Himachal Pradesh University, Shimla
('A' Grade, NAAC Accredited)

Scheme of Examination and Syllabus of
Ph.D. Course Work (Computer Science)
(CBCS)

DEPARTMENT OF COMPUTER SCIENCE

CBCS CURRICULUM (2025-26)
Ph.D. Course Work (Computer Science)
(For the Batches Admitted 2025 Onwards)

HIMACHAL PRADESH UNIVERSITY
Ph.D. Course Work (Computer Science)
Choice Based Credit System
(w.e.f. Session 2025-26 Onwards)

The course work for Ph.D. Computer science is as under:

Course Work	Paper Title	Credits	Workload per Week	Exam Time (Hrs.)	External Marks	Internal Marks	Max. Marks
Compulsory Subjects:							
PhD-CS-01	Research Methodology in Computer Science	4	4	3	75	25	100
PhD-CS-02	Research Ethics	4	4	3	75	25	100
Elective Subjects:							
PhD-E-01	Algorithm Analysis & Design	4	4	3	75	25	100
PhD-E-02	Advanced Software Engineering	4	4	3	75	25	100
PhD-E-03	Advanced Database Concepts	4	4	3	75	25	100
PhD-E-04	Advanced Network Technologies	4	4	3	75	25	100
PhD-E-05	Parallel Processing Architectures	4	4	3	75	25	100
PhD-E-06	Advanced Computer Architecture	4	4	3	75	25	100

The candidate has to qualify three papers i.e. Two compulsory subjects and one of the elective subject out of the list of given elective subjects. The examinations evaluation will be done external. The pass marks in each subject will be 50%. The candidate is required to pass Internal & External examination, separately. The internal evaluation will be done on the basis of one or more of the following criteria:

I. Term Examinations
II. Seminars
III. Assignments
IV. Regularity (Attendance)
V. Quiz etc.

PhD-CS-01: Research Methodology in Computer Science L:4 T:0 P:0

Course Objectives: This course is designed to equip students in computer science with the essential skills and knowledge needed to conduct rigorous and effective research. It covers various research methodologies, techniques, and ethical considerations relevant to the field.

UNIT-I

Introduction to Research Methodology: Overview of research in computer science, Types of research: Basic, Applied, and Experimental, Research paradigms: Positivism, Interpretivism, and Pragmatism, Formulation of research problems and objectives.
Literature Review: Importance of literature review in research, Conducting a systematic literature review, Critical analysis and synthesis of existing research, Identifying research gaps.

UNIT-II

Research Design and Planning: Experimental design, Survey design, Case study design, Mixed-methods research, Sample selection and size determination. Data Collection Methods: Quantitative data collection techniques (Surveys, experiments, observations), Qualitative data collection techniques (Interviews, focus groups, case studies), Ethical considerations in data collection.

UNIT-III

Data Analysis Techniques: Quantitative data analysis using statistical tools (Descriptive Statistics, Inferential Statistics, Data Visualization, Statistical Software), Qualitative data analysis techniques (Thematic analysis, content analysis, grounded theory), Computer-assisted data analysis tools (Programming Languages and Libraries, Database Management Systems, Statistical Software, Data Visualization Tools). Emerging Trends in Computer Science Research and Advanced Data Analysis Techniques: Exploration of current research trends and hot topics, Overview of advanced data analysis techniques in computer science research, Introduction to machine learning for data analysis, Big data analytics and tools in computer science research (Hadoop, Apache Spark, NoSQL Databases, Apache Flink, Tableau).

UNIT-IV

Significance of Report Writing: Different Steps in writing Report, Layout of the Research Report, Types of Reports, Mechanics of Writing a Research Report, Art of scientific writing- Steps to better writing, flow method, organization of material and style, Drawing figures, graphs, tables, footnotes, references etc. in a research paper. Use of Internet in Research Work: Use of internet networks in research activities.

References:

1. Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.
2. Wallwork, A (2016). English for Writing Research Papers.
3. Booth, W. C., Colomb, G. G., & Williams, J. M. (2008). The Craft of Research.
4. Silverman, D. (2016). Qualitative Research.

Course Outcomes:

By the end of this course, the student will be able to:
Co1: demonstrate proficiency in conducting a systematic literature review.
CO2: understand and apply various research paradigms and methodologies relevant to computer science.
CO3: formulate research problems and objectives based on a solid understanding of research design principles.
CO4: apply quantitative and qualitative data analysis techniques.
CO5: develop effective communication skills for presenting research findings.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.

PhD-CS-02: Research Ethics **L:4 T:0 P:0**

Course Objectives: This course aims to familiarize students in computer science with ethical principles and guidelines governing research conduct. It explores the unique ethical challenges within the field and equips students with the knowledge and skills to conduct research responsibly and with integrity.

UNIT-I

Introduction to Research Ethics: Overview of research ethics, Historical perspectives and landmark ethical cases, The role of ethics in computer science research; Ethical Principles in Research: Fundamental ethical principles (e.g. autonomy, beneficence, justice), Application of ethical principles in computer science research, Case studies illustrating ethical dilemmas in research.

UNIT-II

Informed Consent and Human Subjects Research: Importance of informed consent, Guidelines for obtaining informed consent in human subjects research, Ethical considerations in human-computer interaction studies; Privacy and Data Protection: Privacy concerns in computer science research, Responsible handling of sensitive data, Legal and ethical aspects of data protection.

UNIT-III

Intellectual Property and Plagiarism: Understanding intellectual property rights, Ethical use of software, algorithms, and data-sets, Strategies to avoid plagiarism and maintain academic integrity; Emerging Ethical Issues in Computer Science: Ethical considerations in artificial intelligence and machine learning, Autonomous systems and ethical decision-making, Ethical implications of Cyber security research.

UNIT-IV

Research Collaboration and Authorship: Ethical collaboration in interdisciplinary research, Guidelines for authorship and contributor-ship, Addressing conflicts of interest in collaborative projects; Responsible Research Communication: Ethical publication practices, Peer review and ethical responsibilities of reviewers, Ethical use of social media and online platforms for research communication.

References:

1. Shamoo, A. E., & Resnik, D. B. (2015). Responsible Conduct of Research.
2. Steneck, N. H. (2007). Introduction to the Responsible Conduct of Research.
3. Macrina, F. L. (2014). Scientific Integrity: Text and Cases in Responsible Conduct of Research.

Course Outcomes:

By the end of this course, the student will be able to:
CO1: understand the Fundamental Ethical Principles such as autonomy, beneficence, and justice, and their application in the context of computer science research.
CO2: apply ethical principles to address specific challenges and dilemmas that arise in computer science research, including issues related to privacy, data protection, intellectual property, and emerging technologies.
CO3: gain competence in obtaining informed consent, addressing privacy concerns, and ensuring ethical conduct in research involving human subjects, with a particular emphasis on the unique considerations in human-computer interaction studies.
CO4: develop an awareness of and sensitivity to emerging ethical issues in computer science, including those related to artificial intelligence, machine learning, autonomous systems, and cyber security.
CO5: understand the importance of responsible research conduct, including issues related to authorship, collaboration, and responsible communication of research findings.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.

PhD-E-01: Algorithm Analysis & Design **L:4 T:0 P:0**

Course Objectives: This course provides a comprehensive understanding of fundamental algorithms and data structures essential for solving complex computational problems efficiently. As part of this course, students will be introduced to algorithm analysis, design techniques, data structures, sorting and searching algorithms, graph algorithms, and advanced algorithmic techniques. Students will learn how to analyze, design, and implement efficient algorithms to tackle real-world problems effectively.

UNIT-I

Introduction: Algorithms, Analyzing Algorithms, Designing Algorithms, Asymptotic Notations. Data Structures: Elementary.
Data Structures, Hash Tables, Binary Search Trees, Red Black Trees, Skip lists, Binomial Heaps, Fibonacci Heaps, Perfect Hashing, Cuckoo Hashing.

UNIT-II

Design and Analysis Techniques: Divide-and-conquer, Dynamic Programming, Greedy Method, Amortized Analysis.
Sorting & Searching: Simple Sorting Algorithms, Radix Sorting, Heap sort, Quick sort, Linear and Binary search algorithms.

UNIT-III

Algorithms on Graphs: Elementary Graph Algorithms, Single Source Shortest Paths, All Pairs Shortest Paths, Minimum spanning trees, Steiner trees.

UNIT-IV

Advanced Algorithms: Matrix operations, String Processing, Approximation Algorithms.

References:

1. Cormen T.H., Leiserson C.E., Rivest R.L., Introduction to Algorithms Prentice Hall India.
2. Horowitz E., Sahni S., Rajasekaran S., Computer Algorithms, Galgotia Publications.
3. Aho A.V., Hopcroft J.E. Ullman J.D., The Design and Analysis of Computer Algorithms, Pearson Education Asia.
4. Knuth D.E., The Art of Computer Programming Volume 1 (Fundamental Algorithms), Narosa Publishing House.
5. Knuth D.E., The Art of Computer Programming Volume 3 (Sorting and Searching), Addison- Wesley.

Course Outcomes:

By the end of this course, the student will be able to:
CO1: understand time and space complexity of algorithms using asymptotic notations such as Big O, Omega, and Theta.
CO2: design algorithms using various techniques including divide-and-conquer, dynamic programming, and greedy methods, with an emphasis on efficiency and correctness.
CO3: implement and utilize elementary data structures such as arrays, linked lists along with advanced data structures including hash tables, binary search trees, and heaps.
CO4: develop critical thinking and problem-solving skills necessary for algorithm design, analysis, and implementation through practical exercises, assignments, and projects.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.

PhD-E-02: Advanced Software Engineering **L:4 T:0 P:0**

Course Objectives: This course delves into the principles and practices of software project management, software configuration management, software quality assurance, software reuse, and software re-engineering. Through theoretical study and case studies, students will gain insights into effective software project planning, configuration management, quality assurance techniques, and strategies for software re-engineering.

UNIT-I

Software Project Management: Software Project Planning, Conventional Software Management, Evolution of Software Economics, Improvement of Software Economics, Project Metrics.

UNIT-II

Software Configuration Management: Configuration Management, Change Management, Version Management, Build and Release Management.
Software Quality: Introduction, Software Quality Assurance, Quality Models, Study of Quality Metrics.

UNIT-III

Software Reuse: Motivation, Inhibitors, Techniques - Component Based Software Engineering, Process Models, Reuse Metrics.

UNIT-IV

Software Re-engineering: Introduction Re-engineering, Restructuring and Reverse Engineering, Re-engineering existing systems, Data Reengineering and migration, Software Reuse and Reengineering, Reengineering Metrics.

References:

1. Walker Royce, "Software project management", Pearson Education, ISBN: 9780201309584, 2004.
2. Robert S. Arnold, "Software Re-engineering", IEEE Computer Society.
3. R. Pressman, "Software Engineering: A Practitioner’s Approach", McGraw Hill.
4. Pankaj Jalote, "An Integrated Approach to Software Engineering", Narosa Publishers, 1992.
5. Ghezzi, Carlo, "Fundamentals of Software Engineering", Prentice Hall India.

Course Outcomes:

By the end of this course, the student will be able to:
CO1: understand software project planning, scheduling, resource allocation, risk management, and project metrics to effectively manage software projects throughout their lifecycle.
CO2: analyze factors influencing software cost estimation, productivity, and profitability, leading to improved decision-making in software project management.
CO3: implement software configuration management practices including version control, change management to ensure consistency, reliability of software artifacts.
CO4: evaluate the effectiveness of software re-engineering efforts using appropriate metrics and assess the impact on software quality.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.

PhD-E-03: Advanced Database Concepts L:4 T:0 P:0

Course Objectives: The goal of this course is to teach the database analysis and design techniques, covering various methodologies for designing databases at conceptual, logical, and physical levels. The course aims to impart knowledge on the concepts related to normalization theory, distributed databases concepts, object-oriented database management systems, data warehousing, and data mining. Course also offers an understanding of how databases are administered in diverse settings, with a specific emphasis on the security protocols integrated within database management systems.

UNIT-I

Data Base Analysis and Design Techniques: Database Design Methodologies: Conceptual, Logical, Physical Designs, ER Modeling: Specialization, Generalization, Aggregation, Normalization Theory.

UNIT-II

Distributed Databases Concepts: Functions and Architecture of a DDBMS, Data Allocation, Fragmentation and Query Optimization, Transparencies in DDBMS.

UNIT-III

Object Oriented DBMSS Concepts and Design: Abstraction, Encapsulation, object Identity, Methods, Classification and Inheritance, Overloading, Overriding, Polymorphism, Complex Objects, storing objects in Relational Databases, Pointer swizzling techniques, Persistence schemes, versions and schema evolution, Object Relational Databases and Nested Relational model.

UNIT-IV

Data Warehousing: Introduction, Decision Support, Creating and Maintaining a Warehouse, OLAP, Multidimensional Data Model, Data Warehouse Architecture, OLAP and Data Cubes, Operations on Cubes, Data Preprocessing, Need for Preprocessing, Multidimensional Data Model, Study of Data preprocessing, Need for Preprocessing, Simulating and maintaining a Warehouse, Analysis of Data preprocessing.
Data Mining: Introduction, Data Mining Functionalities, Clustering - k means algorithm, Classification - Decision Tree, Baysian Classifiers, Outlier Analysis, Association Rules - Apriori Algorithm, Introduction to Text Mining, Implementing Clustering - k means algorithm, Analysis of Decision tree.

References:

1. Thomas Conolly, Carolyn Begg, "Database Systems", Pearson Education, Third Edition.

2. Navathe and Ellmassri, " Fundamentals of Database Systems" , Pearson Education, Fourth Edition.

Course Outcomes:

By the end of this course, the student will be able to:
CO1: understand the functions and architecture of distributed database management systems, including data allocation and fragmentation to effectively manage distributed data.
CO2: implement distributed database concepts, object-oriented database techniques, data warehousing, and data mining algorithms using appropriate software tools.
CO3: analyze and evaluate database solutions based on their performance, scalability, reliability, and usability and make informed decisions for database design.
CO4: Apply database analysis and design techniques to solve real-world problems in various domains such as business, healthcare and finance.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.

PhD-E-04: Advanced Network Technologies **L:4 T:0 P:0**

Course Objectives: The key objective is to acquire a foundational understanding of data link layer protocols, network design issues and transport layer protocols. As part of this course, students will be introduced to flow control, error control, MAC protocols, IEEE standards, routing algorithms, authentication, email security, security attacks, prevention techniques, IP security, and wireless LANs.

UNIT-I

Data Link Layer: Framing techniques, Flow control, Error Control, data link protocols, MAC protocols and IEEE standards.

UNIT-II

Network & Transport layer design Issues: Routing algorithms, Congestion control algorithms, Internetworking, Services and elements of Transport protocols.
Network Security: Authentication & E mail Security, Security attacks and their preventions.

UNIT-III

IP Security: IP security overview, IP Security Architecture, Authentication Header Encapsulating Security Pay load.

UNIT-IV

Wireless LANs: Introduction, Benefits, WLANs Configurations and Standards, Security, IEEE 802.11, Wireless LAN Standard, Blue tooth.

References:

1. B.A. Forouzan, "Data Communication & Networking", McGraw Hill.
2. A.S. Tanenbaum, "Computer Networks", Prentice Hall, 3rd Edition.
3. William Stallings, "Data & Computer Communication", McMillan Publishing Co.
4. Black, "Data Networks", Prentice Hall India, 1988.
5. Fred Halsall, " Data Communications, Pearson Education.

Course Outcomes:

By the end of this course, the student will be able to:
CO1: understand data link layer protocols, including framing techniques and MAC protocols, to ensure reliable and efficient data transmission over communication channels.
CO2: implement data link layer protocols, network design principles, and security mechanisms using simulation tools, network emulators.

CO3: analyze network performance metrics, identify bottlenecks, and optimize network resources for efficient data transmission to enhance network security posture.

CO4: apply network design principles, security best practices, and industry standards to design secure, scalable, and resilient computer networks.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.

PhD-E-05: Parallel Processing Architectures **L:4 T:0 P:0**

Course Objectives: This course offers an introduction to parallel processing, covering fundamental concepts, architectures, and programming techniques. Course delves into Flynn's classification, SIMD (Single Instruction, Multiple Data) and MIMD (Multiple Instruction, Multiple Data) operations, shared memory versus message passing multiprocessors, distributed shared memory systems, and hybrid multiprocessors. Through theoretical study and case studies, students will gain a comprehensive understanding of parallel processing principles and applications.

UNIT-I

Introduction to Parallel Processing: Flynn’s classification, SIMD and MIMD operations, Shared Memory vs. message passing multiprocessors, distributed shared memory, Hybrid multiprocessors.

UNIT-II

Shared Memory Multiprocessors: SMP and CC-NUMA architectures, Cache coherence protocols, Consistency protocols, Data pre-fetching, CCNUMA memory management, SGI 4700 multiprocessor, Network Processors.

UNIT-III

Interconnection Networks: Static and Dynamic networks, switching techniques, Routers, Internet techniques.

UNIT-IV

Message Passing Architectures: Message passing paradigms, Grid architecture, Workstation clusters, User level software.
Scheduling: Multiprocessor Programming Technique, Scheduling and mapping, Internet web servers, P2P, Content aware load balancing.

References:

1. Michael J. Quinn, "Parallel Computing: Theory and Practice", Tata McGraw-Hill.
2. C. Xavier and S. S. Iyenger, "Introduction to Parallel Algorithms", Wiley Interscience Publication.
3. Wilkinision, "Parallel Programming" , Prentice Hall India.

Course Outcomes:

By the end of this course, the student will be able to:
CO1: understand parallel processing concepts including Flynn’s classification, cache coherence protocols, consistency protocols and switching techniques.
CO2: implement parallel processing systems using appropriate software tools and

parallel programming paradigms.
CO3: analyze the performance and scalability of parallel processing systems under different workloads to improve system efficiency and throughput.
CO4: apply parallel processing concepts and techniques to solve real-world problems in diverse domains such as scientific computing, data analytics and image processing.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.

PhD-E-06: Advanced Computer Architecture L:4 T:0 P:0

Course Objectives: This course provides an exploration of parallelism within Uniprocessor systems and various parallel computer structures. It covers trends in parallel processing, basic Uniprocessor architecture, parallel processing mechanisms, pipeline computers, array computers, and multiprocessor systems. Through theoretical study and practical examples, students will gain a comprehensive understanding of parallelism concepts and their applications in both Uniprocessor and multiprocessor systems.

UNIT-I

Parallelism in Uniprocessor Systems: Trends in parallel processing, Basic Uniprocessor Architecture, Parallel Processing Mechanism.
Parallel Computer Structures: Pipeline Computers, Array Computers, Multiprocessor Systems.

UNIT-II

Architectural Classification Schemes: Multiplicity of Instruction-Data Streams, Serial versus Parallel Processing, Parallelism versus Pipelining.
Pipelining: An overlapped Parallelism, Principles of Linear Pipelining, Classification of Pipeline Processors, Superscalar Pipeline Design, Superpipelined Design.

UNIT-III

Structures for Array Processors: SIMD Array Processors, SIMD Computer Organizations, Inter-PE Communications.
SIMD Interconnection Networks: Static versus Dynamic Networks, Mesh Connected Illiac Network, Cube Interconnection Networks.

UNIT-IV

Multiprocessor Architectures: Functional Structures: Loosely Coupled Multiprocessors, Tightly Coupled Multiprocessors.
Interconnection Networks: Time Shared for Common Buses, Crossbar Switch and Multiport memories.

References:

1. Faye A. Briggs, "Computer Architecture and Parallel Processing", McGraw-Hill International Editions.
2. John D. Carpinelli, "Computer Systems Organization & Architecture", Addison Wesley.

Course Outcomes:

By the end of this course, the student will be able to:
CO1: understand about parallel processing mechanisms such as instruction-level parallelism (ILP) and data-level parallelism (DLP).
CO2: gain proficiency in pipelining techniques including linear pipelining, superscalar pipeline design, and superpipelined design.
CO3: explore static versus dynamic SIMD interconnection networks such as mesh-connected networks and cube interconnection networks.
CO4: analyse loosely coupled and tightly coupled multiprocessor architectures used to connect multiple processing units for parallel computation.

Note: In each theory paper, nine questions are to be set. Two questions are to be set from each Unit and candidate is required to attempt one question from each unit. Question number nine will be compulsory, which will be of short answer type with 5-10 parts, out of the entire syllabus. In all, five questions are to be attempted.