

DETAILED STUDY NOTES / COMPLETE EDITION

COMPUTER FUNDAMENTALS

भारतीय संख्या पद्धतियों से Linux तक

चारों Units के विस्तृत Hindi-English notes

Concepts, examples, numericals और revision

4 UNITS

40 CHAPTERS

120 MCQs

Hindi + English Edition

IKS · Computer Basics · I/O · Memory · OS

पुस्तक का परिचय

Detailed Notes / Units I-IV

यह combined book आपके Computer Fundamentals syllabus के चारों units को Hindi-English mix में समझाती है। Technical terms और commands English में रखे गए हैं। प्रत्येक विषय में definitions, working, comparisons, examples और exam preparation शामिल हैं।

पढ़ने का तरीका

पहले concept और diagram समझें, फिर numerical स्वयं हल करें। Unit के अंत में 30 MCQs हल करने के बाद answer key देखें। Long answers में definition, labelled diagram, working और example लिखें।

Syllabus Map

Unit	Coverage	Chapters
I	Indian mathematics, number systems, history, CPU, hardware and codes	1-13
II	Input/output devices, ports, interfaces and specialised processors	14-23
III	Memory hierarchy, cache, virtual memory, DASD and MMU	24-31
IV	OS, DOS, Windows and Linux commands	32-40

Conventions

KiB = 1024 bytes; MiB = 1024² bytes; MB = 10⁶ bytes. Address calculations state whether addressing is byte-based. Historical Indian methods are compared with modern representations without treating the two as identical. Classic DOS and modern Windows Command Prompt are distinguished. Linux uses mkdir; md is a DOS/Windows command.

Examples are illustrative. Product capabilities vary by version and implementation. Destructive file commands should be practised only on your own temporary exercise files. Source notes [R1]–[R16] are listed at the end.

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UNIT 1 / CHAPTER 01

अध्याय 1: Indian Number Systems एवं Bhūta-Saṅkhyā

UNIT I • Indian Knowledge System and Computer Basics

1.1 Knowledge System को कैसे पढ़ें?

Indian Knowledge System (IKS) में mathematical texts, astronomical computations, measurement practices और oral knowledge traditions का अध्ययन करते हैं। Computer Science से संबंध समझते समय representation, algorithms और systematic reasoning पर ध्यान दें। Ancient methods की आधुनिक concepts से तुलना useful है; इससे यह निष्कर्ष नहीं निकलता कि आधुनिक electronic computer प्राचीन काल में मौजूद था।

1.2 Decimal Place Value और Zero

Decimal positional representation में digit का value उसके स्थान पर निर्भर है। 507 में 5 hundreds, 0 tens और 7 units हैं: $5 \times 10^2 + 0 \times 10^1 + 7 \times 10^0$ । Zero empty place बताता है और arithmetic में स्वयं number भी है। Placeholder symbol, zero का numerical concept और उसके arithmetic rules अलग historical questions हैं।

भारतीय manuscripts और inscriptions numeral development का evidence देती हैं। Bakhshali manuscript और Gwalior inscription ऐसे अध्ययन में discussed examples हैं। Manuscript material की dating और text की composition की dating समान नहीं होती; Bakhshali chronology पर scholarly discussion है। इसलिए “एक exact date पर zero पहली बार बना” जैसे oversimplified claims से बचें। [R1, R2]

1.3 Salient Aspects of Indian Mathematics

Aspect	Learning significance
Place-value notation	Large numbers compactly लिखें
Zero और negative quantities	Arithmetic rules का विकास
Geometry and measurement	Construction और area problems
Astronomy	Numerical tables और prediction
Prosody	Pattern enumeration और combinatorics
Verse-based encoding	Numerical information याद रखने के तरीके

ये broad study areas हैं; अलग authors और periods का काम एक single invention story में merge न करें।

1.4 Bhūta-Saṅkhyā: Word-based Numbers

Bhūta-Saṅkhyā में meaningful objects/ideas के numerical associations से numbers encode करते हैं. “चन्द्र” एक moon→1; “नेत्र” two eyes→2; “वेद” four Vedas→4; “आकाश/ख” zero का association हो सकता है. Synonyms से composer verse की metre के अनुसार word चुन सकता है. Values और reading conventions text/context से verify करें. [R3, R4]

Teaching association	Value	Reason
चन्द्र	1	One moon
नेत्र	2	Two eyes
वेद	4	Four Vedas
ऋतु	6	Traditional six seasons

Common units-first convention में first word units, next tens, next hundreds होता है. **Teaching example:** चन्द्र-नेत्र-वेद → digits 1, 2, 4 in units-to-hundreds order → **421**. यह बनाया हुआ classroom example है, किसी historical verse का quotation नहीं.

1.5 Computer Science Connection

A numeral, binary string और word-code एक information को अलग representations में रख सकते हैं. Encoding rule और decoding rule साझा हों तभी correct recovery होती है. Word-code ordinary encryption नहीं है; secrecy, error correction और memorability अलग purposes हैं.

Exam point: Decimal representation place value उपयोग करती है. Bhūta-Saṅkhyā semantic associations से number याद/encode कर सकती है. Historical evidence और आधुनिक analogy को अलग समझाएँ.

Practice: Units-first नेत्र-चन्द्र → 12. 305 में zero हटाने से 35 बनता है; zero placeholder क्यों महत्वपूर्ण है?

UNIT 1 / CHAPTER 02

अध्याय 2: Kaṭapayādi, Piṅgala एवं Binary Patterns

Letter encoding और two-valued enumeration

2.1 Kaṭapayādi का विचार

Kaṭapayādi consonants को digits से associate करने की mnemonic system है। Consonant groups के initial letters ka, ṭa, pa, ya से name आता है। Vowels pronunciation बनाने में सहायता करते हैं। नीचे basic mapping educational decoding के लिए है; conjunct consonants, standalone vowels और final consonants के rules पढ़े गए text की convention से लें। [R3, R4]

Digit	Consonants in standard basic groups
1	क, ट, प, य
2	ख, ठ, फ, र
3	ग, ड, ब, ल
4	घ, ढ, भ, व
5	ङ, ण, म, श
6	च, त, ष
7	छ, थ, स
8	ज, द, ह
9	झ, ध
0	ञ, न

2.2 Decoding Example एवं Limits

Teaching syllables “क-ख-ग” map 1, 2, 3. Units-first reading gives **321**. Vowels बदलने से basic consonant value नहीं बदलता। Real Sanskrit words में consonant cluster का अंतिम consonant before vowel usually digit-bearing होता है; सभी written consonants को blindly digits मानना गलत हो सकता है। Number-direction और text convention पहले स्पष्ट करें।

Bhūta-Saṅkhyā meaning-based association है; Kaṭapayādi sound/letter-based association. दोनों information representation और memory aids के examples हैं; modern programming languages के substitutes नहीं।

2.3 Piṅgala और Sanskrit Prosody

Piṅgala की prosodic tradition syllables को laghu (light) और guru (heavy) forms में classify करके patterns enumerate करती है. n positions में two choices each होने पर total 2^n combinations हैं. Modern binary strings से structural connection है; historical metrical notation, enumeration order और modern bit convention identical मानना आवश्यक नहीं. [R5]

2.4 Modern Teaching Mapping

यहाँ केवल illustration के लिए $L=0$, $G=1$ और leftmost bit most significant लेते हैं. Classical pra stāra का exact ordering इससे अलग हो सकता है.

Pattern	Teaching bits	Decimal value
LLL	000	0
LLG	001	1
LGL	010	2
LGG	011	3
GLL	100	4
GLG	101	5
GGL	110	6
GGG	111	7

Pra stāra enumeration, counting, pattern-to-index और index-to-pattern ideas algorithmic thinking से जोड़ते हैं. Fixed syllable count और fixed mātrā count अलग counting problems हैं.

2.5 Solved Questions

$n=4$ syllables: $2^4=16$ unrestricted L/G patterns. Exactly one G among three positions: 3 patterns GLL, LGL, LLG. Modern $GLG=101_2=5$. यह calculation modern mapping पर है, historical serial number का दावा नहीं.

10-mark answer: Define systems → mapping example → two-valued patterns → 2^n counting → connection/limits. “Piṅgala ने transistor computer बनाया” जैसे unsupported statements न लिखें.

UNIT 1 / CHAPTER 03

अध्याय 3: Śulba Sūtras एवं Numerical Mathematics

Geometry, approximation और modern interpretation

3.1 Rope Geometry का Context

Śulba Sūtras ritual altar construction से जुड़े geometric rules की परंपरा हैं। Measuring cords, lengths, diagonals और equal-area constructions उनके context में महत्वपूर्ण हैं। Baudhayana और Apastamba जैसे names इस literature से जुड़े हैं। Textual periods approximate हैं; exact universal dates के बजाय mathematical content पर ध्यान दें। [R6]

3.2 Rectangle Diagonal Relation

Modern notation में right triangle/rectangle relation $d^2 = a^2 + b^2$. Example sides 3units और 4units → diagonal $\sqrt{9+16} = 5$ units. Geometry से construction dimension निकालना arithmetic और measurement का संबंध दिखाता है। Historical rule का modern algebraic writing interpretive translation है।

3.3 $\sqrt{2}$ Approximation

Tradition में discussed approximation को modern notation में लिखें:

$$\sqrt{2} \approx 1 + \frac{1}{3} + \frac{1}{(3 \times 4)} - \frac{1}{(3 \times 4 \times 34)} = \frac{577}{408} \approx 1.4142156863. \text{ [R6, R7]}$$

True numerical $\sqrt{2} \approx 1.4142135624$. Absolute error ≈ 0.0000021239 . इसलिए “ $\approx$ ” use करें, exact equality नहीं। Rational $\frac{577}{408}$ irrational $\sqrt{2}$ का approximation है।

3.4 Solved Geometry Example

Square side 10cm. Exact diagonal $10\sqrt{2} \approx 14.142135624$ cm. Above rational approximation gives $10 \times \frac{577}{408} \approx 14.142156863$ cm. Difference ≈ 0.000021239 cm. Tiny approximation error और measurement tool error अलग concerns हैं।

3.5 Area Scaling

Square side a has area a^2 . Area double करने के लिए side $a\sqrt{2}$ चाहिए, side $2a$ नहीं: doubling side makes area 4times. If original side 6cm, doubled-area square side $6\sqrt{2} \approx 8.485281$ cm, area 72cm^2 .

Task	Correct relationship	Common mistake
Rectangle diagonal	$\sqrt{a^2+b^2}$	$a+b$
Double square area	Side $\times \sqrt{2}$	Side $\times 2$
Rational approximation	Finite error stated	Exact irrational equality

Task	Correct relationship	Common mistake
Units	Length vs area distinguish	cm और cm ² mix करना

3.6 Computational Connection

Finite precision, numerical approximation और verification modern computation में भी आवश्यक हैं। Algorithm formula देता है; representation accuracy, rounding और measurement uncertainty result प्रभावित करते हैं। Ancient geometry और modern numerical methods की तुलना mathematical reasoning के आधार पर करें; सभी modern techniques का direct historical identity claim न करें।

Practice: 5cm square diagonal ≈ 7.071068 cm. $5 \times 577/408 \approx 7.071078$ cm. Difference calculate करें।
8×15 rectangle diagonal 17units.

UNIT 1 / CHAPTER 04

अध्याय 4: Computer Fundamentals एवं Historical Development

Mechanical calculation से electronic stored programs तक

4.1 Computer की Definition

Computer programmable system है जो input लेता है, instructions के अनुसार process करता है, data store कर सकता है और output देता है. Speed, accuracy, storage और automation इसकी strengths हैं. Accuracy valid data, correct program और reliable hardware पर depend करती है; wrong input/program wrong output दे सकता है.

Data raw representation; information contextual processed meaning. Student marks data set data है; class average interpret करके information मिलती है. Hardware physical parts, software instructions, user/procedures complete system का हिस्सा.

4.2 Development के Major Steps

Stage / example	Contribution
Abacus और manual aids	Human-guided calculation
Pascal/Leibniz mechanical calculators	Mechanized arithmetic
Babbage Difference/Analytical Engine ideas	Automatic calculation and programmable design
Punched-card data processing	Large record processing
Electromechanical machines	Relays and automatic control
Electronic machines	Vacuum-tube computation
Stored-program machines	Instructions represented in memory
Integrated circuits/microprocessors	Smaller electronic systems

“First computer” का answer category पर depend करता है: mechanical, programmable, electronic, general-purpose और stored-program अलग criteria हैं.

4.3 Selected Milestones

ENIAC public introduction 1946 electronic general-purpose computing का major milestone था; early programming plug boards/switches से होती थी. Manchester Baby ने 1948 में electronic stored-program execution demonstrate किया. EDSAC 1949 early practical stored-program systems में था. Intel 4004 (1971) early commercial microprocessor milestone है. ये technology milestones हैं, single universal “first” label नहीं. [R8, R9]

4.4 Stored-program Concept

Instructions और data memory representation में रखे जाते हैं। CPU fetches instruction, decodes operation और executes. Program बदलने के लिए physical rewiring के बजाय instruction sequence बदलना possible होता है। Modern systems complex memory/cache organization use करते हैं, फिर भी programmable instruction execution central idea है।

4.5 Applications एवं Limitations

Education, science, banking, communication और administration में computers repetitive processing और large datasets handle करते हैं। Automation स्वयं correctness या ethical judgment guarantee नहीं करती। Software errors, biased data, hardware failure और access/security issues results प्रभावित कर सकते हैं।

Classroom example: 50 students की total marks calculation. Input marks → validate 0..100 → sum → average → output. Missing record को 0 assume करने के बजाय policy बताएँ।

10-mark answer: Definition → characteristics → historical stages → stored-program concept → applications → limitations. Historical dates को chronology के साथ लिखें।

UNIT 1 / CHAPTER 05

अध्याय 5: Generations of Computers

Dominant technologies का educational classification

5.1 “Generation” का Meaning

Computer generations hardware changes का commonly used teaching framework है. Boundaries approximate और textbook-dependent हैं; technologies overlap करती हैं. Fifth generation के लिए कोई single universally fixed date/hardware switch नहीं. Technology trend समझना exact year memorization से बेहतर है.

Generation	Dominant textbook technology	Typical implications
First	Vacuum tubes	Large size, heat, high power; machine-level programming
Second	Transistors	Smaller, more reliable; assembly/high-level languages expand
Third	Integrated circuits	More compact integration; OS capabilities grow
Fourth	Microprocessors, high integration	Personal/embedded computing widely expands
Fifth, teaching label	AI, parallel/knowledge-oriented ambitions	Evolving goals, not all systems identical

5.2 First और Second

Vacuum tube switches useful electronic control देते थे but large systems power/heat intensive थे. Transistor semiconductor switch है; size/reliability improvements enabled denser designs. Storage/peripherals भी बदले; generation केवल software language की category नहीं.

5.3 Integrated Circuit एवं Microprocessor

IC many electronic elements एक manufactured chip पर integrate करता है. Microprocessor CPU functions chip पर implement करता है. Every IC CPU नहीं: memory chips और interface chips भी ICs हैं. CPU chip के साथ memory, I/O और power circuitry चाहिए unless integrated device अधिक functions include करे.

5.4 Software का साथ-साथ विकास

Machine codes → assembly → higher-level programming, compilers, operating systems, interactive computing. Languages old hardware category पर strictly locked नहीं: current processors भी machine instructions execute करते हैं.

5.5 Comparative Reasoning

Semiconductor integration generally reduced component size और mass production को support किया. Performance improvement केवल clock frequency से नहीं: architecture, caches, parallel execution, fabrication और workload matter. आधुनिक systems पुराने और नए ideas combine कर सकते हैं.

5.6 Exam Traps

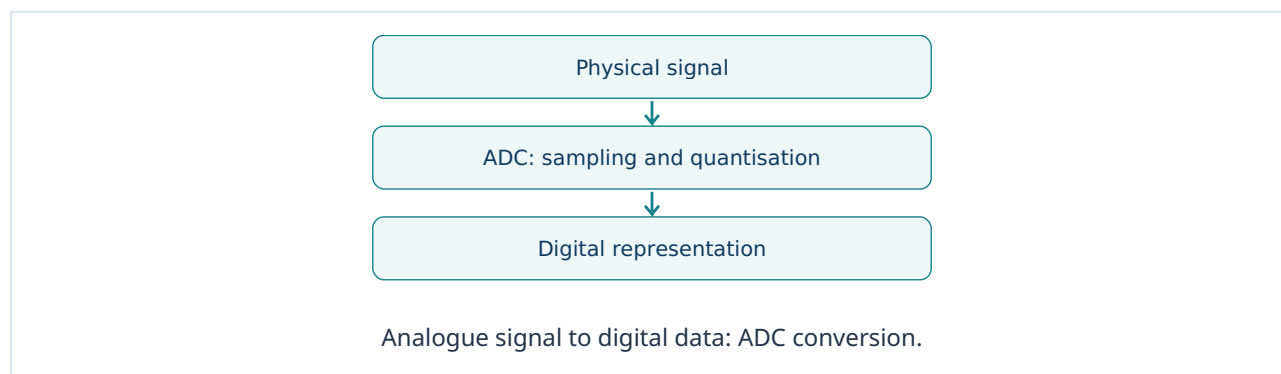
Transistor $\neq$ vacuum tube. IC $\neq$ automatically microprocessor. "Fifth generation means every computer thinks like human" गलत. "All first generation computers have exact same memory" गलत. Example dates approximate ranges as per course text; this book prioritizes dominant technology and concept.

Practice: Which generation commonly associated with microprocessor? Fourth. Which category uses IC as dominant distinction? Third. Why are year boundaries approximate?

UNIT 1 / CHAPTER 06

अध्याय 6: Types of Computers, Digital एवं Analogue

Data representation, purpose और workload



6.1 Analogue Computer

Analogue computation continuously varying physical quantities—voltage, mechanical displacement—से values/model represent करती है। Differential equations की physical simulation जैसे historical applications रहे हैं। Precision components/noise/calibration से limited होती है।

6.2 Digital Computer

Digital system discrete symbols/states पर operate करती है; binary encoding common है। General-purpose laptop digital computer है। Digital physical signals भी real continuous voltage हैं, लेकिन circuits उन्हें discrete logic ranges के रूप में interpret करते हैं।

6.3 Hybrid Systems

Hybrid arrangements analogue sensing/modeling और digital processing combine करती हैं। Hospital monitor में analogue sensor signal ADC से digital samples बनाता है, फिर software analyzes/displays. “Sensor analogue है इसलिए पूरा system केवल analogue computer” निष्कर्ष सही नहीं।

Aspect	Analogue	Digital
Representation	Continuous modeled quantities	Discrete encoded symbols
Error factors	Noise/calibration	Quantization, software, hardware errors
Programming/use	Often specialized physical model	Flexible instruction-based tasks
Example	Analogue simulation circuit	PC, digital embedded controller

6.4 Purpose एवं Capacity Classes

General-purpose systems multiple workloads software से perform करते हैं. Special-purpose systems defined task के लिए designed हो सकते हैं. Microcomputer/PC, workstation, server, mainframe, supercomputer और embedded computer terms roles तथा historical market categories बताते हैं—not strict universal size/speed ranking.

Mainframes transaction throughput, reliability और large organizational workloads focus कर सकते हैं. Supercomputers scientific parallel calculations focus करते हैं. Server network services देता है; small machine भी server हो सकती है. Smartphone भी digital programmable computer है.

6.5 ADC और DAC

ADC analogue signal sample/quantize करके digital code बनाता है. DAC digital code से analogue output level/waveform produce करता है. More bits improve possible amplitude levels but do not alone fix noise or sampling rate.

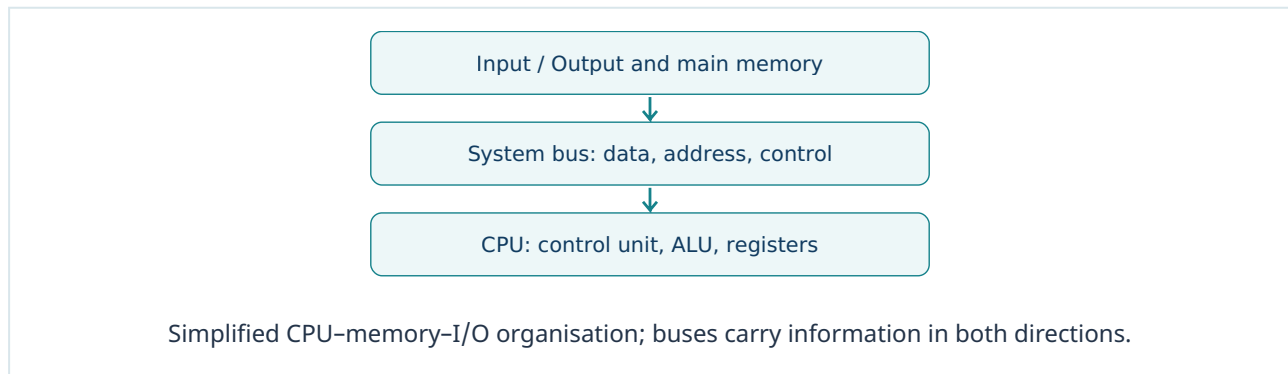
Numerical: 8-bit unsigned ADC has 256 possible codes 0..255. 10-bit has 1024 codes. Voltage per step depends full-scale convention; simplistic full-range/ 2^n model को stated assumption के साथ use करें.

Practice: Scientific cluster, bank transaction platform, washing machine controller और desktop classify करें; overlap possible है.

UNIT 1 / CHAPTER 07

अध्याय 7: Major Components, CPU Block Diagram एवं Instruction Cycle

ALU, Control Unit, registers और buses



7.1 Functional Block View

Input → processing/storage → output. CPU instructions execute करता है, main memory active instructions/data रखती है, I/O devices external interaction देते हैं. Diagram logical functions दिखाता है; actual system topology अधिक complex हो सकती है.

7.2 CPU Components

Component	Function
ALU	Arithmetic and logical operations
Control Unit	Instruction interpretation/control sequencing
Registers	Small fast CPU-local state/data locations
Program Counter (PC)	Next instruction address conceptually
Instruction Register (IR)	Current instruction representation
Status/flags	Carry, zero, sign आदि architecture-specific conditions

Accumulator, general-purpose registers, stack pointer आदि architecture-specific. Every CPU exactly same register set नहीं रखता.

7.3 Buses

Address bus logical location select करता है। Data bus transfer payload carries. Control signals read/write, timing/status आदि coordinate करती हैं। A basic diagram अक्सर CPU→memory address और bidirectional data दिखाता है। Modern interfaces multiplex signals, packet links, caches and controllers use कर सकती हैं।

7.4 Fetch-Decode-Execute

1. PC से instruction location determine.
2. Fetch instruction into execution pipeline/state.
3. Decode opcode and operands.
4. Fetch operands as needed.
5. Execute ALU/control/I/O operation.
6. Store result/update flags and next PC.

यह simplified cycle है; real pipe lining/out-of-order execution multiple instructions overlap कर सकती है। Instruction count, cycles per instruction और clockrate अलग measures हैं।

7.5 Worked Example

Conceptual instruction **ADD R1, R2**: read values R1=5, R2=7; ALU calculates 12; write R1=12 under this chosen convention. Different instruction sets destination format बदल सकती हैं। **LOAD** reads memory, **STORE** writes memory, branch changes next instruction address.

7.6 CPU versus Whole Computer

CPU alone display, keyboard और long-term storage नहीं। System includes memory, interfaces, power, and software. CPU clock GHz cycles per second; program completion speed instructions/workload, caches, parallelism and I/O wait से प्रभावित।

Numerical: 2GHz = 2×10^9 cycles/second. If simplified program has 10^8 instructions, average CPI 2 and clock 2GHz, CPU time = $(10^8 \times 2) / (2 \times 10^9) = 0.1$ s. Model ignores other elapsed time.

Exam point: ALU computes, CU coordinates, registers hold fast local state. Main memory और secondary storage CPU registers से अलग हैं।

Practice: Draw CPU with ALU, CU, registers plus memory and input/output; describe instruction cycle stepwise.

UNIT 1 / CHAPTER 08

अध्याय 8: Memory Addressing Capability of CPU

Address width, data width और addressable units

8.1 What is an Address?

Memory address location identifier है; content value अलग है. CPU generated address memory system translate/check कर सकता है. Physical addresses actual memory resource identify; virtual addresses process view represent. Advanced MMU details Unit III में हैं.

8.2 Address Lines Formula

n independent address bits give 2^n distinct addresses. Capacity = $2^n \times \text{size of addressable unit}$. **Byte-addressable** system unit 1 byte; word-addressable unit several bytes. Data bus width और address width अलग parameters हैं.

Assumption	Address count	Capacity
16-bit address, byte unit	65,536	64KiB
20-bit address, byte unit	1,048,576	1MiB
32-bit address, byte unit	4,294,967,296	4GiB
16-bit address, 2-byte word unit	65,536	128KiB

KiB = 1024 bytes, MiB = 1024², GiB = 1024³. Decimal KB/MB/GB conventions different; use units explicitly.

8.3 Data Width

8-bit data bus may transfer 1 byte per basic transfer; 16-bit 2 bytes, under parallel full-width assumptions. A wider address bus does not automatically mean wider each data word. Processor marketing "64-bit" often register/ISA width; actual physical address bits maybe smaller than 64.

8.4 Address Range Numerical

16-bit unsigned address range 0..65535. Last byte's address 65535 but total bytes 65536; endpoints inclusive. 8 address bits range 0..255, total 256 locations. If each location 4 bytes, capacity 1024 bytes.

8.5 Installed versus Theoretical Memory

Addressable maximum $\neq$ installed RAM. Some address regions map I/O, firmware or reserved resources. Virtual address space $\neq$ current physical RAM. Actual OS/processor/platform limit additionally matter.

8.6 Solve by Assumptions

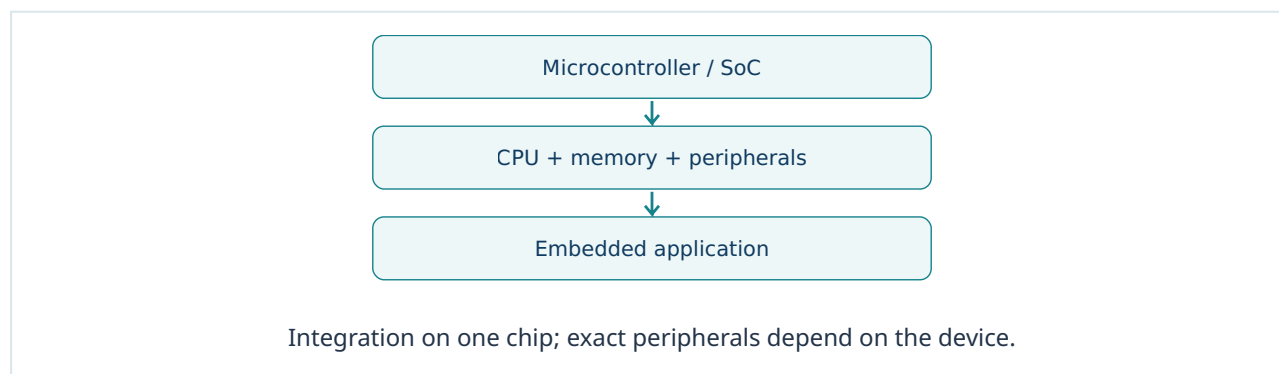
Identify address bits → calculate locations → identify byte/word unit → multiply → convert units. If question only says “16-bit CPU”, memory capacity cannot always infer without address width/unit.

Practice: 24-bit byte address space = 16 MiB. 10 address bits × 8 bits/location = 1024 bytes = 1 KiB. Need address bits for 4096 locations? 12.

UNIT 1 / CHAPTER 09

अध्याय 9: Microprocessors एवं Single-chip Microcomputers

CPU chip और integrated control system



9.1 Microprocessor

Microprocessor CPU functions in semiconductor chip implement करता है। It executes instruction set, manipulates registers, performs computations, and communicates with memory/I/O. A basic microprocessor system external RAM/ROM/interface circuits require कर सकता है।

9.2 Microcomputer

Microcomputer microprocessor-based computer system है: CPU, memory, I/O, interconnections and support software. Desktop historically microcomputer category में है। Microprocessor = chip function; microcomputer = system.

9.3 Single-chip Microcomputer / Microcontroller

Single-chip microcomputer terminology commonly integrated microcontroller-like organization दर्शाती है: CPU plus on-chip memory, I/O, timers and controllers. All features, e.g. ADC/networking, every device में mandatory नहीं। Chapter 21 device control details देता है।

Feature	General microprocessor view	Microcontroller view
Main focus	Flexible computation/performance	Embedded control/integration
Memory/I/O	External plus integrated features possible	Often on-chip RAM/flash/GPIO
System	PC/server/complex embedded	Appliance, sensor, control board
Power/cost	Depends chip/workload	Often optimized small control

Modern SoCs blur these categories: CPU cores, memory controllers, graphics, interfaces can integrate. Do not claim microprocessors never have integrated peripherals.

9.4 Simple Embedded Example

Temperature controller: sensor→ADC/digital interface→CPU control algorithm→output pin→fan/relay driver. Firmware stored flash, working state RAM, timers schedule measurements. Output pin should not directly drive high-power load without appropriate electrical interface.

9.5 Instruction Execution एवं Firmware

Firmware defines control behavior; changing program can change function within hardware limits. Clock/reset inputs establish operation; interrupt signals respond to events. Flash storage is nonvolatile but programmed updates possible.

Practice: Label CPU, memory, input, output in appliance control system. Why is “micro” not guarantee of low capability? Why does one chip not necessarily contain entire physical device?

UNIT 1 / CHAPTER 10

अध्याय 10: Hardware, Software, Firmware एवं User Interfaces

Physical components और instructions की layers

10.1 Hardware

CPU, RAM, SSD, keyboard, monitor और circuit boards hardware हैं। Hardware stores/transforms physical signals. Hardware capability useful only with instructions, configuration and reliable I/O.

10.2 Software Types

Type	Purpose	Example
System software	Platform/resource management	OS, drivers
Application software	User task	Word processor, browser
Utilities	Maintenance/support	Backup, compression tools
Language translators	Source processing	Compiler, assembler, interpreter

Classification can overlap: utility may be bundled with OS. Compiler translates program representation; interpreter executes according to language implementation. Some systems combine compilation and interpretation.

10.3 Firmware

Firmware software closely tied to device operation, commonly stored in nonvolatile memory. BIOS/UEFI implementations, printer control code, microcontroller programs examples. Firmware is hardware-independent physical chip नहीं; it is code/content. Firmware can be updatable; “permanently unchangeable” wrong generalization.

10.4 User Interfaces

CLI typed commands; GUI graphical windows/icons/menus; menu-driven selectable options; touch/gesture/voice alternative interactions. GUI easy visual navigation देता है; CLI scripting/repetition powerful है. Choice user/task/accessibility पर depend करती है.

10.5 Driver एवं Interface Layers

Device driver OS को device control protocol/interface देता है. App print request → OS spool/driver → controller → printer. External connectors physical interfaces हैं; API software interface है; user interface human interaction layer. “Interface” context से define करें.

10.6 Example Work flow

User chooses Save in word processor(GUI)→application requests file write→OS filesystem handles path/permissions→storage driver/controller writes data→SSD firmware manages internal storage. All layers same object नहीं.

Exam point: Firmware software का special role है, RAM/ROM chip की definition नहीं. GUI operating system नहीं; OS एक या कई interface types दे सकता है.

Practice: Classify keyboard, editor, printer driver, UEFI code and command prompt. Explain hardware–software interdependence in one example.

UNIT 1 / CHAPTER 11

अध्याय 11: Number Systems एवं Base Conversion

Decimal, binary, octal और hexadecimal

11.1 Positional Formula

Base b positional number's value $\sum \text{digit} \times b^{\text{position}}$. Valid digits $0..b-1$. Decimal base 10; binary 2; octal 8; hex 16 (0..9, A..F). Subscript/base-label necessary when ambiguous.

11.2 Binary to Decimal

$101101_2 = 1 \times 32 + 0 \times 16 + 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1 = 45_{10}$. Binary fraction $0.101_2 = 1/2 + 0/4 + 1/8 = 0.625_{10}$. Fraction positions negative powers.

11.3 Decimal Integer to Binary

Repeated divide by 2; collect remainders; read bottom-to-top.

Division	Quotient	Remainder
$45 \div 2$	22	1
$22 \div 2$	11	0
$11 \div 2$	5	1
$5 \div 2$	2	1
$2 \div 2$	1	0
$1 \div 2$	0	1

Result 101101_2 . For zero, result 0. Repeated divide by b generalizes octal/hex.

11.4 Fraction Conversion

Multiply fraction by 2; integer part next bit.

For $0.625 \times 2 = 1.25 \rightarrow 1$; remaining $0.25 \times 2 = 0.5 \rightarrow 0$; remaining $0.5 \times 2 = 1.0 \rightarrow 1$. Thus 0.101_2 . Some fractions, e.g. decimal 0.1, repeat in binary; finite bit storage may round.

11.5 Grouping Shortcuts

3 binary bits $\leftrightarrow$ one octal digit; 4 bits $\leftrightarrow$ one hex digit. Group integer part from right, fraction from left; pad zeros if needed.

$101101_2 = 101 | 101 \rightarrow 55_8$; hex $0010 | 1101 \rightarrow 2D_{16}$. Check $2D = 2 \times 16 + 13 = 45$.
Fractions $0.101_2 \rightarrow 0.1010_2 \rightarrow 0.A_{16} = 10/16 = 0.625$.

11.6 Octal/Hex Examples

$157_8 = 1 \times 64 + 5 \times 8 + 7 = 111_{10}$. $3A_{16} = 3 \times 16 + 10 = 58_{10}$. Octal digit 8 invalid; binary digit 2 invalid.
Hex $10_{16} = 16_{10}$, not 10_{10} .

Practice: $25_{10} = 11001_2 = 31_8 = 19_{16}$. $1111_2 = 15_{10} = F_{16}$. $0.25_{10} = 0.01_2$.

UNIT 1 / CHAPTER 12

अध्याय 12: Computer Codes, Binary Arithmetic एवं Complements

Number representation और symbol encoding

12.1 Binary Arithmetic

Addition rules $0+0=0$, $0+1=1$, $1+1=10_2$ (carry 1), $1+1+1=11_2$. Example $1011_2 + 0110_2 = 10001_2$ ($11+6=17$). Subtraction requires borrowing: $1010_2 - 0011_2 = 0111_2$ ($10-3=7$).

12.2 Fixed-width Signed Forms

Representation	4-bit example -5	Notes
Sign-magnitude	1101	Sign bit +magnitude; ± 0
Ones' complement	1010	Invert +5 = 0101; ± 0
Twos' complement	1011	Invert and add 1; one zero

n-bit two's complement range $-2^{(n-1)}..2^{(n-1)}-1$. 8-bit -128..127. Unsigned n-bit $0..2^n-1$. Same bit string different interpretation possible: 11111111 unsigned 255, signed 8-bit -1.

12.3 Twos' Complement Worked Example

8-bit +5 = 00000101 → invert 11111010 → add 1 → **11111011** represents -5. $00000101 + 11111011 = 100000000$; discard carry outside 8 bits → 0. Carryout and signed overflow different conditions.

4-bit $7+3$: $0111 + 0011 = 1010$. Unsigned result 10 fits 4 bits; signed system expected 10 outside range -8..7, stored pattern interprets -6 → signed overflow.

12.4 BCD एवं Gray Code

BCD decimal digit separately 4 bits: 59 → 0101 1001. Pure binary 59 → 00111011. BCD valid digit codes 0000..1001; 1010..1111 not valid decimal digits. BCD not always most compact.

Gray code adjacent ordered codes differ one bit, useful some position-sensing applications. Binary to Gray $g = b \oplus (b \gg 1)$. Example binary 1011 → XOR 0101 = 1110. Gray code नहीं है ordinary positional binary value; conversion needed for arithmetic interpretation.

12.5 Character Codes

ASCII basic 7-bit 128 codes. Unicode assigns characters codepoints; UTF-8/UTF-16 are encoding forms. Unicode is not universally "16 bits per character." UTF-8 variable length; codepoint, grapheme and byte counts differ. Text "ABC" has 3 ASCII-compatible UTF-8 bytes; Devanagari text needs encoding-aware processing.

Code	Use	Trap
Binary number	Arithmetic value	Signed width unspecified
BCD	Decimal digit representation	Confuse with whole value binary
Gray	Adjacent state encoding	Treat as ordinary binary
ASCII	Small character repertoire	Assume all languages
Unicode+UTF	Multilingual text	Codepoint=displayed glyph=byte always

Practice: 8-bit -12=11110100. BCD12=0001 0010, binary12=1100. 0101+0011=1000:4-bit signed overflow though unsigned8valid.

UNIT 1 / CHAPTER 13

अध्याय 13: Unit I Revision एवं Test

Consolidation / 30 MCQs with Answers

A. पढ़ने के बाद स्वयं समझाएँ

1. IKS representations और modern analogies को evidence के साथ अलग करें.
2. CPU, address/data width, processor और integrated system roles compare करें.
3. Base conversions, complements, BCD और Unicode distinctions solve करें.

B. Unit Test: 30 Questions

हर प्रश्न का एक best answer है. Key देखने से पहले स्वयं solve करें.

1. Decimal place value में 507 का 0 क्या दर्शाता है? A. Tens position empty B. Number has no value C. Binary digit D. Always negative
2. Bhūta-Saṅkhyā का आधार? A. File permissions B. Meaning-based numerical associations C. CPU instructions only D. Voltage levels only
3. Units-first चन्द्र-नेत्र-वेद teaching code का number? A. 7 B. 412 C. 421 D. 124
4. Kaṭapayādi chiefly uses? A. Only physical keys B. Memory pages C. Printer pins D. Consonant-to-digit mapping
5. Modern L/G teaching mapping में n positions के patterns? A. 2^n B. n^2 always C. $n-1$ D. $n/2$
6. Śulba approximation $577/408$ किसके करीब है? A. Zero B. $\sqrt{2}$ C. π exactly D. $\sqrt{3}$ exactly
7. Square का area double करने पर side factor? A. 4 B. $1/2$ C. $\sqrt{2}$ D. 2
8. ENIAC public introduction milestone year? A. 1985 B. 1971 C. 2001 D. 1946
9. Manchester Baby stored-program milestone? A. 1948 B. 2021 C. 1995 D. 1830
10. Vacuum tubes textbook generation? A. Fifth only B. First C. Third D. Fourth
11. Transistors dominant distinction? A. Fourth only B. No generation C. Second generation D. First only
12. Microprocessors commonly generation? A. First B. Second C. Third only D. Fourth
13. Analogue representation emphasizes? A. Continuously varying modeled quantities B. Only alphabet strings C. Only Unicode D. Always discrete binary symbols
14. Hybrid sensor system may combine? A. No instructions B. Analogue sensing and digital processing C. Only printed paper D. No conversion
15. Arithmetic/logical CPU block? A. SSD filesystem B. Monitor panel C. ALU D. Keyboard
16. Control Unit chiefly? A. Prints physical paper B. Replaces all RAM C. Converts file extensions D. Coordinates instruction execution
17. Program Counter conceptually holds? A. Next instruction address B. All user files C. Current printer speed D. Screen diagonal
18. 20-bit byte address space? A. 1GiB B. 1MiB C. 20bytes D. 2MiB
19. 32-bit byte addressing theoretical capacity? A. 4MiB B. 32GiB C. 4GiB D. 32bytes

20. 16 address bits with 2-byte unit? A. 64bytes B. 16KiB C. 32GiB D. 128KiB
21. Firmware is chiefly? A. Device-related software B. Only metal chip case C. Always unchangeable hardware D. Screen-only image
22. GUI expands? A. Graph Unit Index B. Graphical User Interface C. General Unit Instruction D. Global USB Input
23. 101101_2 decimal? A. 29 B. 101101 C. 45 D. 55
24. 157_8 decimal? A. 157 B. 87 C. 64 D. 111
25. $3A_{16}$ decimal? A. 58 B. 310 C. 36 D. 48
26. 0.101_2 decimal? A. 0.25 B. 0.625 C. 0.101 D. 0.5
27. BCD59 representation? A. 1111 1111 B. 1001 0101 C. 0101 1001 D. 00111011
28. 8-bit twos complement -5? A. 00000101 B. 11111010 C. 10000101 D. 11111011
29. Unicode versus UTF-8? A. Codepoints versus encoding form B. Both always 7-bit C. Both hardware ports D. Identical fixed-byte scheme
30. CPU address width and data width are? A. No relation to design B. Distinct properties C. Always identical D. Both printer DPI

C. Answer Key

1-A, 2-B, 3-C, 4-D, 5-A, 6-B, 7-C, 8-D, 9-A, 10-B, 11-C, 12-D, 13-A, 14-B, 15-C, 16-D, 17-A, 18-B, 19-C, 20-D, 21-A, 22-B, 23-C, 24-D, 25-A, 26-B, 27-C, 28-D, 29-A, 30-B.

D. 5-mark / 10-mark Preparation

1. Bhūta-Saṅkhyā, Kaṭapayādi और Piṅgala patterns with examples.
2. Śulba approximation: formula, error and geometry application.
3. Computer history/generations तथा analogue/digital classification.
4. CPU block diagram, instruction cycle, address capacity numericals.
5. Hardware/software/firmware/UI with layered work flow.
6. Base conversion, binary arithmetic, complements, codes with worked examples.

E. Practical / Solved Check

Convert 45 decimal into binary/octal and hex; decode units-first teaching words; draw CPU block; compare 16-bit byte-addressable and 16-bit 2-byte-word addressable capacity.
Expected $45_{10} = 101101_2 = 55_8 = 2D_{16}$; capacities 64KiB and 128KiB.

UNIT 2 / CHAPTER 14

अध्याय 14: Keyboard, Mouse एवं Input Devices

UNIT II • Peripheral Devices and I/O Organization

14.1 Peripheral क्या है?

Peripheral computer के input, output, storage या communication functions में सहायता करने वाला device है। Internal और external दोनों arrangements हो सकते हैं। Input device physical action/signal को system-readable representation में बदलता है। Keyboard text/control input और mouse pointing input के common examples हैं।

14.2 Keyboard का Working

Key press switch/contact changes पैदा करता है। Keyboard controller key matrix scan/de bounce कर सकता है और key information host को भेजता है। OS layout और modifiers से interpretation करता है। Physical key code और resulting character एक ही thing नहीं: Shift+A, language layout और shortcuts परिणाम बदलते हैं।

Key group	Typical function
Alphanumeric	Letters, digits, punctuation
Function keys	Application-defined actions
Modifier	Shift, Ctrl, Alt combinations
Navigation	Arrows, Home, End, Page keys
Editing/control	Enter, Backspace, Delete, Escape
Numeric keypad	Convenient number entry, mode-dependent

Membrane और mechanical switch designs अलग tactile/noise characteristics दे सकते हैं। Wired/wireless connection और ergonomic layout physical design choices हैं, instruction-set classifications नहीं।

14.3 Mouse और Related Pointing Devices

Optical mouse surface images से motion estimates बनाती है; older mechanical mouse ball/rollers उपयोग करती थी। Buttons selection/actions; wheel scrolling. Mouse displacement, pointer speed settings और screen coordinates अलग quantities हैं। DPI label स्वयं task accuracy की guarantee नहीं।

Track ball stationary body में ball rotate करके input देती है। Touchpad finger gestures और relative positioning supports करती है। Touchscreen surface position input देती है और display output भी है; यह combined input/output device है।

14.4 Human Action से Application Event

Press/click → device report → driver/OS event → focused application behavior. Double click, right-click/context menu और drag application conventions हैं। Focus महत्वपूर्ण है; command intended application में ही पहुँचे।

14.5 Other Inputs एवं Accessibility

Microphone audio, camera images, barcode reader product identifiers, biometric scanner features capture कर सकता है। Screen reader primarily output/accessibility software है; switch input, alternate keyboard और voice input users की diverse needs support करते हैं। Devices को केवल appearance से input/output classify न करें।

Practice: Keyboard, touchpad, microphone, touchscreen, printer classify करें। Explain why key press और typed Unicode character अलग stages हैं।

UNIT 2 / CHAPTER 15

अध्याय 15: Monitors एवं Display Technology

Visual output, resolution और refresh

15.1 Monitor Output

Display pixel patterns से text/images दिखाता है। Pixel logical image element है; physical display sub pixels/color arrangement अलग हो सकती है। Resolution horizontal×vertical pixel count, e.g. 1920×1080. Diagonal screen size inches में हो सकती है; resolution उससे independently specified है।

15.2 CRT, LCD और OLED

Technology	Basic idea	Study point
CRT	Electron beam and phosphor screen	Historical bulky display
LCD	Liquid-crystal light modulation	Needs light source
LED-backlit LCD	LCD with LED illumination	LED label often backlight, not OLED
OLED	Organic light-emitting elements	Emissive pixels; distinct from LCD

LCD panel variations और display engineering details beyond this basic syllabus हैं। किसी one technology को every situation में perfect न मारें: power, brightness, viewing conditions और implementation matter.

15.3 Resolution Numerical

1920×1080=2,073,600 pixels. Uncompressed single RGB frame at 24bits/pixel =2,073,600×3=6,220,800 bytes≈5.93MiB. Actual display link adds timing/encoding overhead; compressed video size अलग.

15.4 Refresh versus Response

Refresh rate Hz = frames/updates per second supported by chosen mode. Response time pixel transition characteristic, not identical to refresh period. At 60Hz one cycle≈16.67ms; at 120Hz≈8.33ms. Delivered frame rate application/GPU और link capability पर depend करती है।

15.5 Colour Representation

RGB combines red, green, blue components. With 8bits each channel, 24-bit theoretical combinations=2²⁴=16,777,216. This is code-space count, not guarantee कि viewer हर combination distinguish करे या display every colour accurately reproduce करे.

15.6 Interfaces एवं Practical Points

Monitor may connect via suitable graphics interface; connector capabilities, cable और selected mode मिलकर output determine करते हैं. Display adapter renders image; monitor shows it. Scanner captures an existing image, monitor displays processed representation.

10-mark answer: Definition → block working → CRT/LCD/OLED comparison → resolution/pixel/refresh concepts → numerical → interface considerations.

Practice: 1280×720 RGB24 frame size 2,764,800 bytes. Larger physical monitor necessarily higher resolution? No.

UNIT 2 / CHAPTER 16

अध्याय 16: Printers, Plotters एवं Hard-copy Output

Impact और non-impact methods

16.1 Printing का उद्देश्य

Printer computer representation को paper/other medium पर output देता है। Hard copy physical output; soft copy screen/file representation. Print quality dpi, text/image processing, medium, colour handling और device mechanics पर depend करती है। Ppm/cps और duty cycle अलग measurements हैं।

16.2 Impact Printers

Impact printer mechanical strike/ribbon contact से marks बनाता है। Dot-matrix print head pins dots create करती हैं; historical daisy-wheel character mechanism shapes देता है। Impact arrangements multi part forms पर useful हो सकती हैं; noise और image/text flexibility limitations होती हैं।

16.3 Non-impact Printers

Type	Principle	Typical point
Inkjet	Small ink droplets placed on medium	Colour/image printing
Laser	Electrostatic image, toner transfer/fusing	Page-based text/graphics
Thermal	Heat-sensitive medium or transfer ribbon	Receipts/labels, design-dependent

Laser beam सीधे paper को ordinary writing की तरह burn नहीं करता; photoconductive/electrostatic process और toner major elements हैं। Thermal designs direct thermal और thermal transfer अलग हो सकती हैं।

16.4 Dot Matrix versus Laser

Dot matrix impact, pin/ribbon mechanism, often noisy; laser non-impact, toner/page imaging, generally fine text. Exact speed, cost, colour और durability product-dependent हैं। “Non-impact में कोई mechanical movement नहीं” गलत: rollers और moving parts हो सकते हैं, distinction marking strike का है।

16.5 Plotters

Plotter traditionally drawing/engineering output controlled tracing/pen movement से देता था। Modern large-format devices may use inkjet-style printing. CAD maps, architectural drawings और large graphics common examples. “Plotter always faster/better than every printer” unsupported generalization है।

16.6 Spooling और Work flow

Application print request → queued/spooled job → driver rendering → device interface → print engine. Spooling CPU/application को print completion तक synchronously wait करने से बचा सकता है. Printer buffer और disk-based spool different storage layers हैं.

Numerical: A simplified 30ppm sustained printer 50 pages में $50/30 \approx 1.67$ min marking time लेता है; first-page delay, duplex, network wait अलग हैं. Dpi is dots/inch; ppm is pages/minute.

Practice: Multi part carbon-style forms किस technology से compatible हो सकती हैं? Impact. Touchscreen और printed report soft/hard output classify करें.

UNIT 2 / CHAPTER 17

अध्याय 17: Scanners एवं Other I/O Devices

Optical capture, audio और specialised input

17.1 Scanner Working

Scanner document illumination और optical sensors से reflected light samples लेकर digital image बनाता है। Flatbed scanner document glass पर रखता है; sheet-fed scanner page transport करता है। Image capture और OCR अलग stages हैं: scan gives pixels; OCR recognizes text with possible errors.

17.2 Scanner Measures

Optical resolution physical capture detail; interpolated resolution software-generated samples हो सकती है। Colour depth possible tonal codes. Scan speed, page size and automatic document feeder properties workload affect करती हैं।

Numerical: 8×10inch area at300dpi →2400×3000=7,200,000 pixels. RGB24 uncompressed=21,600,000bytes≈20.60MiB, excluding headers/padding/compression. At600dpi both dimensions double, pixels4times.

17.3 Input-specialisation Comparison

Device/process	Main purpose
OCR	Recognise characters from image
OMR	Detect marked positions/bubbles
MICR	Magnetic-ink character reading
Barcode/QR reader	Decode structured visual identifiers
Camera	Capture image/video
Microphone	Capture audio signal

OCR, OMR और MICR interchangeable नहीं। Recognition accuracy document quality, alignment, illumination and processing पर depend करती है। OMR examination marks reading को handwritten essay OCR से अलग समझें।

17.4 Audio I/O

Microphone analogue electrical signal→ADC/digital interface→stored samples. Speaker output often DAC/amplifier path से physical sound बनता है। Sample rate Hz samples/second; bit depth amplitude-code precision; channels mono/stereo etc.

Numerical: PCM mono8kHz, 16bits/sample: $8000 \times 16 = 128,000 \text{ bit/s} = 16,000 \text{ byte/s}$.
 $60 \text{ seconds} = 960,000 \text{ bytes}$, before container/compression. Stereo doubles raw sample payload.

17.5 Other Output एवं Bidirectional Devices

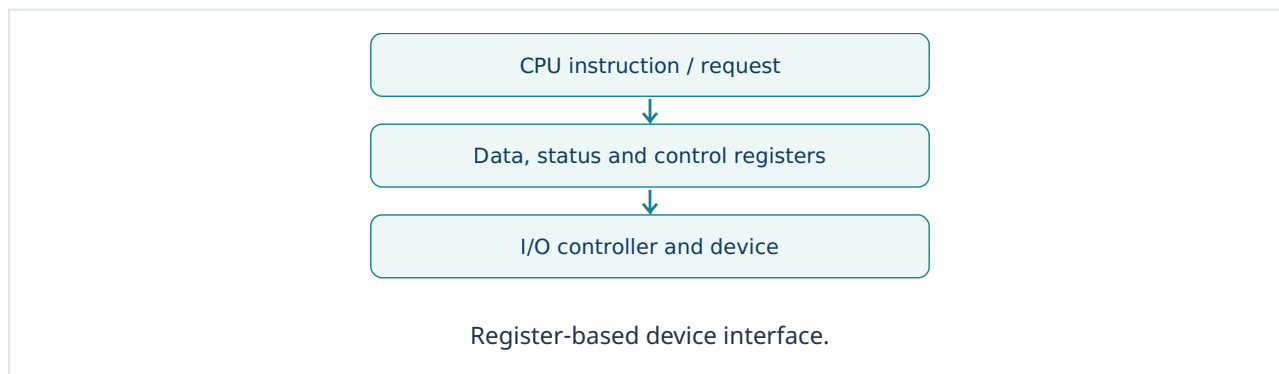
Projector visual display; speakers audio output. Network interface sends/receives data; storage reads/writes; touchscreen has display+touch input. A multi function printer can include scanner, printer and network I/O; classify functions separately.

Practice: Scanner image automatically editable text? No, OCR needed. $300 \rightarrow 600 \text{ dpi}$ size factor 4, assuming unchanged area/depth. Match OCR, OMR, MICR with their applications.

UNIT 2 / CHAPTER 18

अध्याय 18: I/O Ports, Programmable एवं Fixed-function Interfaces

Physical connector और logical port का अंतर



18.1 Two Meanings of Port

Physical port connector/interface है, e.g.USB socket. Logical I/O port CPU/controller addressed register interface हो सकता है. Network port number तीसरा software communication meaning है. इस chapter का focus device interface और hardware I/O registers है.

18.2 I/O Register Roles

Data register payload रखता है; status register ready/busy/error flags; control register mode, enable/command/settings. CPU/device coordination ensures ready data read और valid writes. One physical connector कई logical registers/controllers से supported हो सकता है.

18.3 Programmable versus Non-programmable Port

Programmable interface software configuration से direction, mode/handshake functions choose कर सकती है; classic8255PPI historical example है. Fixed-function/non-programmable interface data flow roles hard wired हो सकते हैं. “Non-programmable” का अर्थ CPU उससे read/write नहींकर सकता ऐसा नहीं; configurable mode capability का distinction है.

18.4 Memory-mapped एवं Isolated I/O

Scheme	Addressing idea
Memory-mapped I/O	Device registers occupy memory address space
Isolated/port-mapped I/O	Separate I/O address space/instructions on architectures supporting it

Register access ordinary RAM access जैसा semantically नहीं: read may acknowledge event, write can trigger action, repeated access side effects possible. OS/drivers hardware ordering/protection handle करते हैं.

18.5 Programmed I/O Distinction

“Programmed I/O” CPU-controlled data transfer method है; “programmable port” configurable hardware interface है. Similar words पर अलग concepts. Programmed polling checks status repeatedly; interrupt-driven I/O signals CPU when service needed; DMA large data transfers offloads CPU's per-item copy.

18.6 Worked Handshake

Input device captures byte→sets ready; CPU reads status→reads data when ready; interface clears/acknowledges ready as protocol requires. Without coordination CPU stale/invalid data read कर सकती है. Actual timing details controller-specific हैं.

Practice: Define physical USB port versus memory-mapped status register. Compare mode programmability and CPU-driven polling. Draw data/status/control register view.

UNIT 2 / CHAPTER 19

अध्याय 19: Parallel, Serial एवं Data Transfer Schemes

Bits, timing, polling, interrupts और DMA

19.1 Parallel Transfer

Multiple bits separate paths पर simultaneously sent. Data width 8 can transfer 8 data bits in one basic cycle under chosen interface assumptions. Historical parallel printer ports और internal buses examples. More wires, cross talk and timing skew engineering concerns हैं.

19.2 Serial Transfer

Bits timed sequence में single lane/differential pair पर भेजे जाते हैं; protocol multiple lanes combine कर सकता है. Modern serial interfaces high signaling rates support कर सकती हैं. "Serial हमेशा parallel से slow" गलत; implementation, clock, coding and distance matter.

Aspect	Parallel	Serial
Payload distribution	Multiple bit paths	Sequential bits per lane
Timing challenge	Inter-line skew	Clock recovery/framing
Connector/wire cost	Often more paths	Often fewer per lane
Examples	Legacy printer parallel port	UART, USB, IEEE1394

19.3 Synchronous एवं Asynchronous

Synchronous transfer timing agreed clock/framing relationship उपयोग करता है. Asynchronous UART often start/stop bits और agreed baud rate से characters frames करता है. Asynchronous ≠ "no timing rules." Protocol symbols per second (baud) और bits per second हमेशा same नहीं; simple binary UART case one bit per symbol common है.

19.4 Framing Numerical

UART 8N1: 1 start + 8 data + 0 parity + 1 stop = 10 transmitted bits per 8-bit payload byte. 9600 bit/s line rate → maximum 960 payload bytes/s, assuming continuous frames, no extra overhead. Payload fraction $8/10 = 80\%$.

19.5 Three I/O Schemes

Scheme	CPU participation	Typical point
Polling/programmed	Repeated status check and data operations	Simple, can waste CPU waiting

Scheme	CPU participation	Typical point
Interrupt-driven	Service routine responds to events	CPU can work between requests
DMA	Setup then controller transfers data	Reduces CPU per-item copy cost

DMA does not mean “CPU has no involvement.” CPU/OS configures addresses, length, direction, completion and protection. Interrupt can announce DMA completion. I/O processor can manage higher-level work than basic DMA engine.

19.6 Rate and Time Example

Raw $480\text{Mb/s} \div 8 = 60\text{MB/s}$ theoretical bit/byte conversion. Effective file copy lower due protocol/storage/software overhead. 100MB at 60MB/s ideal $\approx 1.67\text{s}$; not guaranteed USB transfer performance.

Practice: Distinguish CPU busy waiting from interrupt notification. Under 8N1 framing at 115200bit/s , payload 11520bytes/s .

UNIT 2 / CHAPTER 20

अध्याय 20: USB, IEEE 1394, AGP एवं Built-in Ports

Interfaces को version और purpose से समझें

20.1 Universal Serial Bus

USB host-managed serial interface family है; keyboards, mice, storage and many devices connect हो सकते हैं. Device enumeration identifies capabilities; drivers/protocols support actual functions. Hubs extend connections. Hot plug design does not eliminate safe data removal requirements for storage.

20.2 Protocol versus Connector

Type-A, Type-B, Type-C connector forms हैं. USB2.0/3.x protocol versions/capabilities हैं. Type-C reversible connector अकेले highest speed, power or video function guarantee नहीं करता; cable, host, device and mode compatible होने चाहिए. [R10]

Historical nominal data mode	Rate	Meaning
USB2.0 High-Speed	480Mb/s	Signaling mode, not payload guarantee
USB3.x Gen1 / USB5Gbps	5Gb/s	Version labeling may vary

ये selected historical modes हैं, complete current USB catalogue नहीं. 1byte8bits;Gb/s versus GB/s distinguish करें.

20.3 IEEE 1394 / Fire Wire

IEEE1394 serial interface tradition historically digital video, storage and multimedia connections में used रही है. Fire Wire name associated implementations में आता है. Features include appropriate isochronous timing and device communication capabilities; actual rate/version/connector depend interface. इसे parallel printer port या USB connector name न समझें.

20.4 Accelerated Graphics Port

AGP historical internal graphics interface है, developed for graphics bandwidth; Intel's1997platform announcements mark its expansion. It is not external general USB socket. Versions1×, 2×, 4×, 8×historically recognized; modern systems commonly use other graphics interconnects such as PC I Express. Voltage/keying compatibility matters for legacy hardware. [R11]

20.5 Built-in Ports

Motherboard integrated USB, audio, display, network and other interfaces design-dependent हैं। Legacy examples PS/2, serial COM, parallel LPT. “Built-in” integration बताता है; protocol generation नहीं। External adapter physical shape convert कर सकता है, but electrical/protocol support still required.

20.6 Interface Selection Reasoning

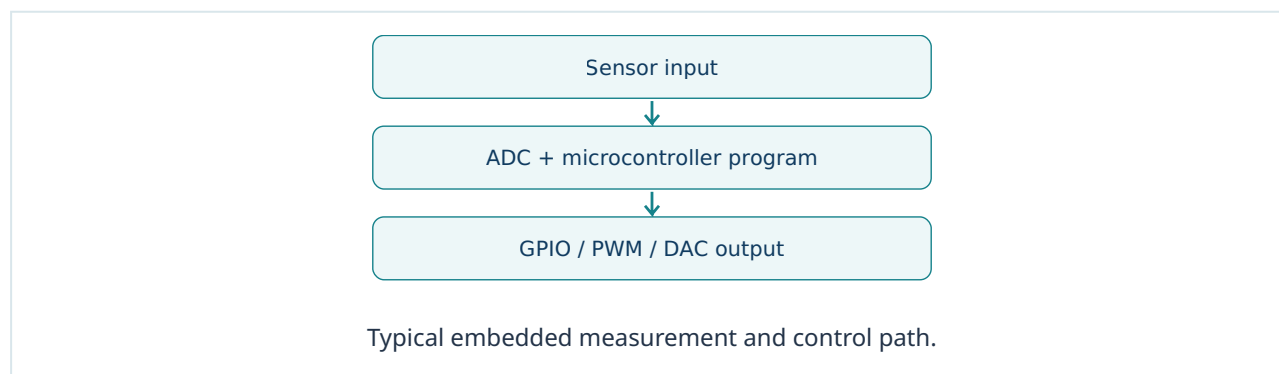
Identify device purpose→host/device protocol match→connector/cable→driver→supported mode. Different-looking connectors could carry related protocol, similar-looking connector could support different capabilities.

Practice: Type-C क्या always USB5Gbps? No. AGP graphics internal interface;IEEE1394serial multimedia interface;USB general peripheral family. Compute $5\text{Gb/s} \div 8 = 625\text{MB/s}$ ideal raw conversion.

UNIT 2 / CHAPTER 21

अध्याय 21: Microcontrollers एवं Embedded Control

On-chip CPU, memory और peripherals



21.1 Architecture

Microcontroller integrated control oriented computer-on-chip arrangement है: CPU, nonvolatile program memory, RAM, GPIO, timers and interrupt controller common features. ADC, DAC, communication controllers optional/design-specific. Every MCU exactly same chip features नहीं.

21.2 Components और Roles

Block	Function
CPU core	Execute instructions
Flash/ROM-type program storage	Firmware retained power off
RAM	Working variables/buffers
GPIO	Digital input/output pins
Timer/counter	Timing, event counts, PW M capabilities
Interrupt controller	Event servicing coordination
ADC, if present	Analog signal measurement

21.3 Closed-loop Example

Desired temperature 25°C. Sensor reading 26°C → controller compares setpoint → fan control action → environment changes → new measurement. Feedback loop continuously updates state. Open-loop fixed timer control has no sensor feedback. This illustrates control concept, not medical/industrial certified design.

21.4 Polling और Interrupt

Polling button status in main loop simple है। Interrupt button/timer event service can reduce waiting; bounce and shared state require handling. IS R small/quick रखकर main logic larger work perform करे—specific platform rules follow करें।

21.5 Resolution Numerical

10-bit ADC 1024 codes; 12-bit 4096 codes. More bits means finer possible code levels, not guaranteed accuracy more without noise/reference/calibration quality. If uniform bin model spans 3.3V over 1024 bins, nominal step $3.3/1024 \approx 3.223\text{m V}$. Endpoint mapping conventions can differ; state assumption.

21.6 MCU versus Microprocessor

MCU often integrates memory/I/O or compact control; general microprocessor systems focus broader processing and external resources. Modern SoCs overlap. Firmware program and physical device interface determine application.

Practice: Sketch sensors → MCU → actuator loop. Give RAM versus flash roles. Why is GPIO output not automatically high-power driver? Electrical ratings/interface matter.

UNIT 2 / CHAPTER 22

अध्याय 22: Signal Processor, I/O Processor एवं Arithmetic Processor

Specialisation और computational offloading

22.1 Digital Signal Processor (DSP)

DSP signal-sample operations जैसे filtering, convolution, audio processing and transforms efficient बनानेकेलिए optimized processor architecture है. Fast multiply-accumulate, buffer addressing and specialized execution features common हो सकती हैं. All DSP devices identical feature list नहीं.

22.2 Simple Filter Numerical

Teaching moving average $y[n] = (x[n] + x[n-1]) / 2$. Assume earlier $x[-1] = 0$. Input[2, 4, 8] → output[1, 3, 6]. Each output two adjacent input values average करता है. Noise/reconstruction effect depends filter and signal; average हर problem का समाधान नहीं.

22.3 I/O Processor (IOP)

IOP/channel processor I/O commands, transfers and device coordination execute करके main CPU से work offload कर सकता है. CPU initiates request; specialised unit manages transfer/control; completion/status returns. Basic DMA copies data with configured parameters; IOP can perform richer command processing. Architectural terminology varies.

22.4 Arithmetic Processor / Co processor

Arithmetic coprocessor specialized numerical operations, especially floating point historically accelerate कर सकता है. Example 8087 with 8086/8088 family historical context. Modern CPUs often integrate FPU/SIMD units rather than external arithmetic chip. ALU, FPU and GPU functional roles different, though workloads overlap.

22.5 Comparison

Processor/unit	Focus	Important distinction
General CPU	Broad instruction/control work	Flexible computation
DSP	Repeated signal numerics	Not only audio device
IOP	Device commands/transfers	Not identical every DMA controller
FPU/arithmetic unit	Numerical arithmetic	Floating point still finite precision
Microcontroller	Integrated embedded control	Includes CPU and peripherals

22.6 Precision and Offload Limits

Floating point approximates many real values; faster unit does not eliminate rounding error. Offloading needs data transfer and synchronization; tiny workloads may not benefit when overhead dominates. Compare task latency, total CPU use and energy within actual system.

Practice: Identify DSP for stream filtering, IOP for device command management, FPU for floating point arithmetic. Show moving average outputs for [4, 6, 10] with prior 0 → [2, 5, 8].

UNIT 2 / CHAPTER 23

अध्याय 23: Unit II Revision एवं Test

Consolidation / 30 MCQs with Answers

A. पढ़ने के बाद स्वयं समझाएँ

1. Device mechanism, input/output role और interface type समझाएँ.
2. Polling, interrupt, DMA तथा programmable port का अंतर बताएँ.
3. Data rates में bits/bytes/framing overhead की assumptions लिखें.

B. Unit Test: 30 Questions

हर प्रश्न का एक best answer है. Key देखने से पहले स्वयं solve करें.

1. Keyboard generally supplies? A. Input B. Only output C. Storage archive D. CPU arithmetic
2. Mouse optical mechanism chiefly estimates? A. Printed dpi B. Surface-relative motion C. File-size compression D. Disk sectors
3. Touchscreen includes? A. Only text encoding B. No sensor C. Input and display output D. Only RAM
4. 1920×1080 count? A. 1920bytes always B. 1080bits always C. 3,000,000pixels D. 2,073,600 pixels
5. 24-bit RGB theoretical combinations? A. 2^{24} B. 24 C. 2^8 D. 3
6. Refresh Hz differs from? A. Display mode parameter B. Pixel response time C. Per second measurement generally D. Frequency concept
7. LED-backlit LCD is necessarily OLED? A. No LCD exists B. Only CRT C. No D. Always yes
8. Dot-matrix printer is usually? A. Laser toner B. OLED display C. Magnetic tape D. Impact
9. Laser marking process uses? A. Electrostatic/toner mechanisms B. Ink-ribbon pin strikes only C. Direct typed magnetic keys D. LCD crystals
10. Dpi chiefly measures? A. Interrupt priority B. Dots per inch C. Pages per minute D. Bits per address
11. Plotter traditional application? A. Memory refresh B. Character encoding only C. Engineering drawings D. CPU scheduling only
12. Scan image to editable text needs? A. Only extension rename B. Always no processing C. MMU bit inversion D. OCR/recognition stage
13. OMR chiefly detects? A. Marked positions B. Only spoken words C. Only magnetic disks D. CPU opcodes
14. MICR related to? A. File copy only B. Magnetic-ink character reading C. Monitor refresh D. Cache tags
15. 300→600dpi same area pixel count factor? A. 1 B. 8 always C. 4 D. 2
16. Mono8kHz PCM16bit raw rate? A. 8,000byte/s B. 128byte/s C. 16byte/s D. 16,000byte/s
17. Physical connector and logical I/O register are? A. Different port meanings B. Always same object C. Both GUI folders D. Both Unicode

18. Programmable port can expose? A. Only printer dpi B. Configurable modes/direction C. No read/write capability D. Only firmware name
19. Programmed I/O and programmable port? A. Both monitor panel types B. Both text codes C. Different concepts D. Always synonyms
20. Memory-mapped I/O places registers in? A. Only filenames B. Only keyboard layout C. Only display pixels D. Memory address space
21. Polling commonly means? A. Repeated status checking B. All work hardware free C. No CPU operations D. Guaranteed no waiting
22. DMA means CPU never involved? A. Only file encryption B. No, setup/control still needed C. Always yes D. No memory transfers
23. 8N1 frame with 8 data bits totals? A. 9 bits B. 16 bits always C. 10 bits D. 8 bits
24. 9600 bit/s under 8N1 maximum payload? A. 1200 bytes/s B. 9600 bytes/s C. 96 bytes/s D. 960 bytes/s
25. Serial always slower than parallel? A. No B. Always yes C. Parallel never exists D. Serial has no timing
26. USB Type-C chiefly specifies? A. Only character encoding B. Connector form C. Guaranteed every speed D. Always AGP
27. USB2 High-Speed nominal rate? A. 48 Gb/s B. 5 GB/s C. 480 Mb/s D. 480 MB/s
28. AGP historical focus? A. Keyboard text code B. Linux directory creation C. Printer ribbons D. Internal graphics interface
29. Microcontroller typically integrates? A. CPU with memory/peripheral functions B. Only display pixels C. No firmware D. Only magnetic platter
30. DSP specialization? A. Only paper printing B. Signal-sample computation C. Only folder renaming D. Only file permissions

C. Answer Key

1-A, 2-B, 3-C, 4-D, 5-A, 6-B, 7-C, 8-D, 9-A, 10-B, 11-C, 12-D, 13-A, 14-B, 15-C, 16-D, 17-A, 18-B, 19-C, 20-D, 21-A, 22-B, 23-C, 24-D, 25-A, 26-B, 27-C, 28-D, 29-A, 30-B.

D. 5-mark / 10-mark Preparation

1. Keyboard/mouse/monitor working and comparison.
2. Impact/non-impact printer, plotter and scanner/OCR distinctions.
3. I/O port structures, programmability and addressing schemes.
4. Parallel/serial, UART framing, polling/interrupt/DMA.
5. USB/IEEE1394/AGP roles, connector/protocol distinction.
6. Microcontroller, DSP, IOP, arithmetic processor with diagrams.

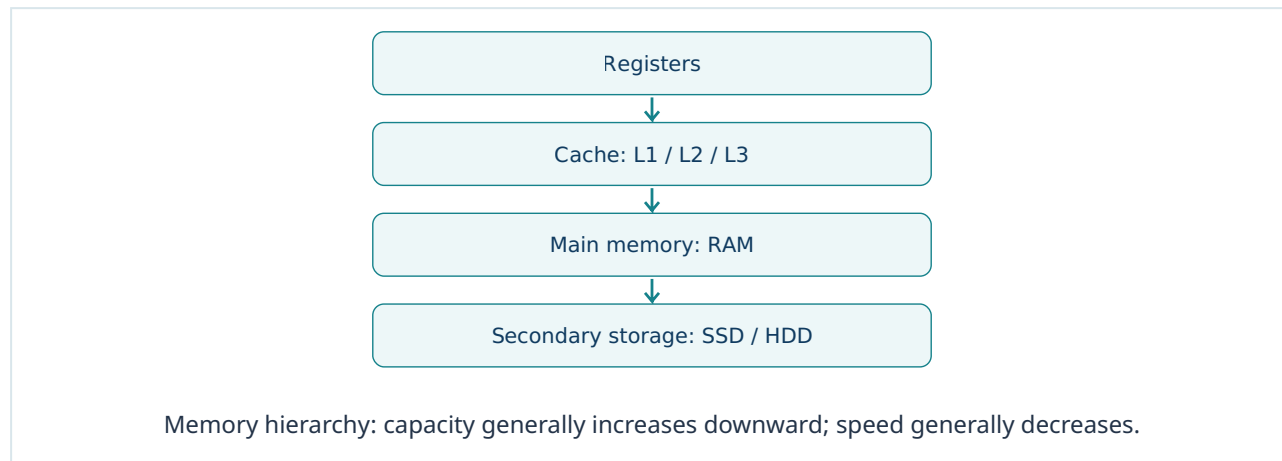
E. Practical / Solved Check

Compute 8N1 payload 9600 bit/s $\rightarrow$ 960 bytes/s; 1920×1080 RGB24 frame 6,220,800 bytes; identify data type/connector/protocol in device list. Explain why raw link rate is not guaranteed file copy rate.

UNIT 3 / CHAPTER 24

अध्याय 24: Memory Hierarchy

UNIT III • Memory and Memory Management



24.1 Hierarchy की आवश्यकता

Computer को fast access और large economical storage दोनों चाहिए. Small fast memory की cost/bit अधिक हो सकती है; large storage की latency अधिक. Hierarchy frequent data को fast levels में रखकर tradeoff manage करती है. सभी data हर level में एक समय duplicate हों यह आवश्यक नहीं.

Level	Typical role	General trend
CPU registers	Current operands/control state	Very small, very fast
Cache L1/L2/L3	Recently/repeatedly accessed blocks	Faster than main-memory misses
Main RAM	Active program/data	Larger working capacity
SSD/HDD	Persistent files/backing data	Larger, storage access latency
Removable/archive media	Distribution/backup/archive	Workload-dependent access

Actual latency, capacity और number of levels architecture-dependent हैं. L3 absent/present/shared/private choices बदल सकती हैं; fixed universal nanosecond values नहीं.

24.2 Locality of Reference

Temporal locality: recently accessed item फिर access होने की tendency. Spatial locality: nearby addresses access होने की tendency. Loop variable temporal locality; consecutive array scan spatial locality. यह workload behavior है, absolute rule नहीं.

24.3 Movement between Levels

Cache transfers blocks/lines; RAM virtual-memory pages backing storage से load हो सकती हैं. CPU load/store operations and OS file read/write different abstractions हैं. Cache miss, page fault और missing file तीन अलग events हैं.

24.4 Capacity, Latency एवं Bandwidth

Capacity storage amount; latency one request response delay; bandwidth data/time sustained transfer capability. High bandwidth medium में single-request latency फिर भी significant हो सकती है. Sequential SSD/HDD throughput और random access time directly interchangeable नहीं.

24.5 Numerical Units

1byte=8bits. KiB= 2^{10} bytes, MiB= 2^{20} , GiB= 2^{30} . Decimal MB= 10^6 bytes. 1MiB=1.048576MB. A512MiB memory=536,870,912bytes. Capacity calculations में bit/byte और decimal/binary prefixes अलग रखें.

24.6 Application Example

Photo editor file storage से reads; decoded image RAM में; active pixel operations cache में; current numerical operands registers में. Save persistence के लिए filesystem/storage path use करता है. Power off पर unsaved volatile state खो सकती है.

10-mark answer: Hierarchy figure → each level → locality → speed/capacity/cost tradeoff → example → measurements and limitations.

Practice: Why not build all storage from registers? Cost/capacity/integration constraints. Which locality consecutive-array access benefits from? Spatial.

UNIT 3 / CHAPTER 25

अध्याय 25: Primary एवं Secondary Memory

Volatility, write ability और storage roles

25.1 Primary Memory

Primary/main memory active execution के लिए accessible instruction/data storage provides करती है. Basic teaching includes RAM and ROM categories. CPU registers/cache primary-storage terminology में कभी separately classified होते हैं; this book उन्हें hierarchy levels में explicitly separates करती है.

25.2 RAM Types

Type	Storage idea	Key point
SRAM	Bistable electronic state	No periodic refresh while powered; commonly cache
DRAM	Capacitive charge state	Periodic refresh; commonly main RAM

Both ordinary SRAM/DRAM volatile हैं: powered maintenance required. SRAM “static” means refresh-free storage mechanism, not nonvolatile/power-free. DRAM density/cost और SRAM access/design tradeoffs differ. Exact size/rate chip-dependent.

25.3 ROM-family और Nonvolatile Storage

Type	Typical programming/erase characteristic
Mask ROM	Contents fixed during manufacture
PROM	One-time programmable forms
EPROM	UV erase in traditional windowed devices
EEPROM	Electrical erase/reprogram, granularity device-specific
Flash	Electrical programming, block-oriented erase

“ROM” family common name का अर्थ all variants forever unchangeable नहीं. Firmware flash में update हो सकती है. Nonvolatile means power removed होने पर stored data retained within specified conditions, unlimited immortal retention guarantee नहीं.

25.4 Secondary Memory

Persistent larger storage: SSD, HDD, optical media, tape etc. Data commonly moves into RAM/cache for CPU processing. SSD uses nonvolatile flash/controller; HDD magnetic rotating media; optical technologies lasers/media patterns; tape sequential physical access.

25.5 Comparison

Aspect	Main RAM	Secondary storage
Role	Working execution state	Persistent files/backing data
Typical ordinary volatility	Volatile	Nonvolatile
Access abstraction	Memory addresses	Blocks/files/device commands
Latency	Generally lower	Generally higher than RAM
Capacity/cost	Working-size tradeoff	Large persistent capacity

There are specialised persistent-memory technologies; table represents standard basic-course contrast.

25.6 Numerical

4GiB RAM = 4×2^{30} bytes. A 256GiB storage device has 64 times that stated binary capacity; this ratio doesn't mean 64 times performance. Marketing GB units may change actual comparison.

Practice: Classify SRAM, DRAM, flash, HDD using volatility and role separately. Why is program stored on SSD not automatically running in CPU?

UNIT 3 / CHAPTER 26

अध्याय 26: Cache Memory

Hits, misses, mapping और write policies

26.1 Cache का उद्देश्य

Cache frequently useful memory blocks की faster copies रखती है। CPU request checks cache; hit data available, miss requires lower-level access/fill. Cache contents volatile ordinary implementation में होती हैं; cache permanent file backup नहीं।

26.2 Cache Lines एवं Mapping

Mapping	Placement rule	Tradeoff
Direct-mapped	Block has one candidate line	Simple; conflict misses possible
Fully associative	Block may occupy any line	Flexible; tag lookup/replacement cost
Set-associative	Block one set, multiple ways	Balance of flexibility/complexity

Tag identifies which memory block is stored; valid bit says usable; dirty bit may record modified line under writeback. Replacement policy chooses victim when candidates occupied. LRU/FIFO/random are possible policies, not all universal hardware choices.

26.3 Miss Types

Compulsory first reference; capacity working set doesn't fit; conflict restrictive mapping collisions. Classification conceptual; actual multicore coherence and policies add complexities. Higher cache capacity may reduce misses but no all-program performance guarantee.

26.4 AMAT Numerical

Average Memory Access Time = hit time + miss rate × additional miss penalty under simple single-level model. Hit 1ns, miss rate 5%, additional penalty 50ns: $1 + 0.05 \times 50 = 3.5\text{ns}$. If quoted miss access time already includes lookup, adjust formula; avoid double-counting.

26.5 Address-field Numerical

Cache data capacity 16KiB, block 64bytes → 256 lines. Direct-mapped byte-addressed 32-bit model: offset bits $\log_2 64 = 6$, index bits $\log_2 256 = 8$, tag bits $32 - 8 - 6 = 18$. Metadata/tag storage extra to 16KiB payload capacity.

2-way version same capacity: 128 sets, index 7, offset 6, tag 19. Two-way does not double total data capacity when capacity held fixed; ways change placement.

26.6 Write Policies

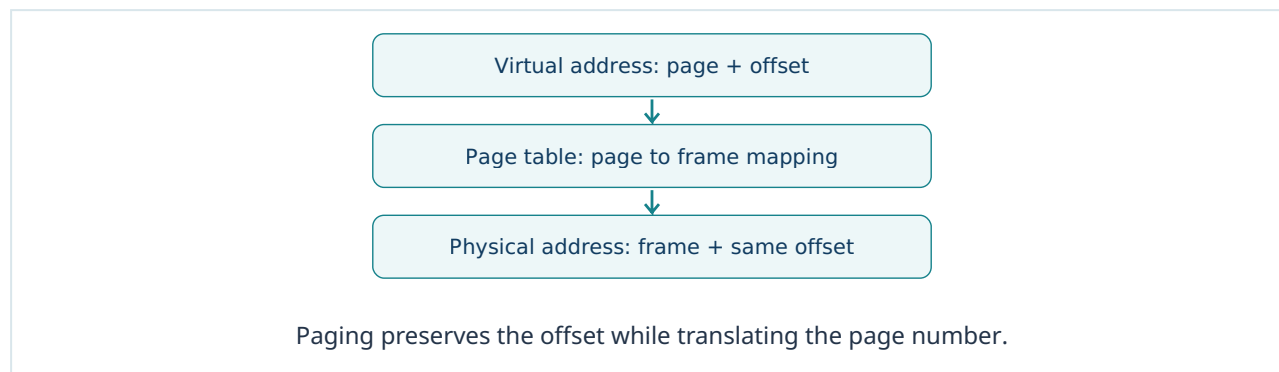
Write-through sends updates onward; write-back marks dirty and writes lower level on eviction/required synchronization. Write-allocate versus no-write-allocate governs write-miss fill behavior. Policies must maintain correctness; CPU cache flush/coherence and filesystem durability differ.

Practice: 8KiB cache, 32byte blocks→256lines. Hit2ns, miss rate10%, penalty80ns→AMAT10ns. Explain cache hit versus TLB hit.

UNIT 3 / CHAPTER 27

अध्याय 27: Virtual Memory

Address spaces, pages, faults और backing storage



27.1 Virtual Memory का Meaning

Virtual memory provides process address space abstraction with mapping/protection. Addresses seen by program need not directly equal physical RAM locations. OS/MMU cooperate; not all virtual pages simultaneously resident. Backing storage can hold some pages, but virtual memory definition is not merely “hard disk used as RAM.”

27.2 Paging

Virtual space fixed-size pages; RAM corresponding frames. Page table map virtual page number → physical frame number with status/permissions. Offset within page unchanged for standard fixed pages ize mapping. Pages may occupy non contiguous frames.

27.3 Address Translation Numerical

Page 4KiB = 4096 bytes = 2^{12} , 32-bit virtual address → 12 offset bits, 20 virtual page-number bits. Virtual address 12,388 = $3 \times 4096 + 100$ gives VPN 3, offset 100. If VPN 3 maps frame 9, physical address = $9 \times 4096 + 100 = 36,964$.

27.4 Page Fault Handling

Requested translation not present or permission issue can trigger fault. For valid not resident page OS may load from file/swap, allocate zero-filled frame, update table and retry. Invalid/prohibited access maybe resolved as program error, not successful page-in. “Every page fault means virus” और “always requires disk read” both wrong.

27.5 Benefits एवं Costs

Isolation, protected address spaces, large logical program organization and efficient sharing possible. Translation needs metadata/TLB; frequent faults expensive. Thrashing when working-set pressure causes excessive paging and little useful work; more virtual space alone never fixes it.

27.6 Demand Paging, Swap और Durability

Demand paging loads needed pages. Swap/backing stores policy OS-dependent; executable file pages often reload from original file. Page-backed data is not automatically user saved file. Power loss durability needs proper application/filesystem commit process.

27.7 Cache versus Virtual Memory

Cache accelerates recent block access; virtual memory maps/protects process addresses and manages residency. Cache miss may fetch RAM; page fault may require OS action/backing storage. TLB recent translations cache, covered chapter30.

Practice: For 8KiB pages offset 13 bits. Given $VPN_2 \rightarrow frame_6$, offset 50, physical $6 \times 8192 + 50 = 49,202$. Explain why virtual address space is not fixed RAM+disk capacity sum.

UNIT 3 / CHAPTER 28

अध्याय 28: DASD, Direct Access एवं Readout Characteristics

Storage access और destructive/non-destructive read

28.1 DASD का Meaning

Direct Access Storage Device (DASD) historically disk-style storage where selected data block can be addressed without reading all preceding records. Direct access does not promise equal/zero access latency. HDD seek/rotation vary; modern SSD block access avoids mechanical seek but controller latency remains.

28.2 Access-mode Comparison

Mode	Idea	Example/context
Sequential	Order-dependent progression	Magnetic tape
Direct/block access	Address selected block	Disk storage
Random memory access	Address selected location	RAM, model-dependent timing

Terminology overlaps across textbooks; describe actual behavior. “Random” means arbitrary address selection, not random stored values.

28.3 HDD एवं SSD Organization

HDD physical platters/heads tracks historically mapped to logical blocks by controllers. SSD flash page/block organization and wear management internal; host typically logical block view sees. File offset→filesystem block mapping→device command→physical storage representation.

28.4 Destructive Readout

A destructive-read mechanism alters stored state during read, requiring restoration to retain value. Traditional magnetic-core memories examples; ordinary DRAM sense/read disturbs cell charge and restoration/refresh maintains data. From program's logical view, reading RAM does not normally delete variable—hardware handles restore.

28.5 Non-destructive Readout

Read observes stored state without needing rewrite as essential part of the basic read mechanism. SRAM static latch read illustrates standard case, though power needed to hold state. ROM-type contents or disk read generally not intended to erase just by read. Technology details cannot reduced to “all primary destructive/all secondary non-destructive.”

28.6 Distinguish Properties

Volatile/nonvolatile concerns power-retention; destructive/non-destructive concerns effect of read; sequential/direct concerns address-selection/access pattern. Three independent classifications. DRAM volatile and read-restored; magnetic core historically nonvolatile and destructive-read—good counterexample to properties being identical.

Practice: Reading file usually changes file contents? No. “DASD needs no head movement” correct for HDD? No. Explain why restoration does not make RAM read software destructive.

UNIT 3 / CHAPTER 29

अध्याय 29: Program एवं Data Memory

Instructions and operands का organization

29.1 Program Memory

Program memory stores instructions/firmware code. Data memory stores operands, variables, buffers, stack and working state. Role classification physical technology classification से अलग है: code can be ROM/flash and/or RAM depending execution design; data also variable/persistent storage में हो सकती है।

29.2 Von Neumann-style Organization

Common memory/address space for instructions and data. CPU fetches code and loads/stores data through memory system. Shared transfer resources can create bottleneck; actual modern caches/controllers mitigate or complicate basic model.

29.3 Harvard-style Organization

Separate program/data memories and paths can allow different widths and parallel fetch/data access. Some embedded architectures use program flash and data RAM with separate address spaces. Modified Harvard designs may separate instruction/data caches but share lower level memory.

Aspect	Basic Von Neumann model	Basic Harvard model
Memory organization	Shared instruction/data	Separate instruction/data
Address spaces	Common view	Separate views possible
Path usage	Shared logical resource	Distinct paths possible
Flexibility	Same format access context	Width/access rules candidates differ

29.4 Program Sections and Working Areas

Text/code instructions; initialized data; zero-initialized data; heap dynamical locations; stack call/local state. Exact layout and permissions OS/tool chain-dependent. "Stack" both data-structure A DT and runtime call storage terminology; use context.

29.5 Example

Sensor controller firmware flash: instructions retained power off; RAM: current temperature, sample buffer, function locals. Configuration could be nonvolatile EEPROM/flash area. One physical chip multiple memory types integrate कर सकता है।

29.6 Protection एवं Loading

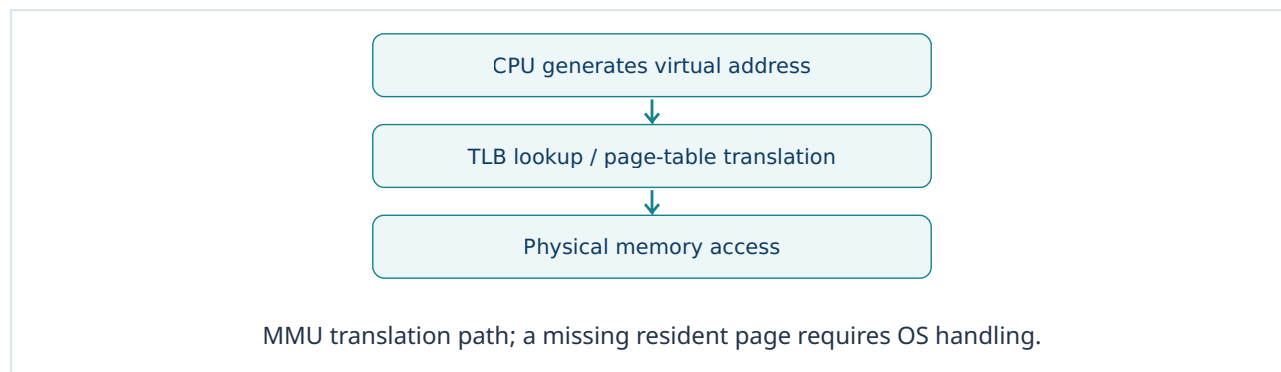
OS loader maps program sections and sets permissions. Code page read/execute permissions and data page write permissions may differ. Self-modifying/JIT code require correct permissions/synchronization policies; basic students need not assume all memory freely writable executable.

Practice: Why is program memory not always ROM? RAM loaded applications also execute. Can firmware and working variables different memories use? Yes. Draw basic Von Neumann versus Harvard blocks.

UNIT 3 / CHAPTER 30

अध्याय 30: Memory Management Unit (MMU)

Translation, protection एवं TLB



30.1 MMU की भूमिका

MMU hardware unit/logical function translates addresses and applies access constraints using processor/OS configured state. OS allocates pages, maintains tables, chooses replacement/backing policy; MMU executes hardware translation/protection checks. MMU does not independently choose all OS policies.

30.2 Translation Path

CPU virtual address → VPN+offset → TLB lookup → page table walk on miss → physical frame+offset → physical memory/cache access as architecture organizes. Valid permissions and presence checked. Cache indexing details vary; this logical diagram is not universal timing pipeline.

30.3 TLB

Translation Lookaside Buffer stores recent address translations/related permissions. TLB hit avoids page table walk; TLB miss needs lookup, not automatically page fault. Page table entry present but not cached in TLB means ordinary translation miss only. Cache hit/data and TLB hit/translation different concepts.

30.4 Page-table Fields

Field	Conceptual meaning
Frame number	Physical frame identifier
Present/valid/residency	Meaning architecture-dependent
Read/write/execute permissions	Allowed operation types
Accessed/referenced	Page use information

Field	Conceptual meaning
Dirty/modified	Writes occurred, backing update consideration

Actual bit names and combinations depend ISA. "Valid" may mean defined mapping rather than resident; don't assume all textbooks one bit meaning.

30.5 Numerical

Virtual address 0x3064, page 4KiB:VPN0x3, offset 0x064=100. Mapping VPN3→PFN9 gives physical 0x9064=36,964. Change offset only within same page means same frame chosen. Unknown/not present VPN requires fault/path policy.

30.6 Protection Example

Two processes can both use virtual 0x1000 while mapped to different physical frames. Isolation depends permissions/context-switch mapping not user-visible address uniqueness. Shared page intentional mapping can allow common physical data with controlled permissions.

30.7 Performance and Correctness

Stale translations need proper invalidation/context management when mappings change. More RAM may reduce paging pressure but does not remove address protection need. MMU, cache, OS scheduler, filesystem different components with related roles.

10-mark answer: Definition → block diagram → VPN/offset translation → TLB → page-table fields → fault/protection → numerical → OS/MMU division of responsibility.

UNIT 3 / CHAPTER 31

अध्याय 31: Unit III Revision एवं Test

Consolidation / 30 MCQs with Answers

A. पढ़ने के बाद स्वयं समझाएँ

1. Hierarchy, cache, virtual memory और TLB अलग mechanisms हैं.
2. Page/frame/offset numericals और MMU/OS responsibilities समझाएँ.
3. Volatility, readout effect और access mode अलग classifications हैं.

B. Unit Test: 30 Questions

हर प्रश्न का एक best answer है. Key देखने से पहले स्वयं solve करें.

1. Temporal locality? A. Recently used items used again B. Only adjacent addresses C. Only disk name D. Only display refresh
2. Spatial locality? A. Only time intervals B. Nearby addresses tend to be used C. Files always permanent D. No memory movement
3. 1MiB equals? A. 1024bits B. 1024GiB C. 1,048,576bytes D. 1,000,000bytes exactly
4. Latency and bandwidth? A. Always same B. Both capacity C. Both colour depth D. Different measurements
5. Ordinary SRAM is? A. Volatile, no periodic refresh while powered B. Always nonvolatile C. Only optical D. Always ROM
6. Ordinary DRAM requires? A. Printer ribbon B. Refresh C. No power D. Only disk sectors
7. EPROM traditional erase method? A. Magnetic strike B. Always impossible C. UV light D. Only CPU clock
8. Flash typical erase granularity? A. Every bit without controller B. Only whole HDD C. No erase ever D. Blocks
9. Primary memory all necessarily volatile? A. No, ROM-type categories exist B. Always yes C. No RAM exists D. Only secondary can be read
10. Cache hit means? A. Disk formatted B. Requested cached block available C. All pages resident D. File saved permanently
11. Direct mapping block candidates? A. No line B. Always all sets C. One cache line D. Every line simultaneously
12. Set-associative placement? A. All blocks one byte B. No tags C. Only hard disk D. One set, several possible ways
13. Hit1ns, miss5%, extra penalty50ns AMAT? A. 3.5ns B. 51ns C. 2.5ns D. 50ns
14. 16KiB cache with64B blocks gives? A. 16lines B. 256lines C. 64lines D. 1024lines
15. 32-bit by tea ddr, 256direct lines, 64B block tag bits? A. 8 B. 32 C. 18 D. 6
16. Write-back modified line commonly needs? A. No eventual lower-level write B. Read-only firmware C. Only Unicode D. Dirty-state tracking

17. Virtual memory primarily provides? A. Mapped/protected address-space abstraction B. Only extra physical RAM soldering C. Always RAM+disk arithmetic sum D. File deletion
18. 4KiB page offset bits? A. 20 B. 12 C. 4 D. 10
19. 32-bit virtual, 4KiB page VP Nbit s? A. 32 B. 4 C. 20 D. 12
20. VPN3→frame9, offset100, 4KiB page physical? A. 12,388 B. 900 C. 4096 D. 36,964
21. Page fault always requires disk read? A. No B. Always yes C. Never OS action D. Always virus
22. Thrashing commonly relates to? A. File extension syntax B. Excessive paging under working-set pressure C. Printer ribbon failure D. Only zero arithmetic
23. DASD direct access implies HDD no seek? A. Only tape B. No addresses C. No D. Always yes
24. Tape traditional access model? A. Always SRAM B. Every byte same zero latency C. Only cache D. Sequential
25. Destructive readout needs? A. State restoration to preserve contents B. Always file deletion by software C. No stored data D. Only power off
26. Volatility and destructive read? A. Both file permissions B. Different properties C. Always identical D. Both only RAM capacity
27. Basic Harvard organization? A. No instructions B. Only disk folders C. Separate program/data memory paths D. One compulsory shared space
28. MMU main role? A. Print rendering B. Keyboard scanning C. Image scanning D. Address translation/protection
29. TLB stores mainly? A. Recent address translations B. All user files C. Printer pages D. Only pixel colours
30. TLB miss always page fault? A. Means all RAM lost B. No C. Always yes D. No page table walk possible

C. Answer Key

1-A, 2-B, 3-C, 4-D, 5-A, 6-B, 7-C, 8-D, 9-A, 10-B, 11-C, 12-D, 13-A, 14-B, 15-C, 16-D, 17-A, 18-B, 19-C, 20-D, 21-A, 22-B, 23-C, 24-D, 25-A, 26-B, 27-C, 28-D, 29-A, 30-B.

D. 5-mark / 10-mark Preparation

1. Memory hierarchy with locality and units.
2. RAM/ROM families and secondary technologies.
3. Cache mapping, AMAT and address-field numerical.
4. Virtual memory, paging, faults, thrashing.
5. DASD and readout properties with counterexamples.
6. Program/data memory, Harvard/Von Neumann, MMU/TLB translation.

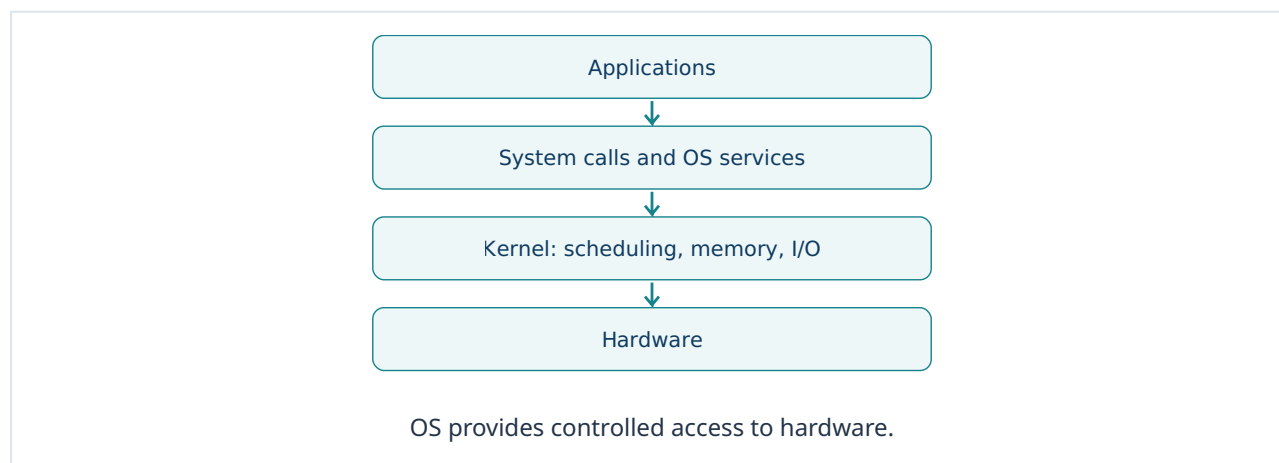
E. Practical / Solved Check

Cache hit1ns, miss5%, extra50ns→3.5ns; 32-bit virtual page4KiB offset12bits; VPN3→frame9, offset100→36,964. TLB miss can be valid resident page table walk without page fault.

UNIT 4 / CHAPTER 32

अध्याय 32: Operating System Concepts, Evolution एवं Types

UNIT IV • DOS, Windows and Linux



32.1 OS क्या है?

Operating system software platform है जो hardware resources manage करता है और applications/ users को controlled services देता है. Process scheduling, memory management, files, I/O, permissions और error handling core responsibilities हैं. GUI alone OS नहीं; kernel और supporting services interface के पीछे काम करते हैं.

32.2 Evolution

Early systems में manual job setup और direct machine use था. Batch processing grouped jobs; multiprogramming memory में multiple jobs रखकर CPU utilization बढ़ाती है; time-sharing interactive users/tasks को scheduled attention देती है. Networked, distributed, embedded और mobile systems ने resource/control requirements आगे बढ़ाई.

32.3 OS Types

Type	Defining emphasis
Batch	Jobs submitted and processed with limited interaction
Multiprogramming	Multiple jobs resident, CPU switched when useful
Multitasking/time-sharing	Scheduled interleaving and responsiveness
Multuser	Multiple user contexts/accounts/services
Multiprocessing	Multiple processors/cores supported

Type	Defining emphasis
Real-time	Timing constraints part of correctness
Network/distributed	Communication/services across connected systems
Embedded/mobile	Device-specific resource/interface needs

Categories overlap. A modern Linux system can be multiuser, multitasking, multiprocessing और networked at once. Distributed OS/system distinction definitions vary; describe actual coordination rather than only label.

32.4 Real-time Distinction

Hard real-time missing deadline invalidates required guarantee; soft real-time delays degrade quality. “Real-time” means defined timing obligations, not simply fastest clock. Audio processing soft timing needs; specific safety-control systems may have hard constraints. This book explains concepts, not deployment certification.

32.5 Process and Program

Program stored instructions; process running execution context with state/resources. Several processes same program run कर सकती हैं. Context switch stores/restores execution state; scheduling policy chooses next eligible task. Threads share some process resources but maintain execution state.

32.6 OS Services Example

Open file→check permissions/path→filesystem finds data→driver performs I/O→memory buffer filled→application reads. CPU scheduling and memory protection continue coordinating other tasks. Application cannot assume unrestricted direct hardware access.

Practice: Distinguish multiprogramming, multitasking, multiprocessing. Why does multiple cores not mean every single program automatically faster?

UNIT 4 / CHAPTER 33

अध्याय 33: DOS Introduction, History एवं Booting

Classic disk operating system और command interpreter

33.1 DOS का संदर्भ

DOS=Disk Operating System as generic term; syllabus usually PC/MS-DOS-style command environment refers. Traditional MS-DOS predominantly single-user, single-task design के रूप में taught है. TSRs और special extensions exist; यह general modern multitasking OS के समान नहीं.

33.2 Historical Role

PC-DOS/MS-DOS families early personal computer era में disk, file, and program services देती थीं. COMMAND.COM command interpreter common था. Modern Windows Command Prompt(cmd.exe) कई similar commands provides करता है, but Windows NT-based OS MS-DOS नहीं है. DOS Box-style emulation भी actual modern host OS से अलग layer है.

33.3 Version-specific Booting

Typical classic MS-DOS6-style overview:

1. BIOS-style firmwareinitialisation/POST.
2. Boot device/boot sector code loads required system files.
3. IO.SYS और MSDOS.SYS-family components initial is e DOS services.
4. CONFIG.SYS handles selected configuration/drivers.
5. COMMAND.COM provides command interpreter.
6. AUTOEXEC.BAT performs startup commands as configured.

Exact filenames/meaning/order vary by DOS version; modern UEFI/Windows boot process uses different components. This is legacy teaching model, not universal boot sequence.

33.4 Prompt, Commands एवं Programs

Prompt shows current drive/path, e.g.C:\LAB>. User types command, interpreter parses arguments and executes internal operation or finds program/batch file. Output/errors return to screen or redirected stream. Current directory affects relative filenames.

33.5 Internal versus External

Internal commands built into command interpreter; external commands separate executable files need availability. Common classic internal DIR, COPY, DEL, REN, TYPE, CD, MD, RD, CLS. External utilities FORMAT, CHKDSK, TREE, XCOPY examples depend version/install. New Windows cmd classification/parameters may differ.

33.6 Booting Concepts

Cold boot power-on/reinitialisation; warm boot restart without ordinary full power cycle, definitions hardware-dependent. Startup configuration and drivers determine environment. Boot failure can be hardware, configuration, media or loader issue; one file missing not universal diagnosis.

Practice: Is Windows cmd.exe same as MS-DOS? No. Define command interpreter and batch file. Explain legacy boot context before listing files.

UNIT 4 / CHAPTER 34

अध्याय 34: DOS Commands एवं File Operations

Syntax, practical work flow और command context

34.1 Core Command Table

Command	Purpose	Example
DIR	List directory contents	DIR /P
CD/CHDIR	Change current directory	CD LAB
MD/MKDIR	Create directory	MD LAB
RD/RMDIR	Remove empty directory	RD LAB
COPY	Copy file data	COPY A.TXT B.TXT
REN/RENAME	Rename	REN A.TXT B.TXT
TYPE	Display text file	TYPE A.TXT
DEL/ERASE	Delete files	DEL B.TXT
CLS	Clear screen	CLS
DATE/TIME	View/change perversion policy	DATE
VER	Display version	VER

Parameters vary between classic DOS and modern Windows cmd. For current cmd documentation use official command help/R12. Files with spaces need quotes in modern cmd; practice examples use 8.3-friendly names for clarity.

34.2 Directory Navigation

Root of C: is C:. CD.. parent, CD\ root under usual command context. Changing current directory and drive can be distinct in classic command behavior. Modern cmd `cd /d D:\LAB` changes both drive/directory; old DOS syntax needs drive switch appropriately. Do not assume all flags all versions support.

34.3 Fresh-folder Lab

Run only in your own new practice folder; if LABCF already exists, choose a new unused name. These examples compatible with ordinary Windows cmd; old DOS available commands may differ.

```
MD LABCF
CD LABCF
ECHO Computer Fundamentals>NOTE.TXT
TYPE NOTE.TXT
COPY NOTE.TXT BACKUP.TXT
REN BACKUP.TXT SAVED.TXT
DIR
DEL SAVED.TXT
DEL NOTE.TXT
CD ..
RD LABCF
```

Expected flow: new folder→note file→copy→rename→listing→delete only created files→remove empty folder. Names and written content persist until delete; DIR does not read file text. Command-line DEL usually doesn't send file to GUI Recycle Bin; deleting is not printing.

34.4 Wildcards and Redirection

`*/?` pattern matching version-specific details; `DIR *.TXT` demonstrates filtered listing. `>` redirects/replaces output file; `>>` app ends where supported. Do not use broad delete patterns for learning; exact practice filenames make operation review able.

34.5 External Utilities

CHKDSK inspects filesystem consistency; FORMAT prepares filesystem/media; XCOPY copies with additional options; TREE displays directory hierarchy. Their write/repair flags or formatting may change data; explanation does not require executing disk maintenance commands in this book.

Practice: COPY creates second file; REN changes name; TYPE shows contents; DIR shows listing; RD requires appropriate folder state. Write commands for new folder, copy, rename without mixing their purposes.

UNIT 4 / CHAPTER 35

अध्याय 35: DOS File Structure, Paths एवं Directories

Filesystem organization और 8.3 names

35.1 Files और Directories

File named collection of data; directory contains entries organising files/sub directories. Root base of volume hierarchy. Absolute path starts from known root/drive; relative path interpreted from current directory.

Example C:\STUDY\NOTES\UNIT1.TXT: drive C, STUDY directory, NOTES sub directory, UNIT1 base name, TXT extension. Extension convention hints format but does not prove actual content.

35.2 Classic 8.3 Format

Traditional DOS short filenames up to 8-character base name and 3-character extension, subject allowed character rules. NOTE.TXT valid example. Modern Windows long filenames different feature; software can provide compatibility short names depending filesystem/policy. Do not claim all modern Windows files must 8.3.

35.3 FAT-style Basic Organization

File Allocation Table tracks cluster chains/free/status information in FAT families. Directory entry stores name, attributes, size and starting location-related information. Data stored clusters; logical file need not physically contiguous. Different FAT versions layouts/limits different; NTFS/ext filesystems not identical FAT.

35.4 Attributes

Read-only, hidden, system, archive attributes commonly discussed. Hidden display filter ≠ encryption. Read-only attribute ≠ full security permission model. Archive flag historically backup work flows helps; not automatic backup copy.

35.5 Paths Worked Example

Current C:\STUDY. Relative NOTES\UNIT1.TXT resolves C:\STUDY\NOTES\UNIT1.TXT. . . \DATA.TXT refers parent-relative location; if parent C:\, full C:\DATA.TXT. Dot means current directory within usual path syntax.

35.6 File versus Storage Capacity

File size logical bytes; allocation clusters may roundup. If cluster size 4KiB, file 5000 bytes needs 2 clusters = 8192 bytes allocated in simplified model; internal waste 3192 bytes, metadata excluded. Two files of 2500 bytes each may occupy 2 clusters also 8192 bytes; allocation not just total bytes ceil if per file calculated.

Practice: Explain file extension, path, root, cluster and FAT. Is renaming.TXT to.JPG valid image conversion? No;changing name alone changes not encoded content.

UNIT 4 / CHAPTER 36

अध्याय 36: Windows History, Versions एवं Basics

GUI environment से modern desktop platforms तक

36.1 Windows का परिचय

Windows family graphical desktop/server operating environments and OSs का historical development है। Early Windows releases DOS-based environment context में थीं; NT line distinct OS architecture पर develop हुई। Current cmd commands are Windows command processor functions, not proof system running MS-DOS.

36.2 Selected Version Timeline

Release family	Historical year	Context
Windows1.0	1985	Early graphical environment
Windows3.x	1990era	DOS-based desktop growth
Windows NT	1993	NT architectural family
Windows95	1995	Consumer desktop milestone
Windows XP	2001	NT-based consumer convergence
Windows7	2009	Desktop release
Windows8/8.1	2012/2013	Interface/platform changes
Windows10	2015	NT-based desktop family
Windows11	2021	Later desktop family

Table history for learning है, not list of every edition/build or claim that old releases are currently recommended. Interface and tool availability differ by version/build.

36.3 Support Context

Microsoft states standard Windows10support ended14October2025;special ESU/LTSC and product-specific arrangements can have different timelines. This book does not present Windows10as current universally supported default. Historical version discussion remains valid for syllabus. [R13]

36.4 Desktop Elements

Desktop work space; Start/app menus launch applications; taskbar shows/runs activities; windows contain application views; dialog boxes request settings/input. Icons represent objects/shortcuts; shortcut is reference not duplicate complete file.

36.5 Accounts and Permissions

User accounts separate settings and access contexts. Administrator operations may need approval/elevation; ordinary work doesn't require full privilege. Login identity, filesystem permissions and application context matter. GUI labels alone not security model.

36.6 Window Operations

Move, resize, minimise, maximise, restore, close standard interaction patterns. Closing application window may prompt to save unsaved data; minimise is not quit. Exact appearance and keyboard shortcuts depend app and version.

Practice: Compare GUI OS services with visible interface. Why does minimise leave app running? What is the difference between file and shortcut?

UNIT 4 / CHAPTER 37

अध्याय 37: Windows Explorer, Accessories एवं Control Panel

File management और system settings

37.1 File Explorer

File Explorer/Windows Explorer navigates folders, drives, files and search. Navigation pane, content view, address bar and context menus provide views/actions; version changes layout. Search results list matches, not necessarily one folder's all contents.

37.2 Operations

Action	Meaning
Copy/paste	Create duplicate at destination
Cut/paste	Move chosen object when completed
Rename	Change object name
New folder	Create container directory
Properties	Inspect metadata/settings
Delete	Remove object subject volume/policy

Keyboard Ctrl+C/X/V common copy/cut/paste; F2 rename common Explorer behavior. Always verify selected object and destination. Cross-volume move may copy then remove; GUI operation name and underlying I/O cost different.

37.3 Recycle Bin

Typical eligible GUI deletions can be held for restoration; permanent deletion, network/removable paths, settings and limits can bypass it. Emptying bin/permanent deletion changes recovery conditions. Recycle Bin not complete backup or universal undelete guarantee.

37.4 Accessories

Notepad simple text; Paint basic image editing; Calculator numerical work; screenshot/accessibility tools varied by Windows release. Classic WordPad was included in many older releases but availability changed in newer Windows builds. Software lists version-specific; “every accessory in every version” wrong.

37.5 Control Panel एवं Settings

Configuration tasks: devices, network, accounts, appearance, accessibility and related system options. Modern Windows Settings and legacy Control Panel share/move functions differently by build. Settings interface applies OS services/policies; not directly all hardware-electrical control.

37.6 Practical Work flow

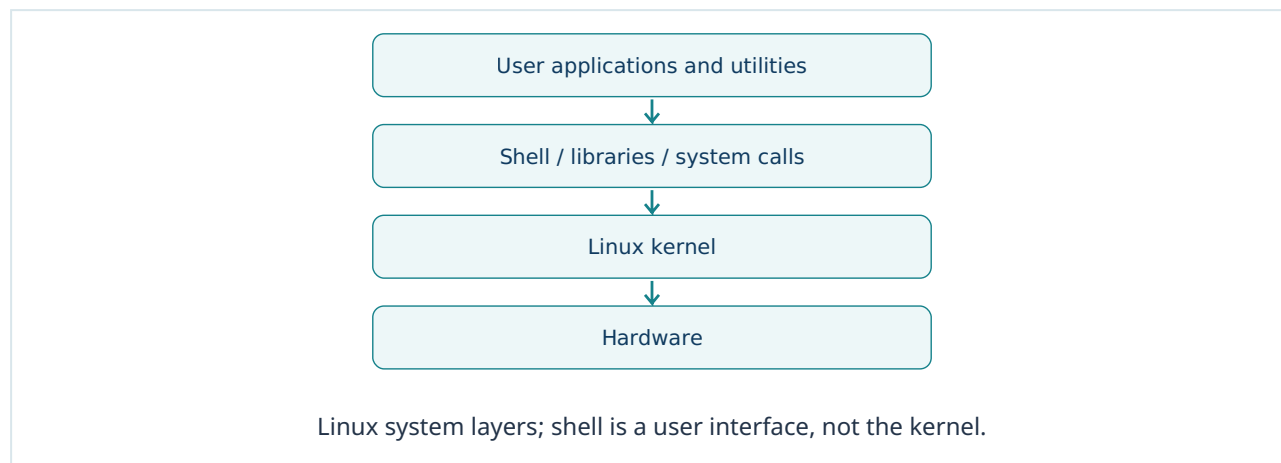
Create fresh study folder→copy a dummy text file→rename copy→view properties→open in editor→save→confirm correct path. Enable view of extensions if needed to distinguish NOTE.TXT from similar names. Change only relevant practice objects; actual system settings lab requires appropriate context.

Practice: Copy versus move; file versus shortcut; Recycle Bin versus backup; Paint image versus Notepad text. Draw logical Explorer view with folder tree and files pane.

UNIT 4 / CHAPTER 38

अध्याय 38: Linux Introduction एवं Structure

Kernel, shell, utilities और distributions



38.1 Linux का Meaning

Linux strictly speaking kernel project है; common usage “Linux OS” usually distribution including kernel, system tools, libraries, services and applications. Many distributions include GNU components; not all Linux-based devices identical userspace. Distribution and kernel version different identities.

38.2 Architecture Layers

Hardware→kernel→system libraries/services→shell/desktop/applications→user interaction. Kernel process scheduling, memory, drivers, filesystems and permissions functions provides. Shell command interpreter है; GUI desktop another interaction layer. Shell is not kernel.

38.3 Filesystem Hierarchy

Path	Typical role
/	Single filesystem root view
/home	Ordinary users' home areas, often
/etc	System configuration
/dev	Device-related special files
/proc	Virtual process/kernel information interface
/tmp	Temporary files, policy-dependent
/usr	Installed user-space programs/data, hierarchy-dependent

Mounting different storage attaches it to filesystem tree. Directory layouts, merged /usr and distribution choices vary. Home “~” shell-expansion concept, not literal universal path name.

38.4 Permissions

Traditional mode bits read(r), write(w), execute(x) for owner/group/others. For regular file execute permits program execution subject conditions; for directory execute allows search/traversal. Directory write and execute affect entry creation/removal; file writability alone doesn't govern all name-deletion rights.

38.5 Multiuser/Multitasking

Processes identified by PID; users/groups credentials; OS scheduling interleaves work and multicore can execute in parallel. Background job and foreground terminal control shell concepts. Root administrative privilege powerful; ordinary course commands don't need root.

38.6 CLI and GUI

Linux distribution can have GUI desktop and terminal. Terminal emulator provides window; shell inside parses commands; programs perform tasks. Bash, other POSIX-style and non-POSIX shells differ syntax. This book's Linux lab assumes ordinary POSIX-like shell with standard utilities.

Practice: Distinguish Linux kernel, distribution, shell, terminal. Is /home always root account's home? No; root account commonly /root, which is different from filesystem root/.

UNIT 4 / CHAPTER 39

अध्याय 39: Linux Commands: cd, mkdir, rm, mv, cp, ls, cat

Correct command names और practical examples

39.1 Syllabus में “md”

Linux में standard directory creation command **mkdir** है. **md** DOS/Windows command name है; Linux shell में alias/local function configured होते available हो सकती है, but portable Linux command assume नकरें. Similarly “cmd” Windows command processor name है, Linux generic command name नहीं.

39.2 Commands

Command	Purpose	Example
pwd	Current working directory	pwd
cd	Change shell working directory	cd study
mkdir	Create directory	mkdir study
ls	List directory entries	ls -l
cp	Copy	cp note.txt copy.txt
mv	Move/rename	mv copy.txt saved.txt
rm	Remove file entries	rm -i saved.txt
rmdir	Remove empty directory	rmdir study
cat	Concatenate/write file contents to output	cat note.txt

Options can vary by utility implementation; GNU coreutils documentation describes chosen common environment. `cd` typically shell built in; changing child process directory alone wouldn't change parent shell. [R14]

39.3 Fresh Practice Work flow

Use unused folder name CF_LAB_01 in an appropriate writable working directory. Removal commands below only delete files created by this exercise.

```
mkdir CF_LAB_01
cd CF_LAB_01
printf '%s\n' 'Computer Fundamentals' > note.txt
cat note.txt
cp note.txt copy.txt
mv copy.txt saved.txt
ls -l
rm -i saved.txt
rm -i note.txt
cd ..
rmdir CF_LAB_01
```

For `rm-i`, prompt requires intentional response before each removal. Expected note content “Computer Fundamentals”; copy and rename produce equivalent content. Names case sensitive in typical Linux filesystems; `NOTE.TXT` and `note.txt` maybe different files.

39.4 Paths and Options

Absolute/home/user/path starts/. Relative path based on working directory. `.` current, `..` parent. Quote filenames with spaces. `ls -a` includes hidden-dot entries; `ls -ll` long format. `cat` doesn't edit files; redirection can write output to new/existing destination.

39.5 cp versus mv versus rm

`cp` creates copy; `mv` renames/moves and may copy-across-filesystems; `rm` removes named entries. Direct terminal `rm` not typically GUI Trash. `rmdir` empty directory removal; recursive broad delete commands not needed for this introductory lab.

39.6 Verification

Check `pwd` before/after `cd`; check `ls` listing; `cat` content before cleanup; verify copy same bytes; confirm new folder empty before `rmdir`. Helpman `command` or available `-help` tool-specific. Internet instructions need environment/version context.

Practice: `mkdir` is Linux portable choice for the `md` topic. Explain why `ren` syntax differs: Windows `REN`, common Linux `mv`. List permission/display concept from `ls-l`.

UNIT 4 / CHAPTER 40

अध्याय 40: Unit IV Revision एवं Complete Book Review

Consolidation / 30 MCQs with Answers

A. पढ़ने के बाद स्वयं समझाएँ

1. OS services/interface तथा DOS/Windows/Linux contexts अलग रखें.
2. File/path/allocation concepts तथा command purposes explain करें.
3. Practical commands केवल अपने fresh lab objects पर चलाएँ.

B. Unit Test: 30 Questions

हर प्रश्न का एक best answer है. Key देखने से पहले स्वयं solve करें.

1. OS core responsibility? A. Resource/service management B. Only desktop colour C. Only CPU manufacturing D. Only file contents
2. Program versus process? A. Both USB cable B. Stored instructions versus execution context C. Always identical D. Both printer type
3. Multiprocessing emphasizes? A. Only one program file B. Only no scheduling C. Multiple processors/cores D. Only multiple filenames
4. Real-time means? A. Always fastest CPU B. Only GUI animation C. No deadlines D. Defined timing constraints matter
5. Traditional MS-DOS teaching model? A. Predominantly single-user, single-task B. Always same as Linux C. Always modern multiuser D. Only spreadsheet
6. COMMAND.COM classic role? A. Main RAM chip B. Command interpreter C. Cache controller D. Printer firmware
7. Modern Windows cmd equals MS-DOS? A. No command compatibility B. Only if GUI C. No D. Always yes
8. Internal command means? A. File always on external USB B. Every program C. Only format utility D. Built into interpreter
9. DIR chiefly? A. Lists directory contents B. Reads all text contents C. Deletes directory D. Renames only
10. TYPE chiefly? A. Always prints to laser B. Shows text file content C. Creates new filesystem D. Renames directory
11. MD in DOS/Windows? A. Move every file B. Only shutdown C. Create directory D. Show cache miss
12. RD basic use? A. Copy text B. Show OS version C. Change colour D. Remove empty directory
13. COPY versus REN? A. Duplicate versus name change B. Always same C. Both delete all folders D. Both boot loader

14. Classic 8.3 means? A. 83 characters fixed B. Up to 8 base name, 3 extension C. Eight directory levels only D. 3-byte CPU
15. Renaming .TXT to .JPG guarantees conversion? A. Only if ASCII B. Always compresses C. No D. Always yes
16. FAT chiefly tracks? A. Only GUI theme B. CPU instructions C. Monitor pixels D. File allocation/cluster organization
17. 4KiB clusters, 5000B file basic allocated size? A. 8192 bytes B. 5000 bytes exactly C. 4096 bytes D. 16384 bytes
18. Modern NT-family Windows has? A. Only 8.3 files B. OS architecture distinct from classic MS-DOS C. Only COMMAND.COM kernel D. No memory management
19. Minimise typically? A. Always save all files B. Delete file C. Window hidden/reduced, app continues D. Always terminate program
20. Shortcut usually? A. Full duplicate every file B. Printer ink C. Cache block D. Reference to object
21. File Explorer mainly supports? A. File/folder navigation operations B. CPU microcode design C. ADC quantization D. RAM refresh
22. Recycle Bin guarantees all deletions recoverable? A. Only if cmd B. No C. Always yes D. Same as backup
23. Control Panel/Settings mainly? A. Only file data B. Physical firmware chip C. System configuration interfaces D. All CPU computation
24. Linux strict meaning? A. Every distribution same package B. Only GUI shell C. Printer driver only D. Kernel
25. Shell versus kernel? A. Command interpreter versus core OS functions B. Always identical C. Both monitor panel D. Both ADC
26. Linux filesystem root? A. /root always B. / C. C:\ always D. /home always
27. Portable Linux directory creation? A. cmd always B. ren always C. mkdir D. md always
28. Linux cp versus mv? A. Both always same effect B. Both only display C. Both cache commands D. Copy versus move/rename
29. Linux cat chiefly? A. Writes/concatenates file contents to output B. Always edits GUI image C. Changes permission only D. Creates CPU
30. Linux cd usually? A. Always kernel name B. Shell built in changing working directory C. Only external child process with parent change D. Disk format utility

C. Answer Key

1-A, 2-B, 3-C, 4-D, 5-A, 6-B, 7-C, 8-D, 9-A, 10-B, 11-C, 12-D, 13-A, 14-B, 15-C, 16-D, 17-A, 18-B, 19-C, 20-D, 21-A, 22-B, 23-C, 24-D, 25-A, 26-B, 27-C, 28-D, 29-A, 30-B.

D. 5-mark / 10-mark Preparation

1. OS evolution, types and process/program distinctions.
2. Classic DOS boot context, internal/external commands.
3. DOS paths, FAT/8.3 names and cluster allocation numerals.
4. Windows versions, desktop, Explorer, accessories, settings.

5. Linux kernel/shell/filesystem/permissions.
6. Compare Windows/DOS and Linux command lab work flows.

E. Practical / Solved Check

Create unused practice folder; create one file, copy, rename, inspect, delete only those copies, remove empty folder. Verify Windows MD versus Linux mkdir. 5000B file with 4KiB cluster uses 8192B simple allocation.

F. Full-course Answer Writing

Definition → labelled figure → working steps → comparison → numerical/example → assumptions/limitations. Technical terms English में रखें और explanation अपनी Hindi-English language में लिखें. केवल one-line answer 10-mark question के लिए पर्याप्त नहीं.

Sources एवं आगे पढ़ें

Historical context और command conventions के लिए नीचे दिए primary/academic resources देखें। Numericals और practice questions इस book के teaching examples हैं।

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<https://epubs.siam.org/doi/10.1137/25M180634X>

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<https://indiainscienceheritage.gov.in/content2.html>

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[R11] Intel: AGP announcement (1997)

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[R16] Microsoft: Windows history

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