# PUNJAB PUBLIC SERVICE COMMISSION
## COMBINED COMPETITIVE EXAMINATION (CCE) SYLLABUS

### COMPUTER SCIENCE

**Total Marks: 100**

### SECTION -A
### ICT / Introduction to Computing

1. **Computers and Computing:** History and evolution of computing, stages of computing, basic machine structure, the Von Neumann model, types of computers (supercomputer, mainframe, mini and microcomputers), and Computer Based Information Systems (CBIS).

2. **Number Systems and Logic:** Representation of numbers, binary arithmetic, data representations, number base conversions, Boolean algebra, and basic operations at machine level.

3. **Hardware, I/O and Storage:** Processor structure and memory structures (difference between primary and secondary memory, RAM and cache memory), input devices (keyboard, pointing devices, data acquisition devices), output devices (monitor, printer, plotter), storage media (hard disk drives, optical drives, flash drives, RAID arrays), and computer security and virus protection.

4. **System Software and Operating Systems:** Differences between system software and application software, functions of the operating system, architecture of personal, server, and mobile operating systems, command line interface (Linux command line interface, file management and redirection), and utilities.

5. **Office Automation:** Microsoft Office package functionalities (formatting in Word, formulas in Excel, presentation slides in PowerPoint, database in Access), and office automation through Google Workspace, OneDrive, Dropbox and note-taking applications.

6. **Data Communication and Computer Networking:** Data communication model, analog and digital data communication, modems, transmission media, network topologies (star, bus, ring), LANs/WANs, network protocols, evolution of the Internet, browsers and search engines.

7. **ICT Applications and Emerging Technologies:** ICT applications in learning (LMS, online learning), health and well-being (telemedicine, wearable devices), personal finance management (electronic wallet, e-commerce), and artificial intelligence in brief, and software engineering.

8. **ICT Citizenship and Ethics:** Issues of intellectual property and copyright, preventing plagiarism, data integrity, managing misinformation and fake news, and social aspects of computing.

**Suggested readings:**


1. Livesley, Robert Kenneth. An introduction to automatic digital computers. Cambridge University Press, 2017.
2. Zawacki-Richter, Olaf, and Colin Latchem. "Exploring four decades of research in Computers & Education." Computers & Education 122 (2018): 136-152.
3. Sinha, Pradeep K., and PritiSinha. Computer fundamentals. BPB publications, 2010.
4. Goel, Anita. Computer fundamentals. Pearson Education India, 2010.
5. "Discovering Computers" by Vermaat, Shaffer, and Freund.
6. Deborah Morley and Charles S. Parker, Understanding Computers: Today and Tomorrow, 16th edition, Cengage Learning, 2016, ISBN-13: 978-1337251853

7. "Computing Essentials" by Morley and Parker.
8. "GO! With Microsoft Office" Series by Gaskin, Vargas, and McLellan.
9. "Exploring Microsoft Office" Series by Grauer and Poatsy.
10. "Technology in Action" by Evans, Martin and Poatsy.
11. Joan Lambert, Curtis Frye, Microsoft Office 2019 Step by Step, First Edition. ISBN: 978-1-50-930597-1.
12. LaBerta, C., &Neibauer, A. R. (2011). Computers are your future (12th ed.). Pearson.
13. Brookshear, J. G., &Brylow, D. (2018). Computer science: An overview (13th ed.). Pearson.

## Computer Communications & Networks

1. **Introduction to Networking and Network Architectures:** Concepts in networking, network topologies, protocol architecture and network system architecture (OSI and TCP/IP reference model) with considerations that apply.
2. **The Physical Layer and Transmission Concepts:** Analog and digital transmissions, transmission mediums, noise considerations, encoding schemes, multiplexing and asynchronous and synchronous transmissions.
3. **The Data Link Layer and Local Area Networks:** Error Control, Flow Control, Data Link Protocols (HDLC, PPP), MAC addressing, access schemes and Local Area Network Technologies (Ethernet, Token Ring).
4. **The Network Layer and Internetworking:** Circuit Switching and Packet Switching, Bridging, Internetworking and Routing, IP addresses (IPv4 and IPv6), Subnetting and CIDR, and routing protocols.
5. **The Transport Layer:** Transport layer protocols (TCP, UDP), Ports and sockets, connection setup and teardown, and Flow and congestion control.
6. **The Application Layer and Current Issues:** Application layer protocols (HTTP, DNS, SMTP, FTP) and current issues in software defined networks and Computer Networks.
7. **Network Security and Programming Exercises:** Network security issues, cryptography basics, firewall concepts, and programming assignments dealing with networking, routing, switching and protocols implementation.

**Suggested readings:**

1. James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach Featuring the Internet, 6th Edition, Pearson, 2012, ISBN: 0132856204.
2. T. Lammle, CCNA Cisco Certified Network Associate Deluxe Study Guide, 6thEdition, Sybex, 2011, ISBN: 978-0-470-90108-3.
3. William Stallings, Data and Computer Communications, 10th Edition, Pearson, 2013, ISBN: 0133506487.
4. Behrouz A. Forouzan, Data Communication and Computer Networks, 5th Edition,McGraw- Hill, 2012, ISBN: 0073376221.
5. R. Perlman, Interconnections: Bridges, Routers, Switches, and Internetworking Protocols, 2nd Edition, Addison-Wesley, 1999, ISBN: 0201634481.
6. Tanenbaum, A. S., & Wetherall, D. J. (2021). Computer networks (6th ed.). Pearson.
7. Stevens, W. R., Fenner, B., &Rudoff, A. M. (2003). Unix Network Programming, Volume 1: The sockets networking API (3rd ed.). Addison-Wesley Professional.
8. Peterson, L., & Davie, B. (2021). Computer Networks: A Systems Approach (6th ed.). Morgan Kaufmann.
9. Shankar, P. M. (2002). Introduction to Wireless Systems. John Wiley & Sons.

## Problem Solving

1. **Introduction and Architecture:** Fundamentals of problem solving, algorithms, pseudo code, flowcharting, and Von Neumann computer architecture.

2. **Language Fundamentals and I/O:** Compilation and linking of programs; data types; variables; type casting; memory concepts; and input output constructs.

3. **Operators and Expressions:** Arithmetic operators, relational operators, logical operators, equality operators, precedence of operators, and integer division.

4. **Control Structures:** Selection constructs (if, else, switch), Structured Programming Theorem, and repetition constructs (while, do while, for).

5. **Modular Programming:** Functions; scope rules; passing arguments by value and by reference; stack frame creation and destruction; recursion; and random numbers.

6. **Data Structures (Arrays and Lists):** One-dimensional arrays/lists; multidimensional arrays/lists; memory organization; searching and sorting; and strings and string manipulations.

7. **Advanced Data Types:** Structures, typedef, unions; pointers; pointer arithmetic; function pointers; and references.

8. **Memory and File Management:** Static and dynamic memory allocation (new / delete); file streams (input/ output); sequential and random file access; and preprocessor directives.

**Suggested readings:**


1. Starting out with Programming Logic & Design, 4th Edition, Tony Gaddis,
2. The C Programming Language, 2nd Edition by Brian W. Kernighan, Dennis M. Ritchie
3. Object Oriented Programming in C++ by Robert Lafore
4. C How to Program, 7th Edition by Paul Deitel& Harvey Deitel
5. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly& Elliot B. Koffman
6. Java: How to Program, 9th Edition by Paul Deitel
7. Beginning Java 2, 7th Edition by Ivor Horton
8. An Introduction to Object Oriented Programming with Java, 5th Edition by C. Thomas Wu
9. Starting Out with C++ from Control Structures to Objects, 10th Edition, Pearson, 2024, Tony Gaddis
10. Savitch, W. (2020). Java: An introduction to problem solving and programming (8th ed.). Pearson.
11. Deitel, P., & Deitel, H. (2016). C++ how to program (10th ed.). Pearson.
12. Keogh, J. (2002). C++ programmer's notebook (2nd ed.). McGraw-Hill Osborne Media.


## SECTION –B

## Data Structures

1. **Introduction and Complexity Analysis:** The roles of data structures and algorithms, abstract data type (ADT), OOP, and asymptotic complexity, including Big-O notation and the analysis of best, average and worst-case scenarios.

2. **Linear Data Structures:** Arrays, linear lists, singly and doubly and circular linked lists, sorted lists, stacks, queues, deques and priority queue, and their practical applications such as bracket checking, expression conversion, and scheduling.

3. **Recursion and Sorting Algorithms:** Direct recursion and recursive tracing and divide and conquer approaches, along with the discussion on different sorting algorithms like bubble sort, selection sort, insertion sort, merge sort, quick sort, heap sort, shell sort, radix sort and bucket sort.

4. **Searching and Hashing:** Linear and binary search, hash functions, hash collision resolution, open addressing, chaining and indexing.

5. **Advanced Trees:** Binary tree, tree traversal, binary search tree (BST), balanced tree (AVL trees, M-way trees) and heaps.

6. **Graph and Advanced Applications:** Graph representations (Adjacency matrix and adjacency list), BFS, DFS, shortest path, minimum spanning trees, topological sort, cycle detection, graph coloring and data compression using Huffman coding.

**Suggested readings:**


1. Data Structures and Abstractions with Java by Frank M. Carrano & Timothy M. Henry
2. Data Structures and Algorithms in C++ by Adam Drozdek
3. Data Structures and Algorithm Analysis in C++ by Mark Allen Weiss
4. Classic Data Structures by Debasis Samanta
5. C++ Plus Data Structures by Nell Dale
6. Weiss, M. A. (2013). Data structures and algorithm analysis in C++ (4th ed.). Pearson.
7. Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). Introduction to algorithms (4th ed.). MIT Press / McGraw-Hill.


## Operating Systems

1. **Introduction to Operating Systems and System Structures:** History and Evolution, Classification of Operating Systems, System Components, System Services, Dual Mode Operation, Protection from Hardware/ Memory/ I/O, System Call Interface and Virtual Machines.
2. **Processes and Threads:** Concept of Processes, Process Control Block, States of Process, Process Scheduling, Process Creation and Process Termination (fork(), wait(), exec()), Multi-Threading Models, Threading Issues and Thread Libraries (Pthreads).
3. **CPU Scheduling:** Criteria for Scheduling, Pre-Emptive and Non-Pre-Emptive Algorithms (FCFS, SJF, SRTF, Priority, Round Robin, MLQ, MLFQ), Thread Scheduling, Multiprocessor Scheduling.
4. **Process Synchronization and Concurrency:** Race Condition, Critical Section Problem, Software & Hardware Solutions to critical section problem (Peterson's Solution and Test-and-Set lock), Mutex Locks, Semaphores, Classical Problems in Synchronization (Producer – Consumer Problem, Dining Philosophers Problem, Reader – Writer Problem) Monitors.
5. **Deadlock:** System Model, Deadlock Characteristics, Four Necessary Conditions of Deadlock, Resource Allocation Graphs, Deadlock Prevention & Avoidance (Banker's Algorithm), Deadlock Detection & Recovery.
6. **Memory Management:** Address Binding, Logical Addresses vs Physical Addresses, Contiguous Memory Allocation (Text Segment, Data Segment, Heap Segment, MFT, MVT; Fragmentation), Paging, Page Tables and Hierarchical Inverted Page Tables, Segmentation and Paged Segmentation.

7. **Virtual Memory:** Demand Paging, Performance of Virtual Memory, Page Replacement Algorithms (FIFO, OPTIMAL, LRU, LFU), Frame Allocation, Thrashing, Working Set Model, Memory Mapped Files.
8. **Storage Management, File Systems and Security:** File Concept, Access Methods, Directory Structure and Disk Structure, Free-Space Management, Disk Scheduling Algorithms, RAIDs, File System Reliability and Protection, Security of Operating System.

**Suggested readings:**


1. A. Silberschatz, P. B. Galvin, G. Gagne, Operating Systems Concepts, 10th Edition, Wiley,2018.
2. Andrew S. Tanenbaum, Herbert Bos, Modern Operating Systems, 4th Edition, Pearson, 2014, ISBN: 013359162X.
3. William Stallings, Operating Systems: Internals and Design Principles, 9th Edition,Pearson, 2017, ISBN: 0134670957.


## Digital Logic Design (DLD)

1. **Number Systems and Binary Arithmetic:** Numerical representation, number system conversions, data representations, Radix and Diminished Radix Complements and Binary Subtraction.
2. **Boolean Algebra and Reduction of Boolean Functions:** Basic theorems and properties of Boolean algebra, Boolean functions, standard forms (canonical forms) (minterms and maxterms), reduction of Boolean functions (K-maps and QuineMcCluskey method).
3. **Combinational Logic Circuits:** Design and analysis techniques, design of combinational circuits (using gates), adders, subtractors, converters, magnitude comparators, decoders, encoders, multiplexers and demultiplexers.
4. **Sequential Logic Circuits:** Latches, Flip-Flops (SR, D, JK, T), Analysis of clocked sequential circuits, State reduction and assignment, registers and Shift Registers.
5. **Synchronous and Asynchronous State Machines:** Ripple and synchronous counters, timing sequences, Mealy and Moore Finite State Machines.
6. **Memory Units and Programmable Logic Devices:** Random Access Memory (RAM), Read Only Memory (ROM), Programmable Logic Arrays (PLA's), CPLDs, FPGAs, logic families and digital integrated circuits.
7. **Hardware Description Languages and Circuit Simulations:** Overview of hardware description language (Verilog HDL/VHDL) and electronic design automation tools for digital logic simulation (MultiSim, SPICE or similar).

**Suggested readings:**


1. Fundamentals of Digital Logic with Verilog Design, Stephen Brown
2. M. Morris Mano, Digital Logic and Computer Design, 1st Edition, Pearson, 1979, ISBN:0132145103.
3. Thomas L. Floyd, Digital Fundamentals, 10th Edition, Prentice Hall, 2008, ISBN:0132359235.
4. Mano, M. M., & Ciletti, M. D. (2017). Digital design: With an introduction to the Verilog HDL, VHDL, and SystemVerilog (6th ed.). Pearson.
5. Yarbrough, J. M. (1996). Digital logic applications and design. Thomson Learning / Cengage.
6. Tocci, R. J., Widmer, N. S., & Moss, G. L. (2019). Digital systems: Principles and applications (12th ed.). Pearson.
7. Wakerly, J. F. (2007). Digital design: Principles & practices (4th ed.). Pearson.
8. Ciletti, M. D. (2010). Advanced digital design with the Verilog HDL (2nd ed.). Pearson.
9. Ercegovac, M. D., Lang, T., & Moreno, J. (1999). Introduction to digital systems. Wiley.

## SECTION -C

### Software Engineering

1. **Introduction and Process Models:** The nature of software engineering, the motivations behind software engineering, and professional software engineering. Traditional process models (Linear sequential, Prototyping, RAD, Incremental, Spiral) as well as Agile software development process frameworks are covered.

2. **Requirements Engineering:** Concepts of requirements elicitation and analysis, functional and non-functional requirements, and different perspectives on modeling such as context, interaction, structure and behavior as well as requirement tracing.

3. **Analysis and Modeling (structured and object-oriented):** Structured analysis (Data Flow Diagrams, State Transition Diagrams), UML modeling (Use Cases modeling, Activity Diagrams, Interaction Diagrams, Domain Modeling).

4. **Architectural and Component Level Design:** Architectural design patterns, Data design, component level design, User Interface Design and GRASP (Cohesion, Coupling, Information Expert, Creator, Controller, Polymorphism).

5. **Software Verification, Validation and Testing:** Software verification and validation approaches, criteria for measuring software correctness, efficiency and performance as well as technical reviews and the basics of software testing and test planning.

6. **Project Management and Evolution:** Software evolution, project planning and management, configuration management, software process improvement and software reliability and performance standards.

**Suggested readings:**


1. Software Engineering, A Practitioner's Approach, Pressman R. S.& Maxim B. R., 8th Edition, McGraw-Hill, 2015.
2. Ian Sommerville, Software Engineering, 10th Edition, Pearson, 2015, ISBN-13: 978-0133943030.
3. Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, Fundamentals of Software Engineering, 2nd Edition, Pearson, 2002, ISBN-13: 978-0133056990.


### Database Management Systems (DBMS)

1. **Introduction and File Systems:** Comparison of file systems vs database systems, data redundancy, structural data dependency, database environment, three-schema architecture, and data independence.
2. **Data Models and E-R Modeling:** Survey of data models (Hierarchical, Network, Relational, Object-oriented) and ER modeling.
3. **Relational Model and Relational Algebra:** Concepts related to relations, attributes, tuples, domains, keys, integrity constraints, and relational algebra operations (Selection, Projection, Cartesian product and Joins).
4. **SQL:** Data Definition Language (DDL), Data Manipulation Language (DML), complex queries, subqueries, grouping and aggregation, views and security/authorization mechanisms.
5. **Database Design and Normalization:** Functional dependencies, inference rules and normal forms (1NF, 2NF, 3NF, BCNF) within relational design.

6. **Physical Storage and Indexing:** Storage structure, file organization, indexed files, hashed files, B-tree structure, dense and sparse indices, and database tuning.
7. **Transactions, Concurrency Control, and Database Recovery:** Atomicity, consistency, isolation and durability, transaction processing, concurrency control using locking, two phase locking, timestamps and optimistic concurrency control, deadlock and database recovery mechanisms.
8. **Advanced and Emerging Databases:** Distributed databases, data warehousing, data mining, and NoSQL.

**Suggested readings:**


1. Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom
2. Database System Concepts, 6th Edition by Abraham Silberschatz, Henry F. Korth and S. Sudarshan.
3. Database Management Systems, 3rd Edition by Raghu Ramakrishnan, Johannes Gehrke
4. Carlos Coronel, Steven Morris, Database Systems: Design, Implementation & Management, 13thEdition, Cengage Learning, 2017. ISBN-10: 1337627909.
5. Introduction to Oracle 9i: SQL By Oracle Press
6. Jeffrey A. Hoffer, Ramesh Venkataraman, HeikkiTopi, Modern Database Management, 12th Edition, Pearson, 2015. ISBN-10: 0133544613.
7. Thomas Connolly, Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management, 6th Edition, Pearson, 2015. ISBN-10: 1292061189.
8. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, 7th Edition, Pearson, 2016. ISBN-10: 1292097612.


## Artificial Intelligence (AI)

1. **Introduction and Intelligent Agents:** The definition of artificial intelligence, Turing test, rationality, PEAS, agent architectures, and some classical AI systems (General Problem Solver, ELIZA, OPS-5, Common Lisp)
2. **Search Strategies and Adversarial Search:** Uninformed search (Breadth-first search, Depth-limited search, Depth-first search, Iterative Deepening Search); Informed search (Greedy Best-first, A*), Local Search (Hill climbing, Simulated Annealing), Game Theory, Minimax Algorithm, Alpha-Beta Pruning
3. **Knowledge Representation and Logic:** Propositional and Predicate Logic, Rule-Based Systems, Semantic Networks, Frames, Objects, Scripts, Forward and Backward Chaining, Resolution, Unification, Logic Programming (Prolog)
4. **Symbolic Mathematics and Probabilistic Reasoning:** Symbolic mathematics problem solvers (Macsyma, PRESS); Management of Uncertainty, Bayes' Rule, Naive Bayes models, Fuzzy sets, Genetic Algorithms.
5. **Foundations of Machine Learning:** Types of learning, Learning from Examples, Decision Trees, Linear Regression, Classification, Clustering, Evaluation Techniques.
6. **Neural Networks and Deep Learning:** Perceptron, Multilayer Perceptron (MLP), Backpropagation, and shift from classic architecture to deep learning and neural networks.
7. **Generative AI, Large Language Models, and Natural Language Processing (NLP):** NLP, Transformer Architecture (self-attention), Tokenization, Pre-training, Fine-Tuning, RAG (Retrieval-Augmented Generation), Vector Databases, Prompt Engineering (few-shot learning and chain-of-thought).
8. **AI Ethics, Safety and Future Trends:** Bias in models, Deepfakes, AI Privacy, Professional Ethics, Safety Alignment, Agentic Workflows (AutoGPT, considerations towards AGI).

**Suggested readings:**


1. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc., 1992.
2. Luger, G.F. and Stubblefield, W.A., "AI algorithms, data structures, and idioms in Prolog, Lisp, and Java", Pearson Addison-Wesley. 2009.
3. Severance, C.R., 2016. "Python for everybody: Exploring data using Python 3." Create Space Independent Publ Platform.
4. Miller, B.N., Ranum, D.L. and Anderson, J., 2019. "Python programming in context." Jones & Bartlett Pub.
5. Joshi, P., 2017. "Artificial intelligence with python." Packt Publishing Ltd
6. Artificial Intelligence: A Modern Approach by Stuart Russell & Peter Norvig, (4th Edition, Global Education, 2020); ISBN-13: 978-0134610993.
7. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow (3rd Ed. 2022) by Aurélien Géron.
8. Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play (2nd Ed. 2023) by David Foster
9. Deep learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville, the MIT press, (2018).
10. Artificial Intelligence-Structures &S trategies for Complex Problem Solving by George F. Luger, 5th Edition, Pearson Education (2008); ISBN-13: 978- 0321545893.
11. Luger, G. F. (2008). Artificial intelligence: Structures and strategies for complex problem solving (6th ed.). Pearson.


**Note: The above list is only suggestive and not exhaustive. Candidates may consult other standard books and relevant material covering the prescribed syllabus.**

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