts	MS Word (1983): .docx since 2007, .dotx template; Ribbon tabs: Home (font, paragraph, styles, find), Insert (table, header, footer, WordArt, drop cap), Design (watermark), Layout (margins, orientation), References (contents, footnotes), Mailings (mail merge), Review (spelling F7, track changes Ctrl+Shift+E, comments), View; font size 1-1638 points; table up to 63 columns; zoom 10-500 percent; Ctrl+E centre, Ctrl+J justify, Ctrl+Enter page break.
MS Excel: Cell References, Formulas, Functions, Charts and Error Values	Excel (1985): workbook .xlsx with worksheets; 1,048,576 rows and 16,384 columns (A to XFD); cell address C5, range A1:D10; formulas start with =; relative A1, absolute A1, mixed $A1 or A$1, F4 toggles; SUM, AVERAGE, COUNT, COUNTA, IF, VLOOKUP, HLOOKUP, COUNTIF; pie chart = parts of a whole; F11 chart sheet; Filter hides rows; errors #DIV/0!, #N/A, #NAME?, #REF!, #VALUE!; ##### = column too narrow.
MS PowerPoint, Access, Outlook, Common Shortcuts and File Extensions	PowerPoint (1987, Forethought, bought by Microsoft): .pptx, .ppsx show, .potx template; layouts, placeholders, themes, Slide Master; transitions between slides, animations on objects (entrance, emphasis, exit, motion path); Normal view default, Slide Sorter; F5 show, Shift+F5 from current slide, Ctrl+M new slide; Access .accdb (tables, queries, forms, reports); Outlook Outbox; Alt+F4, Alt+Tab, Windows+D, Windows+L, Ctrl+Shift+Esc; .exe, .dll, .jpg, .png, .gif, .mp3, .mp4, .zip, .pdf.

Computer Networks, the OSI Model, Internet Protocols and Email	PAN, LAN (Ethernet 802.3, Wi-Fi 802.11), MAN, WAN; bus, star, ring, mesh (n(n-1)/2 links); hub, switch (MAC), router (IP), modem, gateway; OSI (ISO, 1984) 7 layers: physical, data link, network, transport, session, presentation, application; TCP/IP (Cerf, Kahn); HTTP 80, HTTPS 443, SMTP 25, POP3 110, IMAP 143; IPv4 32-bit, IPv6 128-bit, MAC 48-bit; DNS; ARPANET 1969; email 1971; VSNL 1995; CC visible, BCC hidden.
Cyber Security, the IT Act 2000 and Database (DBMS and SQL) Basics	Virus (needs a host), worm (spreads itself), Trojan (disguised, does not replicate), ransomware (WannaCry 2017), spyware, keylogger, botnet; phishing, vishing, smishing, spoofing, pharming, DoS/DDoS; firewall, antivirus, encryption (AES symmetric, RSA public-key), digital signature, two-factor authentication; IT Act 2000 in force 17 October 2000, amended 2008, 66A struck down 2015; DBMS, relational model (Codd 1970); primary, candidate, foreign keys; SQL DDL, DML, DCL, TCL.

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