College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Computer Engineering and Information Technology

Curriculum Structure & Detailed Syllabus (UG Program)

Honors and Minor Certification in Computer Engineering

(Revision: A.Y. 2016-17, Effective from: A.Y. 2017-18)

List of Minors and Honors from Semester V to VIII

No.	Semester	Minor Course	Honors Course	Lectures	Credits
1	V	Data Structures, Files and Algorithms	Advanced Data Structures	3	3
2	VI	Object Oriented Programming and Design	Advanced Database Management Systems	3	3
3	VII	Database Management Systems	Advanced Computer Networks	3	3
4	VIII	Internet Technologies	Multicore Technologies	3	3

Minor Course

(CT -) Data Structures, Files and Algorithms

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
Programming Tasks/Quizzes – 40 marks
End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

Write neat code by selecting appropriate data structure and demonstrate a working solution for a given problem.

Demonstrate the ability to implement different data structures with variety of implementations.

Analyze and compare given algorithms for time and space complexity.

Unit I : Introduction: Concept of Data types and Abstract Data types; Characteristics of an algorithm; Analyzing programs; Frequency count; Time and space complexity; Big 'O' and Ω‟ notation; Best, average and worst cases; Programming language provided data types, operations on various data types; Dangling pointers and garbage memory **[4 Hrs]**

Unit II : Arrays, Searching and Sorting: Searching: linear and binary search algorithm; Hashing: hashing functions, chaining, overflow handling with and without chaining, open addressing: linear, quadratic probing; Sorting: bubble sort, selection sort, quick sort, merge sort, insertion sort. Time complexity analysis of searching and sorting techniques. **[8 Hrs]**

Unit III: Files: Files handling: various library functions for handling files; system call interface and library interface; Different file formats like csv, pdf, odt, etc; Text and binary files; Programs to copy, concatenate, rename files; Programs to handle existing file types; arguments to main(); **[6 Hrs]**

Unit IV : Stacks and Queues: Stack and queue as ADT; Operations on stack and queue; Implementations using arrays and dynamic memory allocation; Application of stack for expression evaluation, expression conversion; Recursion and stacks; Problems like maze and knight's tour. **[6 Hrs]**

Unit V : Lists: List as ADT; Concept of linked organization of data against linked list; Singly linked list, doubly linked list, circular linked list; Representation & manipulations of polynomials/sets using linked lists; Dynamic memory management; Representation of sparse matrix; Addition and transpose of sparse matrix; Polynomials; Representing Numbers **[8 Hrs]**

Unit VI : Trees: Basic terminology; Binary trees and its representation; Binary tree traversals (recursive and non recursive) and various operations; Insertion and deletion of nodes in binary search tree; Applications of trees. **[8 Hrs]**

Text Books:

- E. Horowitz, S. Sahni, S.Anderson-freed, “Fundamentals of Data Structures in C”, Second Edition, University Press, ISBN 978-81-7371-605-8
- B. Kernighan, D. Ritchie, “The C Programming Language”, Prentice Hall of India, Second Edition, ISBN 81-203-0596-5

Y. Langsam, M. Augenstin and A. Tannenbaum, “Data Structures using C”, Pearson Education Asia, First Edition, 2002, ISBN 978-81-317-0229-1

Reference Books:

- Ellis Horowitz, S. Sahni, D. Mehta “Fundamentals of Data Structures in C++”, Galgotia Book Source, New Delhi 1995 ISBN 16782928
- Jean-Paul Tremblay, Paul. G. Soresan, “An introduction to data structures with Applications”, Tata Mc-Graw Hill International Editions, 2nd edition 1984, ISBN-0-07-462471-7

Minor Course

(CT-) Object Oriented Programming and Design

Teaching Scheme:
Lectures: 3 Hr/week

Examination Scheme:
Programming Tasks/Quizzes – 40 marks
End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

1. Design a class hierarchy using object oriented thinking for a given problem.
2. Write object oriented application code for a given problem.
3. Write small pieces of code demonstrating various object oriented programming concepts.
4. Describe, annotate, compare, and comment on various object oriented programming concepts.

Unit I: Introduction: Various programming paradigms: Procedural, object-oriented, logic and functional, concurrent programming. Classes, Objects, Methods; Data types provided by OO languages; Input/Output mechanisms; Abstract Data Types; Private, public, protected members; **[8 Hrs]**

Unit II: Encapsulation; Constructors, Destructors; Polymorphism; Access specification **[6 Hrs]**

Unit III: Inheritance; Multiple Inheritance; Class hierarchies; Virtual Functions; **[8 Hrs]**

Unit IV: Templates; Generic Programming; , Packages; Interfaces. Iterators; Containers. **[8 Hrs]**

Unit V: Exception Handling & File I/O: Exception handling, Exception types, file I/O. **[6Hrs]**

Unit VI: Multi-Threaded Programming: Concurrent Programming, Basic Concepts of Concurrent Programming, Threads. Design: Unified Modelling language; use case diagrams; Class Diagrams; **[6Hrs]**

Text Books:

- Cay S Horstmann and Gary Cornell, Core Java Vol-1 and Vol-2, 9th Edition, Pearson Education India, ISBN-10: 9332518904 and 9332518890
- Bjarne Stroustrup, The C++ Programming Language, 3th Edition, Pearson Education, ISBN-10: 8131705218
- E. Balagurusamy, Object Oriented Programming with C++, 6th Edition, McGraw Hill, ISBN-10: 125902993X

Reference Books:

- Herbert Schilt, “JAVA Complete Reference”, 7th Edition, Tata McGraw Hill, ISBN: 9780070636774
- Sharon Zakhour, Scott Hommel, Jacob Royal, Isaac Rabinovitch, Tom Risser, Mark Hoeber, “The Java Tutorial,”Addison Wesley Professional, 2006, Print ISBN-10: 0-321-33420-5
- M. Ben Ari, “Principles of Concurrent Programming, 1989
- Eckel B., "Thinking in Java", 3rd Edition, Pearson Education, 2012

Minor Course

Sem VII: (CT) Database Management Systems

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
Assignment/Quizzes – 40 marks
End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

1. Construct Entity-Relationship Model for given applications and Relational Model for the same.
2. Design and write SQL queries for given problems
3. Normalization to database design
4. Describe, compare, and solve analytical problems based on storage mechanisms, and transactions

Unit I : Introduction: Basic Concepts: Database System Application, Purpose of Database Systems, View of data, Data base languages, Database Architecture: Components of DBMS and overall structure of DBMS **[4 Hrs]**

Unit II : E-R and Relational Model: Database Design and the E-R Model: Modeling, entity, attributes, relationships, constraints, Components of E-R Model. Relational Model: Basic concepts. Attributes and domains, concept of integrity and referential constraints, schema diagram.. **[6 Hrs]**

Unit III : Relational Algebra and SQL: Fundamental relational algebra operations, Additional relational algebra operations, Extended relational algebra operations ,null values, Modification to database, SQL: Basic structure and operations, Aggregate functions ,Nested subqueries , Complex queries, Views. **[8 Hrs]**

Unit IV : Relational Database Design: Basic concept of normalization, Decomposition using Functional dependencies. **[6 Hrs]**

Unit V : Indexing and Hashing : Basic of query processing, Basic concepts, Indices, B+ trees and B tree index file, static and Dynamic hashing **[6 Hrs]**

Unit VI : Transactions and Concurrency control: Transaction: Basic concepts, States, concurrent execution, serializability, Recoverability, Isolation. Concurrency control: timestamps and locking protocols, validation Based protocols, Multiple granularity protocols, Deadlock handling, Recovery **[8 Hrs]**

Text Books:

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, “Database system concepts”, 5th Edition, McGraw Hill International Edition.
2. Raghu Ramkrishnan, Johannes Gehrke, “Database Management Systems”, Second Edition, McGraw Hill International Editions

Reference Books:

1. Rob Coronel, “Database systems : Design implementation and management”, 4th Edition, Thomson Learning Press.
2. Ramez Elmasri and Shamkant B. Navathe, “Fundamental Database Systems”, 3rd Edition, Pearson Education, 2003

Minor Course

Sem VIII: (CT) Internet Technologies

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hrs/week	Assignment/Quizzes – 40 marks End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

1. Describe, draw diagrams, solve analytical problems based on, structure of computer networks.
2. Describe, solve analytical problems based on, networking protocols
3. Create WWW pages to serve as front-end for Internet applications
4. Demonstrate the ability to write server side and client side programs.

Unit I: Introduction: Introduction to Internet, Evolution of Internet, Internet applications, Protocols and Standard, Important Internet Services: WWW, File Transfer, Email, DNS, Remote Access: Telnet, SSH, Search Engines, Browser Basics **[6 hrs]**

Unit II: Computer Network – Overview: Introduction to computer network, OSI Model: Layered Architecture, Functions of the layers, Peer-to-Peer Processes, Encapsulation, TCP/IP protocol suite: Addressing, Packet forwarding, Introduction to UDP. **[8 hrs]**

Unit III: Web Essentials: Clients, Servers, Communication, HTTP Request Message, HTTP Response Message, Web Clients, Generations of web applications. **[6 hrs]**

Unit IV : Markup languages : An Introduction to HTML, Fundamental HTML Elements head, body etc. Document publishing, Introduction to XML. Introduction to Cascading Style Sheets, CSS features, CSS syntax, Style properties of text, box, layout, list, table, cursor etc **[6 hrs]**

Unit V : Client-Side Programming : Introduction to JavaScript, Basic Syntax, Variables and Data Types, Statements, Operators, literals, functions. Javascript Objects – properties, references, methods, constructors. Arrays, other built-in objects. Debugging javascript. Browsers. **[6 hrs**]

Unit VI : Server-Side Programming : PHP - Client Request – form data, request headers. Server Response - HTTP Status Codes, HTTP Response Headers. Sessions, Cookies, URL Rewriting. Introduction to Web services. **[8 hrs]**

Text Books:

1. Jeffrey C.Jackson, "Web Technologies : A Computer Science Perspective", Pearson Education, 2nd edition, 2007
2. B. A. Forouzan and Firouz Mosharraf, Computer Networks, A Top-Down Approach, Tata McGraw-Hill, 2012

Reference Books:

1. A S Tanenbaum, “Computer Networks”, 4th Edition, Pearson Education, ISBN 9788177581652
2. Marty Hall, Larry Brown, "Core Web Programming", Pearson Education, 2nd Edition, 2001.
3. Robert. W. Sebesta, "Programming the World Wide Web", Pearson Education, 4th Edition, 2007.
4. H.M. Deitel, P.J. Deitel and A.B. Goldberg, "Internet & World Wide Web: How To Program", Pearson Education, 3rd Edition, 2006.

Honors Course

(CT(HO) - 17001) Advanced Data Structures

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
Assignment/Quizzes – 40 marks
End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

1. Understand operations associated with advanced data structures such as priority queues, dictionary structures, multi-dimensional data structures etc.
2. Analyze the time and space complexity of the operations associated with the advanced data structures and there by appreciate the use of these structures
3. Use advanced data structures to solve real life problems

Unit I : Review of Basic Concepts: Abstract data types, Data structures, Algorithms, Big Oh, Omega and Theta notations, Solving recurrence equations, Amortized complexity **[4 Hrs]**

Unit II : Priority Queues: Leftist Heap, Skew Heaps, Binomial, Fibonacci and Pairing Heaps, Double ended priority queues **[6 Hrs]**

Unit III: Dictionary Structures: Hash Tables, Universal hash functions, Balanced Binary Search Trees, Splay Trees, 2-3 trees, 2-3-4 trees, Red-black trees, Skip lists, Randomized Dictionary Structures, Treaps. **[6 Hrs]**

Unit IV : Multidimensional and Spatial Structures: Interval, Segment, Range, and Priority Search Trees, Quadtrees and Octrees, R-trees. **[8 Hrs]**

Unit V : Miscellaneous Topics: Persistent Data Structures, Cache-Oblivious Data Structures

[8 Hrs]

Unit VI: Applications: IP Router Tables, Data Structures in Web Information Retrieval, Computational Biology, Geographic Information Systems, Computational Geometry: Geometric data structures. **[8 Hrs]**

Text Books:

- Advanced Data Structures; by Prof Peter Brass; Cambridge University Press; ISBN-10: 1107439825; ISBN-13: 978-1107439825
- Introduction to Algorithms; 3rd Edition; by by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein; PHI Learning Pvt. Ltd.; ISBN-10: 0262033844; ISBN-13: 978-0262033848

Reference Books:

- Handbook of Data Structures and Applications; by Dinesh P. Mehta (Editor), Sartaj Sahni (Editor); Chapman and Hall/CRC; ISBN-10: 1584884355;ISBN-13: 978-1584884354

Internet Resources:

- MIT OpenCourseWare
  https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-851-advanced-data-structures-spring-2012/index.htm
- COP 5536: Advanced Data Structures: Prof. Sartaj Sahni, University of Florida
  https://www.cise.ufl.edu/~sahni/cop5536/

Honors Course

(CT(HO)-17002) : Advanced Database Management Systems

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hrs/week	Assignment/Quizzes – 40 marks End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

1. Explain concepts of parallel, distributed databases, data warehousing and OLAP
2. Exploit big data platforms like Hadoop and NOSQL databases
3. Identify, Compare and Choose the right data models

Unit I : Parallel Databases : Introduction, I/O Parallelism, Inter-query and Intra-query Parallelism, Inter-operational and Intra-operational Parallelism, Design of Parallel systems. **[6 Hrs]**

Unit II : Distributed Databases : Homogeneous and Heterogeneous databases, Storing data in distributed DBMS, Distributed catalog management. **[6 Hrs]**

Unit III: Distributed Transactions: Distributed Transactions and Query processing, Distributed Concurrency and recovery. **[8 Hrs]**

Unit IV : Data Warehouse and OLAP: Introduction to Decision Support, Data Warehousing, Creating and maintaining a warehouse. OLAP: Multidimensional data Model, OLAP Queries, Database design for OLAP, Implementation Techniques for OLAP Bitmap Indexes, Join Indexes, Views and decision support, Top N Queries, Online Aggregation. **[8 Hrs]**

Unit V : XML : Introduction, Structure of XML Data, XML Document Schema, Querying and Transformation, API to XML, Storage of XML Data, XML Applications. **[6 Hrs]**

Unit VI: Advanced Topics : Hadoop / Map Reduce, No SQL Databases **[6 Hrs]**

Text Books:

- Abraham Silberschatz, Henry F. Korth, S. Sudarshan, “Database system concepts”, 5th Edition , McGraw Hill International Edition.
- Raghu Ramkrishnan, Johannes Gehrke, “Database Management Systems”, Second Edition, McGraw Hill International Editions

Reference Books:

- Rob Coronel, Database systems: “Design implementation and management”, 4th Edition, Thomson Learning Press.
- J. D. Ullman, Principles of Database Systems, Galgotia Publication, 2nd Edition, 1999.

- R. Elmasri, and S. Navathe, Fundamentals of Database Systems, Benjamin Cummings, Pearson, 6th Edition, 2010.

Honors Course

Sem VII: Advanced Computer Networks

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hrs/week	Assignment/Quizzes – 40 marks End Sem Exam - 60 marks

Course Outcomes:

Students will be able to

I. Understand issues in the design of network processors and design network systems
II. Analyze different possible solutions for communications at each network layer
III. Simulate working of wired and wireless networks to understand networking concepts
IV. Develop solutions by applying knowledge of mathematics, probability, and statistics to network design problems
V. Understand and Compare various storage and networking technologies

Unit 1: Internetworking: Routing Algorithms, Congestion Control, Quality of Service, Queue Management, High Speed Networks, Performance Modeling and Estimation

Unit 2: IPv6: IPv4 deficiencies, patching work done with IPv4, IPv6 addressing, multicast, Anycast, ICMPv6, Neighbour discovery, Routing

Unit 3: Software Defined Networking and OpenFlow: Centralized and Distributed Control and Data Planes, SDN Controllers, Data Center Concepts, Network Function Virtualization, Mininet, Programming SDNs, Openflow Switch, Wire Protocol, Openstack Neutron plug-in

Unit 4: Ad Hoc Wireless Networks : MAC Protocols for Ad Hoc Wireless Networks, Routing Protocols for Ad Hoc Wireless Networks, Multicast routing in Ad Hoc Wireless Networks, Transport Layer and Security Protocols for Ad Hoc Wireless Networks, Quality of Service in Ad Hoc Wireless Networks.

Unit 5: Network management Protocols: SNMPv1 Network Management: Organization and Information Models, SNMPv2: major changes, SNMPv3, RMON, Network Management Tools, Systems, and Engineering, Network Management Applications

Unit 6: Storage and Networking: Storage and Networking Concepts, Fiber Channel Internals, Fiber Channel SAN Topologies, Fiber Channel Products, IP SAN Technology, IP SAN Products, Management of SANs, SAN Issues

Text Books:

- Thomas D NAdeau and Ken Grey, Software Defined Networking, O'Reilly, 2013
- Pete Loshin IPv6, Theory, Protocols and Practiice, Morgan Kaufmann, 2nd Edition, 2004
- Mani Subramanian, Timothy A. Gonsalves,N. Usha Rani; Network Management: Principles and Practice; Pearson Education India, 2010

References

- William Stallings, High-Speed Networks and Internets, Pearson Education, 2nd Edition, 2002.
- C. Siva Ram Murthy, B.S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall, 2004
- Muthukumaran B, Introduction to High Performance Networks, Tata Mc Graw Hill, 2008
- Tom Clark, Designing Storage Area Networks, A Practical Reference for ImplementingFibre Channel and IP SANs, Addison-Wesley Professional, 2nd Edition, 2003.

Honors Course

Sem VIII: (CT) Multicore Technology

Teaching Scheme:
Lectures : 3 Hrs/week

Examination Scheme:
Assignment/Quizzes – 40 marks
End Sem Exam - 60 marks

Course Outcomes:

Students will be able to:

1. Understand the working principles of multicore architectures.
2. Optimize performance of multicore systems.
3. Specify the necessity of GPU.
4. Comprehend and differentiate between CPU and GPU.
5. Identify and demonstrate the need of domain specific architectures.

Unit I :Introduction to Multicore Systems: Fundamentals, The Era of Multicore Machines, Unicore vs Multicore, Understanding Performance, Shared Memory Multicore Systems, Distributed Memory Multicore Systems, Hybrid Systems, Symmetric and Asymmetric Multicore Systems – Overview of Multithreading – Multithreading in different forms – Homogeneous and Heterogeneous Multicore systems – Examples of different Multicore Systems. **[5 Hrs]**

Unit II :Cache Memory: Large Cache Design: Shared vs. Private Caches, Centralized vs. Distributed, Shared Caches – Coherence: Snooping, based cache coherence protocol, directory, based cache coherence protocol, Uniform Cache Access, Non, Uniform Cache Access, S, NUCA, D, NUCA, Inclusion, Exclusion – Examples of different Cache Organization, Consistency Models – Case Study. **[7 Hrs]**

Unit III :Performance and Optimizations for Multicore Systems: Select the right “core”, Improve serial performance, Achieve proper load balancing, Improve data locality, Reduce or eliminate false sharing, Use of affinity scheduling, Lock granularity and frequency, Remove synchronization barriers, Minimize communication latencies, Use of thread pools, Managing thread count, Use of parallel libraries. **[4 Hrs]**

Unit IV :Programming Multicore Systems: Programming models for Multicore Systems – Shared Memory Programming using pthreads, Shared Memory Programming using OpenMP – Use of OpenMP compiler directives – #pragma with different clauses – Understanding parallelized loops – Synchronization Constructs towards dependencies – Function parallel program, OpenMP Library Functions, OpenMP Environment Variables, Compilation, Debugging, Performance. **[8 Hrs]**

Unit V :Special Case Graphics Processing Unit: CPU architecture, GPU hardware – CPU and GPU: Design Goals – Compute levels – Case Study: Nvidia GPU – GPGPU, Compute Unified Device Architecture (CUDA) Programming model – Applications of CUDA, Threads, Blocks, Grids – Memory management – Examples – Alternatives to CUDA. **[7 Hrs]**

Unit VI :Domain Specific, Architectures: Guidelines for domain specific architectures – Deep Learning Architecture, Google's Tensor Processing Unit (TPU) for Deep Neural Networks (DNNs), Pixel Visual Core, a Personal Mobile Device Image Processing Unit. **[5 Hrs]**

List of Assignments:

- Program for matrix vector multiplication using pthreads.
- Program to implement data sharing and thread scheduling.
- Program for matrix vector multiplication using OpenMP clauses.
- Program to implement sorting using OpenMP clauses.
- Program to find n^{th} term of Fibonacci sequence to implement function/ task parallel aspect using OpenMP clauses.
- Setting up CUDA environment on Linux and first CUDA program.
- Program to implement Matrix-Matrix Multiplication using CUDA.
- Program to implement sorting using CUDA.
- Program to Histogram calculation using CUDA.
- Program to create threads using default stream in CUDA.
- CUDA for Deep Learning - A Case Study.

Text Books:

- Gerassimos Barlas, "Multicore and GPU Programming: An Integrated Approach", Morgan Kaufmann, 2015, ISBN: 978-0-12-417137-4.
- Rob Oshana, "Multicore Application Development Techniques: Applications, Tips and Tricks", Elsevier, 2016, ISBN: 978-0-12-800958-1.
- John L Hennessy, David A Patterson, "Computer Architecture: A Quantitative Approach", Sixth Edition, Morgan Kaufmann, 2018, ISBN: 978-0-12-811905-1.

Reference Books:

- Rajeev Balasubramonian, Norman P. Jouppi, and Naveen Muralimanohar, "Multi-Core Cache Hierarchies", Morgan & Claypool Publishers, 2011,ISBN: 9781598297546.
- Daniel J. Sorin, Mark D. Hill, David A. Wood "A Primer on Memory Consistency and Cache Coherence", Morgan & Claypool Publishers, 2011, ISBN: 9781608455652.
- Shane Cook, "CUDA Programming: A Developer's Guide to Parallel Computing with GPUs", Morgan Kaufmann, 2013, ISBN: 978-0-12-415933-4.
- Barbara Chapman, Gabriele Jost, Ruud van der Pas, "Using OpenMP Portable Shared Memory Parallel Programming", The MIT Press, 2008, ISBN-13: 978-0-262-53302-7.
- David B. Kirk and Wen-mei W. Hwu, "Programming Massively Parallel Processors", Second Edition, Morgan Kaufmann, 2013, ISBN: 978-0-12-415992-1.