# NIST UNIVERSITY

## Master of Computer Application (MCA)

Syllabus

**(2024-2026 Batch)**

# NIST UNIVERSITY

Institute Park, Pallur Hills, Berhampur,
Odisha, India – 761008

### *4.2.6 Master in Computer Application (MCA)*

**MCA Course Structure**

| First - Year Course Structure (I Semester) | | | | | | | |
|---|---|---|---|---|---|---|---|
| S. No. | Course Category | Course Code | Course Title | L | T | P | Credits |
| 1 | CC | MCA-500 | Data Structure using C | 4 | 0 | 2 | 5 |
| 2 | CC | MCA-501 | Computer Organization and Architecture | 3 | 0 | 0 | 3 |
| 3 | CC | MCA-502 | Database Management Systems | 4 | 0 | 2 | 5 |
| 4 | CC | MCA-503 | Mathematics – I: (Mathematical Foundation of Computer Science) | 3 | 0 | 0 | 3 |
| 5 | AEC | MCA-504 | Communicative English | 3 | 0 | 2 | 4 |
| Total Credits | | | | | | | 20 |

| First -Year Course Structure (II Semester) | | | | | | | |
|---|---|---|---|---|---|---|---|
| S. No. | Course Category | Course Code | Course Title | L | T | P | Credits |
| 1 | CC | MCA-505 | Object Oriented Programming using JAVA | 4 | 0 | 2 | 5 |
| 2 | CC | MCA-506 | Computer Networks | 4 | 0 | 2 | 5 |
| 3 | CC | MCA-507 | Operating Systems | 4 | 0 | 2 | 5 |
| 4 | CC | MCA-508 | Software Engineering | 3 | 0 | 0 | 3 |
| 5 | CC | MCA-509 | Mathematics - II (Probability & Statistics) | 3 | 0 | 0 | 3 |
| 6 | AEC | MCA-510 | Personality and Soft Skill Development | 0 | 0 | 4 | 2 |
| Total Credits | | | | | | | 23 |

| Second - Year Course Structure (III Semester) | | | | | | | |
|---|---|---|---|---|---|---|---|
| S. No. | Course Category | Course Code | Course Title | L | T | P | Credits |
| 1 | CC | MCA-600 | Design and Analysis of Algorithms | 4 | 0 | 2 | 5 |
| 2 | CC | MCA-601 | Data Warehousing and Data Mining | 3 | 0 | 0 | 3 |
| 3 | CC | MCA-602 | Python Programming | 4 | 0 | 2 | 5 |
| 4 | CC | MCA-603 | Artificial Intelligence | 3 | 0 | 0 | 3 |
| 5 | DSE | MCA-630* | Department Specific Elective - I | 3 | 0 | 0 | 3 |
| 6 | PR | MCA-680 | Minor Project with Seminar | 0 | 0 | 8 | 4 |
| 7 | PR | MCA-681 | Summer Internship | 0 | 0 | 2 | 1 |
| Total Credits | | | | | | | 24 |

**Department Specific Elective - I**

MCA-630A: Computer Graphics

MCA-630B: Natural Language Processing

MCA-630C: Wireless Sensor Network

MCA-630D: Soft Computing Techniques

MCA-630E: CBOT (Computer-based optimization techniques)

| Second - Year Course Structure (IV Semester) | | | | | | | |
|---|---|---|---|---|---|---|---|
| S. No. | Course Category | Course Code | Course Title | L | T | P | Credits |
| 1 | CC | MCA-604 | Machine Learning | 4 | 0 | 2 | 5 |
| 2 | CC | MCA-605 | Internet &Web Technology | 4 | 0 | 2 | 5 |
| 3 | DSE | MCA-631* | Department Specific Elective - II | 3 | 0 | 0 | 3 |
| 4 | PR | MCA-682 | Major Project | 0 | 0 | 24 | 12 |
| Total Credits | | | | | | | 25 |

**Department Specific Elective – II**

MCA-631A: Internet of Things (IoT)

MCA-631B: Computer Network Security

MCA-631C: Web Application Development

MCA-631D: Cloud Computing

MCA-631E: Data Science

MCA-631F: Software Testing and Quality Assurance

MCA-631G: Block-chain Technology

**FIRST SEMESTER DETAIL SYLLABUS**

| MCA-500 | Data Structure using C | 4 Credits |
|---|---|---|

**Course Objective**

1. To impart the basic programming skills in C Language so as to enable students to implement Data structures in C language
2. To impart the basic concepts of data structures and algorithms
3. To Understand basic concepts about stacks, queues, lists, trees
4. To understand concepts about searching and sorting techniques

**Course Outcome:**

1. Being able to develop a C program, control the sequence of the program, and implement 1D and 2d arrays in the program
2. Being able to use pointers, structures along with Functions to help write programs in C
3. Demonstrate an understanding and implement the basic data structures like STACK, QUEUE, LISTS using C
4. Understand and implement the non linear data structure like Trees in C and their variants

**Module-I: Introduction to Programming: (12 Hrs.)**

Structure of C Program, Keywords, Identifiers, and Primitive Data types, variables, constants, Operators and Expressions, Expression evaluation, Operator Precedence and Associativity.

Conditional Branching: One (simple if), two (if else) and multi way selection (else if ladder and switch and nested selection), Iteration and loops: Iterative statements, nested loops, break and continue statements. Arrays -One-dimensional, Two dimensional arrays, Strings,

Sorting and Searching: Bubble sort, Selection sort, Quick sort and Merge sort. Linear and Binary search.

**Module-II: Function, Pointer and Structure: (12 Hrs.)**

Functions: Declaration, Definition, Call by value, Call by reference, Scope of variables, Storage classes, Recursive functions.

Pointers - Declaration Of A Pointer, Initialization Of A Pointer, Pointer To An Array, Pointer To A Function, Pointer To A Structure, void pointer, Dangling pointer

Structure – Declaring structure, structure initialization, accessing members of a structure ( . and -> ), array of Structures, Structure vs Union

**Module-III: Introduction to Data Structure: (10Hrs.)**

Abstract Data Types – Definition and Representation, ADT of Stack and Queue , Stack operations, Applications of stack- reversing string, Decimal to Binary conversion, infix to postfix conversion. Queue: linear & circular queue. Self-referential structures, Singly Linked list Double linked list operations.

**Module-IV: Tree** **(06 Hrs.)**

Tree: Definition and Terminology ( Root, internal node, external node, level, height, degree, forest, depth), Binary tree, Strictly Binary tree, complete Binary tree and almost complete binary tree, Binary tree traversals. Binary Search Tree (BST) – insert(), findmin(), findmax(), traversals(), countleaf(), countinternalnodes(), AVL Trees – Balance factor and Insertion into AVL, Rotations – numerical based.

**Text Books:**


1. Behrouz A. Forouzan & Richard F. Gilberg, "A structured Programming Approach Using C", 3rd Edition, Cengage Publication, ISBN: 9788131503638, 2007.
2. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, 2nd Edition, Prentice Hall of India, 2015.
3. Byron Gottfried, Schaum's Outline of Programming with C, 3rd Edition, McGrawHillBook, 1st July 2017.
4. Data Structures: A Pseudocode Approach with C – Gilberg&Forouzan, 2nd Edition, Cengage, Indian Reprint 2016
5. Data Structures and Program Design in C – Kruse, Leung, 2nd Edition, Pearson,2008


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|---|---|
| Course Name | Programming and Data Structures |
| Course Link | https://nptel.ac.in/courses/106105085/4 |
| Course Instructor | Dr. P. P. Chakrabarti<br>Department of Computer Science and Engineering<br>Indian Institute of Technology Kharagpur |

| MCA-501 | Computer Organization and Architecture | 3 Credits |
|---|---|---|

**Course Objectives:**

1. Able to understand the basic organizational structure of computer system along with the operational concepts, the concepts of ALU, CU and Memory design, the concept of cache memory, virtual memory and principle of pipelining.
2. Able to solve the problems related to cache memory and performance, page replacement algorithms, memory construction, arithmetic operations, and pipelining.
3. Able to explain and apply the basic concepts of memory, its construction and analysis of performance related memory hierarchy.
4. Able to analyze the performance differences of computing evolution on basic operation like addition, multiplication and division, page replacement algorithms and cache memory mappings.

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**Module-I** **(10 hrs)**

Functional blocks of a computer: CPU, memory, input-output subsystems, Von-Neumann's Harvard Architecture, Instruction set architecture of a CPU–registers, instruction execution cycle, Basic Operational Concepts, addressing modes, instruction set. Case study – instruction sets of some common CPUs.

**Module-II** **(10 hrs)**

Computer arithmetic – integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication – shift-and add, Booth multiplier, carry save multiplier, etc. Division restoring andnon-restoring techniques, signed number representation, fixed and floating-point representations, floating point arithmetic.

**Module-III** **(10 hrs)**

Memory system design: semiconductor memory technologies, memory organization.

Memory organization: Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs. block size, mapping functions, replacement algorithms, write policies.

**Module-IV** **(10 hrs)**

Peripheral devices and their characteristics: Input-output subsystems, I/O device interface, I/O transfers–program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Basic concepts of pipelining, throughput, speedup and efficiency, pipeline hazards: Structural hazards, data hazards, control hazards.

**Course Outcomes**:

1. Understand the basic organization of computer and instruction execution cycles along with
their instruction formats and different addressing modes.
2. Gain knowledge on the architectural and circuit level design of arithmetic logic unit & control
unit and can solve different arithmetic problems.
3. Explain and apply the basic concepts of memory, its construction and analysis of performance
related memory hierarchy.

4. Gain knowledge on the different I/O interfaces, modes of data transfer and basic principles of
pipelining.

**TEXT BOOKS:**

1. "Computer Organization" 5th edition Carl Hamacher, Zvonkovranesic, SafwatZaky, McGraw Hill.
2. "Computer Organization and Design: The Hardware/Software Interface", 5th Edition by David A. Patterson and John L. Hennessy, Elsevier.

**REFERENCE BOOKS:**

1. "Computer Architecture and Organization", 3rd Edition by John P. Hayes, WCB/McGraw-Hill.
2. "Computer Organization and Architecture: Designing for Performance", 10th Edition by William Stallings, Pearson Education.
3. "Computer System Design and Architecture", 2nd Edition by Vincent P. Heuring and Harry F. Jordan, Pearson Education.

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|---|---|
| Course Name | Computer Organization and Architecture |
| Course Link | https://nptel.ac.in/courses/106/106/106106166/ |
| Course Instructor | V. Kamakoti<br>Indian Institute of Technology Madras, Chennai, India. |

| MCA-502 | Database Management Systems | 4 Credits |
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**Course Objective:**

1. Introducing basic database concepts like E-R Diagram, Relational Algebra,
2. Designing Normalized databases
4. Advantages, disadvantages and implementation of NoSQL database design in contrast to SQL based database.
5. Introducing database transactions

**Module-I:** **(10 Hours)**

Introductory concepts of DBMS: Introduction and applications of DBMS, Purpose of data base, Data, Independence, Database System architecture- levels, Mappings. Entity-Relationship model: Basic concepts, Design process, constraints, Keys, Design issues, E-R diagrams, weak entity sets. Reduction to E-R database schema.

**Module-II:** **(10 Hours)**

Database Programming: Relational Algebra and calculus (Domain and Tuple relational calculus) Basics of SQL, DDL, DML, creation, alteration, defining constraints – Primary key, foreign key, unique, not null, check, IN operator, Functions - aggregate functions, Built-in functions numeric, date, string functions, set operations, sub-queries, correlated sub-queries, Use of group by, having, order by, join and its types, Exist, Any, All, view and its types. Transaction control commands Commit, Rollback, save point. Concepts, Cursors, Stored Procedures, Stored Function, and Database Triggers.

**Module-III:** **(10 Hours)**

Normalization of Databases: Functional Dependency – definition, trivial and non-trivial FD, closure of FD set, closure of attributes, irreducible set of FD, Normalization – 1NF, 2NF, 3NF,Decomposition using FD- dependency preservation, BCNF, Multi- valued dependency, 4NF, Join dependency and 5NF.

**Module-IV:** **(10 Hours)**

Transaction Management: Transaction concepts, properties of transactions, serializability of transactions, testing for serializability, System recovery, Two- Phase Commit protocol, Recovery and Atomicity, Log-based recovery, concurrent executions of transactions and related problems, Locking mechanism, solution to concurrency related problems, deadlock, , two-phase locking protocol. User security, grants, privileges, roles, access control. Introduction to NoSQL.

**Course Outcome:**

1. Designing database and manipulating data for different real life problems
2. Apply SQL queries for retrieving columns using functions and related database.
3. Displaying data from multiple table using join and sub-queries
4. Designing and differentiating solutions using schema based database.

**Suggested Books:**

1. Elmasari; Navathe, Fundamentals of Database System, Seventh Edition, Pearson Education Book .
2. Sudarshan, Korth, Database System Concepts, 6th edition, McGraw-Hill Education Book .
3. Prof. Partha Pratim Das, Department of Computer Science & Engineering, IIT Kharagpur
https://onlinecourses.nptel.ac.in/noc18_cs15/preview
4. Prof. Arnab Bhattacharya, IIT Kanpur https://nptel.ac.in/courses/106104135/
5. Dr. Leo Mark, Georgia Institute of Technology, https://in.udacity.com/course/database-systems-concepts-design--ud150

| MCA-503 | Mathematics-I(Mathematical foundation of Computer Science) | 3 credit |
|---|---|---|

**Course Objectives:**

1. Apply the knowledge of matrix to compute Eigen values, Eigen vectors, solve system of linear equations, inverse of matrices.
2. To develop logical thinking and its applications to computer science.
3. Mathematical (computing, reasoning, analytic, and geometric) approach to data analysis.
4. To understand the concept of graphs, theory and their application in solving practical network based problems.

**SYLLABUS**

**Module-I: Systems of Linear Equations, Eigen Values and Eigen Vectors (8 Hrs)**
Basic concept of matrix and its operation, System of linear equations (Gauss-Elimination and Gauss-Jordan method), Rank of a matrix, Existence and uniqueness of solution of linear systems, Inverse of matrices (Gauss-Jordan Method), Eigen values and Eigen vectors of a matrix with their properties.

**Module-II: Logic and Counting Principle (9 Hrs)**
Logic: Propositions, Propositional equivalences, Predicate and quantifiers, Rules of inference, Introduction to proofs, Mathematical induction.
Counting: The basics of counting, the Pigeonhole principle, Permutations and combinations, Recurrence relations, Solving linear recurrence relations, Generating functions, Inclusion-Exclusion and applications of Inclusion-Exclusion.

**Module-III: Relations, Elementary Algebraic Structure (08 Hrs)**
Relations: Relations and their properties, n-ary relations and their applications, Representing relations, Closures of relations, Equivalence relations, Partial orderings.
Definition and elementary properties of groups, subgroups, ring, fields, and vector spaces.

**Module-IV: Lattice and Boolean Algebra (07 Hrs)**
Boolean Algebras: Lattices and algebraic systems, Principle of duality, Basic properties and algebraic systems defined by lattices, Distributive and complemented lattices, Boolean lattices and Boolean algebras.

**Module-V: Graph Theory (08 Hrs)**
Introduction to graphs, Graph Terminology, Representing Graphs and Graph Isomorphism, Euler and Hamilton Paths, Shortest Path Problem, Dijkstra's Algorithm, Planar Graphs (Euler's formula and its applications only), Graph colouring.
Trees: Introduction to Trees, Spanning Tree, Minimum Spanning Tree, Kruskal's Algorithm, Prim's Algorithm,

**OUTCOMES**

1. Application of matrix theory and linear algebra to solve system of equations .
2. Applying set theory and logic to solve the real valued problems easily.
3. Solving different problems suing Lattice..
4. Solving different practical network based problems through graphical methods..

**TEXT BOOKS**

1. K. H. Rosen, *Discrete Mathematics and Its Applications*, 6th Edition, Tata McGraw Hill Publication. [Chapters - 1(1.1 – 1.3, 1.5 – 1.6), 4(4.1), 5(5.1 – 5.3), 6(6.1 – 6.2, 6.4 – 6.6), 7(7.1 – 7.6), 8(8.1 – 8.3, 8.5 – 8.8), 9(9.1, 9.4, 9.5)]
2. C. L. Liu and D. P. Mohapatra, *Elements of Discrete Mathematics–A Computer Oriented Approach*, 4th Edition, Tata McGraw Hill, 2013. [Chapter – 10(10.1 – 10.3, 10.10), 11(11.1 – 11.5)]
3. E. Kreyszig, Advanced Engineering Mathematics, 10th Edition, Willey. [Chapter – 7(7.1 – 7.5, 7.8)]

**REFERENCE BOOKS**

1. B. Kolman, R.C. Busby, and S.C.Ross, *Discrete Mathematical Structures*, Pearson Education.
2. J. P. Trembly, and R. Manohar, Discrete Mathematical structures with Applications to Computer Science, Tata McGraw Hill.

| MCA-504 | Communicative English | 4 Credits |
|---|---|---|

**Course Objectives:**

1. To communicate effectively by developing competent textual, visual, and non-verbal communication abilities.
2. Todrafteffectiveformalwrittenbusinessmessagesinvariousformatsandstyles.
3. Tolearntheskillstoeffectivelydeliverformaloralpresentationstoavarietyofaudiences inmultiple contexts
4. To be acquainted with the soft skills and various selection procedures adopted by the recruiters.

**Module-I:** **(8 Hours)**

Understanding Fundamentals of Communication: Significance of Communication Skills, 7Cs of communication, Process and Factors of Communication, communication Barriers, Difference between General and Technical Communication, Verbal and Non-verbal Communication, Formal and Informal channels of Communication.

**Module-II:** **(10 Hours)**

Learning Verbal communication: Introduction to Phonetics, IPA Chart, British Received Pronunciation, resentation Skills, Group Discussion, Interview Skills. Decoding Body language for communication impact. Persuasive communication

**Module-III:** **(10 Hours)**

Learning written communication
Fundamentals of Sentence construction. Using Figures of Speech (Simile, Metaphor, Irony, Personification, Onomatopoeia, Alliteration), Phrasal Verbs, Derivatives and meaning of words, Idioms, One word substitution, Homonyms and Homophones.
Creative Writing: Copywriting Skills, Story board writing. Barriers to effective writing.

**Module-IV:** **(8 Hours)**

Improving Reading and Listening skills for effective communication
Types of Reading, Sub-skills of reading (Skimming, Scanning, Reading Comprehension) Listening Skills. Purpose of Listening. Listening to Conversation (Formal and Informal) Active Listening. Benefits of Effective Listening. Barriers to Listening
Letter, Memo, Circular, Proposal, E-mail, Resume Writing , Cover Letters, Minutes of Meeting.

**Course Outcomes:**

Attends of the course, the student will be able to:

1. Becomeadeptintheiruseofthespokenwordininterpersonalcommunication,small group interaction and public speaking.
2. Use an appropriate style and format to write letters (Formal and Informal),prepareresult-orientedreports,prepareCVsanddraftbusinessdocuments.
3. Gatherandprepareinformationandapplyittopersuadeorarticulateone’sownpointofclearlyandefficiently.
4. Comprehendtheemployabilitymarket,identifytheorganizationstogetgoodplacementsand broadencareerplansbydevelopingall-roundpersonality.

Reference Books:

1. Communication Skills by Sanjay Kumar and Pushpa Lata, Oxford University Press.
2. Technical Communication, Principle and Practice by Meenakshi Ramanand Sangeeta Sharma, Oxford University Press.
3. A Course in English Phonetics by T.R.Kansakar, Orient Long men Press.
4. Basic Communication Skills for technology-Andrea J Rutherford, Pearson
5. English Grammar, Wren and Martin

| MCA-500L | Data Structure Laboratory | 1 Credits |
|---|---|---|

**Course Objective:**
This course is aimed at concepts of programming and software code development of moderate complexity using C programming language within the framework of structural and procedural programming paradigms and data structure.

**List of Suggested Programs**

1. Familiarity with basic LINUX command, vi editor.
2. Programs on arithmetic expressions, data type limits, operators and precedence.
3. Programs on Conditional Branching and Loops.
4. Programs on 1D and 2D array handling.
5. Programs on String handling and Functions
6. Programs on Pointers and Structure.
7. Implementation of Stack and Queue
8. Infix to Postfix conversion, Insertion sort
9. Linear and Binary Search
10. Bubble sort, Merge sort and Quick sort.

**Course Outcomes:**
Upon the successful completion of the sessional course, students will be able to:

3. Understand problem solving approach of moderate complexity in Linux environment.
4. Design and develop C program to solve different real life problems efficiently.
5. Analyse and compare different possible solutions.

| MCA-502L | Database Management Systems Laboratory | 1 Credits |
|---|---|---|

1. Retrieving Data Using the SQL SELECT Statement.
2. Restricting and Sorting Data.
3. Manipulating Data.
4. Using DDL Statements to Create and Manage Tables.
5. Using Single-Row Functions to Customize Output.
6. Reporting Aggregated Data Using the Group Functions.
7. Displaying Data from Multiple Tables.
8. Using Sub queries to Solve Queries.
9. Creating Other Schema Objects (indexes, views).
10. User security (privileges, roles).
11. Cursors and composite data types...
12. Functions and procedures.
13. Packages.
14. Triggers.
15. Mini project (Application Development )

Suggested Books: Murach's My SQL: Joel Murach , 2nd Edition.

| MCA-504L | Communicative English Laboratory | 1 Credits |
|---|---|---|

(This unit involves interactive practice sessions in Language Lab)

1. Listening Comprehension
2. Pronunciation, Intonation
3. Stress and Rhythm practice
4. Common Everyday Situations: Conversations and Dialogues
5. Formal Presentations
6. Reading Comprehension
7. Report writing
8. Writing letters, e-mails,
9. Writing essay, CV, etc…
10. Grammar activities

# SECOND SEMESTER DETAIL SYLLABUS

| MCA-505 | Object Oriented Programming using JAVA | 4 Credits |
|---|---|---|

**Course Objective:**

1. Understand the basic object-oriented programming concepts and apply them in problem solving.
2. Illustrate inheritance concepts for reusing the program.
3. Students will able to learn about. Multi-Threading, String Handling and Java I/O.
4. Students will Develop and implement Graphical User Interface(GUI) Applications in Java using AWT and Swing

**Module- I** **(8 Hrs)**

Introduction to Java and Java programming environment. Object Oriented Programming Concepts: Encapsulation, Abstraction, Inheritance, Polymorphism. Fundamental Programming Structure: Data Types, variables, keywords, typecasting, Arrays, Operators, and their precedence. Control Flow: Java's Control Statements (if, switch, iteration, statement, while, do-while, for, Nested loop). Objects and Classes: Concept of Objects and Classes, Using Existing Classes building your classes, constructor overloading, static, final, this keyword. Array and String Handling: String constructors, String length, Character Extraction, String Comparison, Modifying a string.

**Module - II** **(12 Hrs)**

Inheritance: Introduction, types of inheritance, use of super keyword, method overriding, Dynamic method Dispatch, Using Abstract Classes, Using final with inheritance, the object class. Packages & Interfaces: Packages, Access Protection, importing package, Interface, Implementing Interfaces, variables in Interfaces, and Interfaces can be extended. Java I/O: Classes & Interfaces, Stream classes, Byte streams, Character streams, Serialization.

**Module –III** **(12 Hrs)**

Exception Handling: Fundamentals, Types Checked, Unchecked exceptions, Using try and catch, Multiple catch, throw, throws, and finally, Java's built-in exceptions, and user-defined exceptions. Multi-Threading: Java Thread Life Cycle, Thread Priorities, Synchronization, Creating a thread, Runnable interface, Creating Multiple threads, Using isAlive () and join (), wait () &notify(). Wrapper Classes: Wrapper classes and their methods.

**Module IV** **(8 Hrs)**

Collection Framework: Introduction, interfaces, List, Set, Map, etc, List interfaces and their classes. Event Handing: Event Delegation Model, Event Classes, Event Listener

Interfaces, Adapter classes. AWT: AWT Classes window fundamentals, component, container, panel, Window, Frame, working with Graphics, Control Fundamentals, Layout managers, Handling Events by Extending AWT components. Introduction to Database: Introduction to Database. Driver Types, Registering Driver, Creating Connection, Executing SQL query using Statement, Prepared Statement. ResultSet methods.

**Course Outcome:**

1. Understand and implement various Object Oriented Concepts like inheritance, abstraction and polymorphism.
2. Work with Collection Classes and Files, Multiple Threads, & handle Exceptions.
3. Develop applications to interact with a Database.
4. Design and implement Graphical User Interface (GUI) Applications in Java using AWT and Swing.

**Text Books:**


1. Java: One Step Ahead by Anita Seth (Author), B.L. Juneja (Author) Oxford University Press.
2. Head First Java 2nd edition Kathy Sierra & Bert Bates 3. JAVA Complete Reference (9th Edition) Herbert Schildt.
4. https://www.udemy.com/java-the-complete-java-developer-course/
5. Java Programming Master class for Software Developers Created by Tim Buchalka, Tim Buchalka's Learn Programming Academy, Goran Lochert


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|---|---|
| Course Name | Object Oriented Programming using JAVA |
| Course Link | https://onlinecourses.nptel.ac.in/noc21_cs03/preview |
| Course Instructor | Prof. DebasisSamanta<br>Dept. Computer Science and Engineering from Indian Institute of Technology, Kharagpur |

| MCA-506 | Computer Networks | 4 Credits |
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**Course Objectives:**

1. Understand the concepts of data communication, layered model, wireless devices in computer networks.
2. Students will be able to understand the various techniques used to access a shared channel in the network and IEEE specifications for LANs.
3. Students will learn about different types of networking devices, backbone networks and Internet Protocol (IP) addressing.
4. Understand the responsibilities of network, transport and application layers.

**Module – I** **(12 Hrs)**

Overview of Data Communication Networks, Design issues, structure and topology, Protocols and standards, OSI Reference model, TCP/IP Protocol. Physical Layer: Analog Signals, Digital Signals, Data Rate Limits, Transmission Impairment Datarate limit, multiplexing: Time Division Multiplexing (TDM), frequency Division Multiplexing (FDM), Wave Division Multiplexing (WDM), Transmission Media: Guided Media (Twisted-Pair Cable, Coaxial Cable and Fiber Optic Cable) and unguided media (wireless), Switching: Circuit Switched Network, packet switching, Datagram Network, Virtual-Circuit Network, Telephone Network, Dial-up Modems and Digital Subscriber Lines.

**Module – II** **(12 Hrs)**

Error Detection and correction: Types of Errors, Error Detection mechanism (Linear codes, CRC, Checksum), Error Correction mechanism: Hamming Encoding. Data Link Control and Protocols: Flow and Error Control, Stop-and-Wait ARQ. Go-Back-N ARQ, Selective Repeat ARQ, HDLC and Point-to-Point Protocol Multiple Access: Random Access (ALOHA, CSMA, CSMA/CD, CSMA/CA), Controlled Access (Polling, Reservation, Token Passing), Channelization (FDMA, TDMA, and CDMA). Wired LANs(Ethernet): Traditional Ethernet, Fast Ethernet, and Gigabit Ethernet.

**Module – III** **(06 Hrs)**

Wireless LANs: IEEE 802.11 and Bluetooth2.0.

Connecting Devices: Passive Hub, Repeater, Active Hub, Bridge, Two layers Switch, Router, Three layers Switch, Gateway. Virtual Circuit Networks: Frame Relay, Architecture & layers, ATM: Design goals, Architecture & layers.

**Module – IV** **(10 Hrs)**

Network Layer: IPV4 addresses, IPV6 addresses, Internet Protocol: Internetworking, IPV4datagram, IPV6 packet format and advantages. Network Layer Protocols: ARP,

RARP,IGMP and ICMP. Routing: Unicast Routing Protocols and Multicast Routing Protocols. Transport Layer: Process to Process Delivery, User Datagram Protocol (UDP) and Transmission Control Protocol (TCP).

Domain Name System (DNS): Name Space, Domain Name Space, DNS in Internet, Resolution and Dynamic Domain Name System (DDNS), Remote logging, Electronic Mail(SMTP) and file transfer (FTP), WWW: Architecture & Web document, HTTP: Transaction & Persistent vs. Non-persistent connection. Introduction to Wi-Fi and Li-Fi Technology.

**Course Outcome:**

1. Understand the layered communication architectures (OSI and TCP/IP) and different transmission techniques for communication over a network.
2. Recognize devices used in 3 lower layers. Understand and apply flow and error control during data transmission with the associated protocols and mechanism of channel access methods.
3. Understand and apply host addressing logic & subneting concepts with associated protocols of network layer and transport layer. Understand protocols involved in application layer to facilitate high level applications

**TEXT BOOKS:**

1. Data Communications and Networking, Behrouz A. Forouzan, Tata McGraw-Hill, 5$^{th}$Edition(2013).
2. Computer Networks, A. S. Tannenbum, D. Wetherall, Pearson Education, 5thEdition(2014).

**REFERENCE BOOKS:**

1. Data and Computer Communications, William Stallings, Pearson Education, 10$^{th}$ Edition(2018).
2. Computer Networking, A Top-Down Approach, James F. Kurose, Keith W. Ross, Pearson publication, 6$^{th}$ Edition(2017).

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|---|---|
| Course Name | Computer Networks |
| Course Link | https://nptel.ac.in/courses/106105183/ |
| Course Instructor | Prof. SoumyaKantiGhosh,<br>IIT, Kharagpur |

| MCA-507 | Operating Systems | 4 Credits |
|---|---|---|

**Course Objectives:**

1. Student will be able to understand the basic components of a computer operating system, and the interactions among the various components.
2. The course will cover an introduction on the policies for scheduling, deadlocks, memory management, synchronization, system calls, and file systems.
3. Students will be able to understand the concepts of virtual memory management, file system.
4. Students will be able to understand the concepts of secondary storage structure, protection and case study of Linux operating system.

**Module-I:** **(10 Hrs.)**

Overview: Operating System, Simple Batch Processing Systems, Multiprogramming and Time-sharing systems Operating System Structures, Operating System Services and system calls.

Process: Process Concept, Process Scheduling, Operation on Processes, Inter-process communication, Examples of IPC Systems, Multithreading Models, Threading Issues.

**Module-II:** **(10 Hrs.)**

Process Scheduling: scheduling criteria, scheduling algorithms

Process Synchronization: Critical section problem, two-process and multi-process solutions, Semaphores, Classical problems of synchronization, Monitors.

Deadlocks: System model, Deadlock Characterization, Handling Deadlocks, Deadlock Prevention, Deadlock avoidance, Deadlock Detection and recovery from Deadlock.

**Module-III:** **(10 Hrs.)**

Memory Management: Memory Management strategies, Logical versus Physical Address space, swapping, contiguous Allocation, Paging, Segmentation.

Virtual Memory: Background, Demand paging, performance of Demand paging, Page Replacement, Page Replacement Algorithms, Allocation of frames, Thrashing and its prevention, Paging with segmentation

**Module-IV:** **(10 Hrs.)**

File system: file structure, file operations, file access methods, Directory Structure, Directory Implementation, and Allocation Methods

Mass Storage: Overview of Mass Storage Structure, Disk Structure, Disk Scheduling, Disk Management, Swap-Space Management

**Course Outcome:**

1. Understand the different services provided by Operating System at different level and the design structure and learn real life applications of the same.
2. Solve and implement different process scheduling algorithms, synchronization techniques and methods of handling deadlock.

3. Describe different memory management techniques and solve problems related to paging, segmentation, fragmentation and page replacement.
4. Use concepts of file management, disk management and solve problems regarding file allocation methods and disk scheduling.

**Suggested Books:**


1. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne: Operating System Concepts, 8th edition, Wiley-India, 2009
2. William Stallings, Operating Systems: Internals and Design principles, 6th Edition, PHI Learning Pvt. Ltd, 2010
3. H.M. Deitel, P. J. Deitel, D. R. Choffnes, Operating Systems, 3rdEdition, Pearson Education, Dec 2003
4. Andrew S. Tanenbaum: Mordern Operating Systems, 4th Edition, Pearson Education, 2014
5. Naresh Chouhan: Principles of Operating System, Oxford University Press.


**Web Courses/Online courses**

| | |
|---|---|
| Course Name | INTRODUCTION TO OPERATING SYSTEMS |
| Course Link | https://nptel.ac.in/courses/106106144/2 |
| Course Instructor | Prof. Chester Rebeiro,<br>IIT Madras |

| MCA-508 | Software Engineering | 3 credit |
|---|---|---|

**Course Objectives:**

1. To understand the rationale for software development process models
2. To learn how to develop requirement specification for software development
3. To understand the importance of architectural design and software testing methods
4. To learn how to manage software development projects, software quality and ensure software reliability

**Module-I** **(10 Hrs.)**

Introduction to software engineering, keyaspects of SE, SDLC, Software Development process models: Waterfall, V-model, Incremental, RAD, Iterative, Spiral, Prototype, and Agile software development model: Agile methods, Extreme programming, Agile Process models: Adaptive software development, Scrum, Crystal.

**Module-II** **(10 Hrs.)**

Requirements engineering: Functional and non-functional requirements, software requirements specification (SRS), Requirements engineering process, Requirements elicitation and analysis, Requirements validation& management.

Object-oriented design using UML: Object oriented concepts, Dynamic and Functional Modelling, System modelling: Building Context models, Structural models, Behavioural models, and Interaction models using UML.

**Module-III** **(10 Hrs.)**

Architectural design: Architectural views, Architectural patterns, Application architectures, cohesion and coupling, Software measurement and metrics, Software testing methods: Blackbox and Whitebox testing, unit testing, integration testing, system testing, software verification and validation, Software Maintenance.

**Module-IV** **(10 Hrs.)**

Software project management: Risk management, managing people, Project planning, Project scheduling, Software cost estimation, COCOMO model.

Software Quality Management, Configuration management, Software reuse and reliability. Component based software engineering, Service-oriented Software Engineering

**Course Outcome:**

1. To understand the phases of software development
2. To be able to develop software requirement specifications for different types of software and also use UML as a design tool
3. To understand the architectural design of software systems and various software testing techniques

TEXT BOOKS

1. Rajib Mall, Fundamentals of Software Engineering, Fifth Edition, PHI, 2018

REFERENCE BOOKS

1. Software Engineering, A Practitioner's Approach, Roger S. Pressman, TMG Hill.
2. Fundamentals of Software Engineering, Rajib Mall, PHI, 2014.
3. Software Engineering, I. Sommerville, 9th Ed., Pearson Education.

Digital Learning Resources

| | |
|---|---|
| Course Name | SOFTWARE ENGINEERING |
| Course Link | https://nptel.ac.in/courses/106105182/ |
| Course Instructor | PROF. RAJIB MALL<br>Dept. of Computer Science and Engineering, IIT Kharagpur |

| MCA-509 | Mathematics - II<br>(Probability & Statistics) | 3 Credits |
|---|---|---|

**Course Objectives:**

1. Enrich the knowledge of probability on single random variables and probability distributions.
2. Understand the foundations for classical inference involving confidence intervals and hypothesis testing.
3. Analyse the given data for appropriate test of hypothesis.
4. Apply the concept of correlation and regression.

**Module-I: Probability, Random Variables and Distributions (14 hrs)**

Sample Space, Events, Counting sample points, Probability of an event, Additive Rules, Conditional Probability, Multiplicative rules, Baye's Rule. Discrete and continuous random variables, Discrete and continuous probability distributions, Joint probability distribution, Mathematical expectation: mean, variance and standard deviation of a probability distribution. Binomial distribution, Poisson process and Poisson distribution, Normal distribution, Areas under the normal curve, Applications of the normal distribution, Normal approximation to the binomial.

**Module-II: Fundamental Sampling and Estimations (10hrs)**

Random Sampling, Some important statistics, Sampling distribution: Sampling distribution of mean and variance, t-distribution, Statistical inference, Classical methods of estimation, Single sample: estimating the mean, Standard error of point estimate, Prediction intervals, and estimation of variance.

**Module-III: Testing of Hypothesis (8 hrs)**

Statistical hypothesis, Testing a statistical hypothesis, One and two tailed tests, Decision making in testing hypothesis, Test concerning a single mean, Goodness of fit test.

**Module-IV: Correlation and Regression (8 hrs)**

Bivariate distribution, Correlation, Scatter Diagram, Karl Pearson coefficient of correlation, Calculation of the Correlation Coefficient for a Bivariate Frequency Distribution, Probable Error of Correlation Coefficient, Rank Correlation, Regression..

**Course Outcome:**

On completion of this course, students are able to:

1: Use the basic probability rules, discrete and continuous probability distributions, including requirements of mean and variance.

2: Identify the characteristics of different discrete and continuous distributions. Identify the type of statistical situation to which different distributions can be applied.

3: Use of continuous distribution and various hypothesis of testing.

4: Employee the principles of linear regression and correlation and significance of the correlation coefficient.

**TEXT BOOKS**

1. R. E. Walpole, S. L. Myers, and K. Ye, *Probability and statistics for engineers and scientists*, 8th Edition, Pearson. [Chapter- 2, 3(3.1 – 3.4), 4(4.1 – 4.3), 5(5.3 and 5.6), 6(6.1 – 6.5), 8(8.1, 8.2, 8.4 – 8.7), 9(9.1 – 9.6, 9.12), 10(10.1 – 10.7, 10.14)]
2. S. C. Gupta, V. K. Kapoor, *Fundamental of Mathematical Statistics*, 10th revised edition, Sultan Chand & Sons. [Chapter- 10(10.1 – 10.7)]

**REFERENCE BOOKS**

1. J. E. Freund, *Mathematical Statistics*, 5th Edition, Prentice Hall of India pvt. Ltd., Eastern Economy Edition.
2. D. C. Montgomery and G. C. Runger, *Applied Statistics and Probability for Engineers*, 6th Edition, Wiley.
3. R. C. Johnson, *Probability and Statistics for Engineers*, 6th Edition, Prentice Hall of India pvt. Ltd., Eastern Economy Edition.

| MCA-510 | Personality and Soft Skills Development | 2 credit |
|---|---|---|

**Module –I: Know Your Self (Self-Assessment) (LAB 1 & 2)**

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|---|---|
| Understand | Know Your Self: Purpose-Importance and Benefits-<br>How to do Self Assessment |
| Practice | SWOC Analysis<br>Big Five Personality Assessment<br>Introduce Yourself |

**Module –II: Understanding the Dynamics of Communication (The 3Cs) (LAB 3 & 4)**

Understand

The language beyond words: Purpose-Importance and Benefits of Kinesics-Listen to Understand- Importance of Listening skill – Purpose- Process-Types- Barriers- Effective Listening.

What is Phonetics: Speech Sounds – Vowels and Consonants – Minimal Pairs- Consonant Clusters

Structure of Syllables – Word Stress and Rhythm– Weak Forms and Strong Forms in Context.

Intonation--Errors in Pronunciation-the Influence of Mother Tongue (MTI)

Fundamentals of English Grammar

Communicate to Connect: the significance of creating the First Impression using conversation, collaboration and convincing skills

Practice

Understanding Body Language Mastering Active Listening

Basic Rules of Word Accent - Stress Shift - Weak Forms and Strong Forms in Context.

Common Indian Variants in Pronunciation- Differences in British and American Pronunciation.

Writing Flawlessly: Usage of Verbs, Sentence patterns, Use of Different parts of speech

**Module –III: Communicate to Connect (Creative & Persuasive Communication)**
**(LAB 5-8)**

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|---|---|
| Understand | Communicating in a Group: The Elements of Group Dynamics<br>Speaking to Public: Fundamentals of Public Speaking.<br>How to Design and Deliver Presentations |

**How to Express Yourself for communication effectiveness**

Practice

Participating in Mock Group Discussion Speaking Extempore/ Impromptu

Deliver Power Point Presentation

Script writing and Role play JaM

Mock Press Meet Mock Interview

Expressions in Various Situations

Making Requests and Seeking Permissions

Telephone Etiquette Writing Professional E-mail Collage and Poster Making

Debate

**Module-IV** **Communicating for Career Building**
**(LAB 9 & 10)**

Understand

The Dynamics of the Job Market: The Skill-Demand-Gap Analysis. Up-skilling and Re-skilling.

Making the Move: Building your Personal Brand: Building Professional Social Media Profile. Professional networking.

Practice

How to face Job Interview.

Goal Setting

Resume Building Mock

Job Interview

**Final Lab**

| MCA-505L | Object Oriented Programming using JAVA Lab | 1 Credits |
|---|---|---|

**Course Objective:**

1. Learn and implement Programs with the syntax, semantics and idioms of the Java programming language.
2. Gain confidence in object-oriented programming principles through lots of practical exercises that provide useful exposure to the core Java class libraries.
3. Students will able to learn about. Multi-Threading, String Handling and Java I/O.
4. Students will Develop and implement Graphical User Interface(GUI) Applications in Java using AWT and Swing

**Lab Assignments**

1. Data types & variables, decision control structures: if, nested if etc. Loop control structures: do, while, for etc.
2. Classes and objects.
3. Data Abstraction & Data hiding, Inheritance. 4.Interfaces and inner classes, wrapper classes.
4. 5.Exception handlings
5. Threads
6. IO Files
7. Collections
8. Database Connectivity.
9. Applets AWT and Swing.

**Course Outcome:**

1. Understand and implement various Object-Oriented Concepts like inheritance, abstraction and polymorphism.
2. Work with Collection Classes and Files, Multiple Threads, & handle Exceptions.
3. Develop applications to interact with a Database.
4. Design and implement Graphical User Interface (GUI) Applications in Java using AWT and Swing.

| MCA-506L | Computer Network Laboratory | 1 Credits |
|---|---|---|

**Course Objective:**

1. Understand the concepts of data communication, layered model, wireless devices in computer networks.
2. Students will be able to understand the various techniques used to access a shared channel in the network and IEEE specifications for LANs.
3. Students will learn about different types of networking devices, backbone networks and Internet Protocol (IP)addressing.
4. Understand the responsibilities of network, transport and application layers.

**Lab Assignments**

1. Introduction to LAN hardware and IP addresses configuration
2. Understanding and use of networking tools: ifconfig, ping, traceroute, arp, dig and nslookup
3. Configuration of CISCO Switches and Routers.
4. Study of network traffic using Wireshark filters.
5. Controlling of network scenario using Netam and etc. 6 to 8 are based on the following experiments:
6. Simulate a three node point to point network with duplex links between them. Set queue size and vary the bandwidth and find number of packets dropped.
7. Simulate a four node point to point network with the links connected as follows: n0 – n2, n1 – n2 and n2 – n3. Apply TCP agent between n0 – n3 and UDP agent between n1 – n3. Apply relevant applications over TCP and UDP agents changing the parameter and determine the number of packets sent by TCP / UDP.
8. Simulate the transmission of ping messages over a network topology consisting of 6 nodes and find the number of packets dropped due to congestion.
9. Simulate an Ethernet LAN using ‘n’ nodes, change error rate and data rate and compare throughput.
10. Simulate an Ethernet LAN using ‘n’ nodes and set multiple traffic nodes and plot congestion window for different source / destination.
11. 9 to 10 are based on the following experiments to be implemented in C/Java:

12. Implementation of Distance Vector Algorithm to find suitable path for transmission.
13. Program for ERROR detecting code using CRC-CCITT (16bit).
14. Using TCP/IP Sockets, write a client-server program to make client sending the file name and the server to send back the contents of the requested file if present.
15. Program for CLIENT SERVER communication using message Queues or FIFOs as IPC channels that client sends the file name and the server to send back the contents of the requested file if present.
16. Program for Congestion control using Leaky Bucket Algorithm.

| MCA-507L | Operating System Laboratory | 1 Credits |
|---|---|---|

**Course Objective:**

1. To write UNIX shell scripting.
2. To understand and implement IPC mechanism using named and unnamed pipes.
3. To implement the scheduling algorithms.
4. To develop solutions for synchronization problems using semaphores.
5. To implement Deadlock avoidance algorithms.
6. To implement page replacement algorithms Lab Assignments

**Lab Assignments**

1. Practicing of basic UNIX Commands as well as Linux administrative commands
2. UNIX Shell Programming covering array, string and functions
3. Shell scripting using GREP commands.
4. Shell scripting using AWK commands.
5. Inter Process Communication (IPC) using Pipes.
6. Programs on signals and system calls
7. Implement the algorithms of CPU scheduling algorithms like FCFS, SJF, SRTF, Priority and RR using C/C++.
8. Write C/C++ programs to implement the classical synchronization problems like Dinning Philosopher and reader-writer problems using semaphore.
9. Implementation of deadlock avoidance algorithm using C/C++.
10. Implementation of page replacement algorithms like FIFO, LRU and Optimal.

## THIRD SEMESTER DETAIL SYLLABUS

| MCA-600 | Design and Analysis of Algorithms | 4 Credits |
|---|---|---|

**Course Objective:**

1. Translating a plain text problems to convert into an algorithm .Calculate best case, worst case time complexity and space complexities of different algorithm and choosing the best solution from the available options
2. Applying different design paradigm to solve different problems and comparing their best case, worst case scenarios.
3. Designing and applying different data structures over different algorithms for solving different problems.
4. Understand different P-class, NP class problems.

**Module-I:** **(12 Hrs)**

Introduction to problems and algorithms , Mathematics for algorithm analysis , Insertion sort Analysing algorithms, Designing of algorithms, Asymptotic notation Standard notations and common functions, Recurrence relations, The substitution method, The recursion-tree method, The master method, Divide and conquer: Min-Max Heap, Heapsort , Quicksort, Merge Sort, Sorting in Linear Time: Lower bounds for sorting: Counting sort

**Module-II:** **(8 Hrs)**

Greedy method: Elements of the greedy strategy, Huffman codes Fractional Knapsack problem, Dynamic programming: Assembly-line Scheduling, Matrix-Chain Multiplication, Longest Common Subsequence(LCS), 0/1 Knapsack problem

**Module-III:** **(12 Hrs)**

Graph algorithms: Basic Definitions and Application, Representations of graphs, Breadth-first search and Depth-first search, Data Structures for Disjoint Sets, Strongly connected components, Minimum Spanning Trees: The algorithms of Kruskal and Prim. Single-Source Shortest Paths: The Bellman-Ford algorithm, Dijkstra's algorithm, All-Pairs Shortest Paths-Shortest paths algorithm

**Module-IV:** **(8 Hrs)**

String Matching: The Naive string-matching algorithm, The Rabin-Karp algorithm, The Knuth-Morris-Pratt algorithm. Network Flow: Flow networks, The Ford-Fulkerson method, Backtracking – n-Queen problem – Hamiltonian Circuit Problem – Subset Sum Problem. NP- Completeness: Classes P and NP, NP-complete problems

**Course Outcome:**

1. Given a English language problem description define the problem precisely with input/output

requirements, examine its inherent complexity and develop a generic or set of initial solutions and justify their correctness.

2. Given an algorithm descriptions, analyse the time and space complexity of the algorithm in the worst case, average case, and amortized scenario as needed in terms of asymptotic order of complexity.

3. Given a problem definition explore different alternative algorithmic solutions, compare them with respect to time and space complexity and choose the design scheme and /or design parameter and data structure appropriately to obtain the best possible choice(s) that can be converted to an executable programs.

4. Examine and prove whether a problem is of polynomial complexity, hard( np complete) or otherwise and develop optimal and approximate algorithm for them as applicable.

**Text Books:**

1. Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, Introduction to Algorithms, Third Edition, MIT Press/McGraw-Hill, 2009.

2. Ellis Horowitz, SartajSahni and SanguthevarRajasekaran, Computer Algorithms/ C++, Second Edition, Universities Press, 2007.

**Reference Books:**

1. Sanjoy Dasgupta, Christos H. Papadimitriou and Umesh V. Vazirani, Algorithms, McGraw-Hill, 2008.

2. Jon Kleinberg and ÉvaTardos, Algorithm Design, Addison-Wesley/PEARSON EDUCATION-2006.

3. S. Sridhar, ―Design and Analysis of Algorithms‖, Oxford University press, First Edition, 2015.

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|---|---|
| Course Name | DESIGN AND ANALYSIS OF ALGORITHMS |
| Course Link | https://nptel.ac.in/courses/106101060/ |
| Course Instructor | Prof. Abhiram G Ranade, Prof. Ajit A Diwan, Prof. Sundar Viswanathan, IIT Bombay |

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|---|---|
| Course Name | DESIGN AND ANALYSIS OF ALGORITHMS |
| Course Link | https://nptel.ac.in/courses/106106131/ |
| Course Instructor | Prof. Madhavan Mukund, Chennai Mathematical Institute |

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|---|---|
| Course Name | DESIGN AND ANALYSIS OF ALGORITHMS |
| Course Link | https://online.stanford.edu/courses/cs161-design-and-analysis-algorithms |
| Course Instructor | Reyna Hulett, CS161, Stanford School of Engineering, |

| MCA-601 | Data Warehousing and Data Mining | 3 Credits |
|---|---|---|

**Course Objectives:**

1. Identify the scope and necessity of Data Mining and Knowledge Discovery.

2. To understand various tools of Data Mining and their techniques to solve the real time problems.

3. To develop ability to design various algorithms based on data mining tools.

4. To develop further interest in research and design of new Data Mining techniques.

**Module – I** **(10 Hrs)**

Motivation for Data Mining, Introduction to Data Mining, DBMS vs. Data Mining, Issues and Challenges in Data Mining, Application Areas, Knowledge Discovery steps, Concept of Data Warehousing, 3-Tier Architecture, Multidimensional Data Model, OLAP, ROLAP, and MOLAP Operations,

**Module – II** **(10 Hrs)**

Data Preprocessing: Why Preprocess the data, Data Preprocessing – Descriptive data summarization, Data cleaning, Data Integration and Transformation, Data Reduction, Concept Hierarchies, Interestingness Measures, Mining Association Rules, Apriori Algorithm for finding Frequent Item-Sets,, Mining Multilevel Association Rules, Mining Distance-Based Association mining, Correlation Analysis

**Module – III** **(10 Hrs)**

Classification and Prediction: Decision Tree based Classification, Bayesian Classification, Classification by Back Propagation, K-Nearest Neighbor Classifier

Cluster Analysis: Categorization of Clustering Methods, Partitioning Methods, K-Means and K-Medoids, Hierarchical Methods, Density-Based Clustering (DBSCAN)

**Module – IV** **(10 Hrs)**

Web Mining, Classification of Web Documents, Web Content Mining, Web Structure Mining, Web Usage Mining, Text Mining, Text Clustering, Mining Spatial Databases, Mining Multimedia Databases, Temporal Data Mining, Temporal Association Rules, Sequence Mining.

**Course Outcomes:**

1. Understand warehousing architectures and tools for systematically organizing large

Database and use their data to make strategic decisions. Understand KDD process for finding interesting pattern from warehouse.

2. Remove redundancy and incomplete data from the dataset using data pre-processing methods.

3. Characterize the kinds of patterns that can be discovered by association rule mining.

4. Discover interesting patterns from large amounts of data to analyze for predictions and

classification

**Text Books:**

1. Data mining; Concepts and techniques by J. Han and M. Kamber (Morgan Kaufmann)

2. Data Mining by A.K. Pujari (University press)

3. Data Mining by Vikram Pudi and P. Radha Krishna (Oxford University Press)

4. Introduction to Data Mining - Tan, Steinbach & Kumar (Pearson)

5. Data Mining: Practical Machine Learning Tools and Techniques - Ian H. Witten & Eibe Frank (Elsevier India)

6. Data Mining Techniques: For Marketing, Sales, and Customer Relationship Management - Gordon S. Linoff & Michael J. A. Berry (Wiley)

7. Data Mining and Analysis Fundamental Concepts and Algorithms - Zaki & Meira (Cambridge University Press)

8. Jiawei Han, Micheline Kamber, and Jian Pei, “Data Mining Concepts and Techniques”, Third Edition, Elsevier.

9. Data Warehousing, Data Mining & OLAP by Alex & Stephen, McGraw Hill.

10. Vikram Pudi & P. Radha Krishna, Data Mining, Oxford University Press.

11. 10. Reema Thareja, Data Warehousing, Oxford University Press.

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| Course Name | Data and Web Mining |
| Course Link | https://nptel.ac.in/courses/106/105/106105174/ |
| Course Instructor | PROF. PABITRA MITRA<br><br>Department of Computer Science and Engineering, IIT Kharagpur |

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| Course Name | Data and Web Mining |
| Course Link | https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs12/ |
| Course Instructor | |

| MCA-602 | Python Programming | 4 Credits |
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**Course Objective:**

1. To understand programming skills in core Python.
2. To learn Abstract data type in Python i.e. array, string, list, set, dictionary.
3. To understand Object Oriented Programming concepts using Python
4. To learn Exception Handling, and Database Connectivity in Python.

**Module-I** **(10 Hrs)**

Python: History and Features of Python Programming, Comparison between C, Java and Python, Comments, Docstrings, How Python sees variables, Data types in Python, built in types, sequences in Python, sets, literals in Python, user defined data types, identifiers & reserved words, Naming convention in Python. Various Operators in Python, Input & Output, Control statements, if statements, while loop, for loop, infinite loop, nested loop, else suit, break, continue, pass ,assert, return statements, command line arguments.

**Module-II** **(10 Hrs)**

Arrays and Strings in Python, Creating strings, Length of a string, Indexing in strings, Slicing strings, Concatenation and Comparing strings, Finding Sub-Strings, Replacing a String.

Iterator objects in Python: list, tuple, string, or dictionary and their usages.

Functions in Python, define a function, calling a function, return from function, pass by object Reference, Positional arguments, Default arguments, Recursive functions.

**Module-III** **(10 Hrs)**

Introduction to OOP, features of OOP, creating classes, the self-variable, constructor, types of variables, namespaces, types of methods.

Inheritance: Define inheritance, types of inheritance, constructors in inheritance, overriding super class constructors & methods, the super() method, MRO

Polymorphism: Duck typing philosophy of Python, operator overloading, method overriding, interfaces in Python.

**Module-IV** **(8 Hrs)**

Exceptions: Errors in a Python program, Exceptions, Exception handling, Types of Exceptions, Exception block, the assert statement, user defined exceptions

Python Database Connectivity: DBMS, types of databases used with Python, installation of MySQL database, working with MySQL connector, database, retrieving rows, deleting rows, updating rows in a table.

**Course Outcomes:**

1: Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements.

2: Express proficiency in the handling of strings and functions. Understand and determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets.

3: Identify the commonly used operations involving file systems and regular expressions.

4: Understand and implement inheritance, exceptions and database handling

**Text Books**

1. T. Budd, Exploring Python, TMH, 1st Ed, 2011.

2. Core Python Programming, Dr. R. Nageswar Rao, Dreamtech Press

3. Python Programming for Absolute Beginners, Michael Dawson, CENGAGE Learning

Reference Books

1. Allen Downey, Jeffrey Elkner, Chris Meyers , How to think like a computer scientist : learning with Python , Freely available online.2012

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|---|---|
| Course Name | Python Programming |
| Course Material Link | Python Tutorial/Documentation www.python.or 2015 |
| Course Material Link | http://docs.python.org/3/tutorial/index.html |
| Course Material Link | http://interactivepython.org/courselib/static/pythonds |

| MCA-603 | Artificial Intelligence | 3 Credits |
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**Course Objective:**

1. To learn the concepts of Agent based search techniques.
2. To understand adversal searching methods and knowledge representation.
3. To learn the types of uncertainty, planning, and Bayesian networks.
4. To understand the concepts of Expert Systems and it design procedure.

**Module-I:** **(12 Hrs)**

Intelligence and AI, Agents, Model of different types of agents: reactive, deliberative, goal-driven, utility-driven, and learning agents, Environment, Properties of Environment, State Space, Knowledge, Rationality, and Turing Test. Search Techniques definition and importance, uninformed search–DFS, BFS, iterative deepening, iterative broadening, depth limited search, Issues In Design Of heuristics, Best First search, A* and AO* search, Hill climbing, Simulated Annealing, ConstraintSatisfactionProblem,8-puzzle problem, Crypt-arithmetic Problem.

**Module-II:** **(10 Hrs)**

Adversarial Searching Techniques: Game Playing, minimax search, alpha-beta pruning. Knowledge Representation in AI, Logic-propositional, predicate, FirstOrder Logic. Normal forms. Modus Ponens & Modus Tollens, Theorem Proving, Principle of Resolutions, Non-Monotonic Reasoning. Semantic Net Frame.

**Module-III:** **(10 Hrs)**

Planning and its Importance. Classical Partial order planning, Conditional Planning. Uncertainty, type of uncertainty, Probabilistic Reasoning-joint distribution reasoning, Bayesian networks, learning, Explanation based learning, induction learning-Decision Tree, statistical learning-Bayesian Learning, expectation maximization, hidden Markov model, closed world problems.

**Module-IV:** **(6 Hrs)**

Expert Systems–Design Techniques, components, Problem And Knowledge Domain, Knowledge Engineering Approach, error in design of expert system, life cycle of expert system, MYCIN and Dendral–an expert system.

**Course Outcome:**

1. Ability to comprehend AI&ES to analyze and mapreal world activities to digital world
2. Ability to identify problems that are amenably solved by AI methods

3. Ability to design and carryout an empirical evaluation of different AI algorithms

**Textbooks:**

1. Artificial Intelligence–Knight&Rich, McGrawHill, 3rdEdition.
2. Principles of Artificial Intelligence –N.J.Nilson, 2ndEdition, Narosa Publishing.

**Reference Books:**

1. ArtificialIntelligenceAModernApproach–Russel&Norvig,2ndEdition,Pearson.
2. IntroductiontoArtificialIntelligenceandExpertSys–D.W.Patterson,PrenticeHall.
3. Expert System: Principle and programming-Joseph Giarratano, GaryRiley
4. NPTEL course-https://nptel.ac.in/courses/106106126/

Digital Learning Resources

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|---|---|
| Course Name | Artificial Intelligence |
| Course Link | https://nptel.ac.in/courses/106/105/106105079/ |
| Course Instructor | Prof.P.Dasgupta, IIT Kharagpur |

| MCA-630A | Department Specific Elective – I (Computer Graphics) | 3 Credits |
|---|---|---|

**Course Objective:**

1. To understand the basic principles of the geometric objects in the 2D and 3D coordinates.
2. To learn various transformation techniques, and Window and View Coordinate systems.
3. To study the rendering and shading technique used to produce realistic illustrations, and understand the curves tracing algorithms.
4. To understand the different projection method, back-face detection, and shading techniques.

**Module-I:** **(10 Hrs.)**

Overview of Graphics System: Video Display Units, Raster-Scan and Random Scan Systems, Graphics Input and Output Devices. Output Primitives: Line drawing Algorithms: DDA and Bresenham's Line Algorithm, Circle drawing Algorithms: Midpoint Circle Algorithm and Bresenham's Circle drawing Algorithm.

**Module-II:** **(10 Hrs.)**

Two-Dimensional Geometric Transformation: Basic Transformation (Translation, Rotation, Scaling) Matrix Representation, Composite transformations, Reflection, Shear, Transformation between coordinate systems. Two-Dimensional Viewing: Window-to- View Port Coordinate Transformation. 3D Geometric and Modelling Transformations: Translation, Rotation, Scaling, Reflections, shear, Composite Transformation.

**Module-III:** **(8 Hrs.)**

Clipping: Line Clipping (Cohen-Sutherland Algorithm) and Polygon Clipping (Sutherland-Hodgeman Algorithm), Aliasing and Antialiasing, Half Toning, Thresholding, Dithering. Polygon Filling: Seed Fill Algorithm, Scan line Algorithm. Two-Dimensional Object Representations: Spline Representation, Bezier Curves, B-Spline Curves.

**Module-IV:** **(10 Hrs.)**

Projections: Parallel Projection, Perspective Projection. Visible Surface Detection Methods: Back-Face Detection, Depth Buffer, Z- Buffer, Scan- Line Algorithm, Painters Algorithm. Illumination Models: Basic Models, Displaying Light Intensities. Surface Rendering Methods: Polygon Rendering Methods: Gouraud Shading, Phong Shading.

**Course Outcome:**

1. Student will understand the basic principles for representation of the geometric objects in the 2D and 3D coordinates.

2. Student will learn the implement the algorithms and techniques necessary to produce geometric objects in 2D and 3D space illustrations.
3. Student will understand Shading algorithms to determine how a surface should be shaded to produce realistic illustrations. Curves and surfaces methods for rendering and shading curved objects.
4. The students will be able to design and implement a substantial computer graphics system to represent some complex illustrations with the help of graphics system.

**Suggested Books:**

1. Computer Graphics, C version; D. Hearn and M. P. Baker; Pearson Education, 2nd Edition, 2002

2. Computer Graphics Principle and Practice, J.D. Foley, A. Dam, S.K. Feiner, Addison Wesley, 4th Edition, 2014.

3. Procedural Elements of Computer Graphics, David Rogers, TMH. 1998

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|---|---|
| Course Name | Programming and Data Structures |
| Course Link | https://nptel.ac.in/courses/106105085/4 |
| Course Instructor | Dr. P. P. Chakrabarti<br>Department of Computer Science and Engineering<br>Indian Institute of Technology Kharagpur |

MOOC courses:

https://www.coursera.org/learn/interactive-computer-graphics by Takeo Igarashi (Professor) Department of Computer Science, Graduate School of Information Science and Technology, University of Tokyo.

| MCA-630B | Department Specific Elective – I (Soft Computing) | 3 Credits |
|---|---|---|

**Course Objective:**

1. Learn about soft computing techniques and their applications, gain knowledge of different neural network architectures.

2. Gain knowledge of Back-Propagation network, Radial basis function, and Competitive learning.

3. Gain knowledge of Fuzzy logic, Fuzzy inferencing, Defuzzification methods.

4. Analyze the genetic algorithms and their applications.

**Module -I:** **(10 Hrs.)**

Introduction: Introduction to soft computing, application areas of soft computing, classification of soft computing techniques, structure & functioning of biological brain & Neuron, and concept of learning/training. Model of an Artificial Neuron, transfer/activation functions, Neural Network architectures, Perceptron learning model, linear separability, Characteristics and Applications of Neural Network.

**Module-II:** **(10 Hrs.)**

Multilayer Neural Networks: Feed Forward network - significance, training, loss function, Back-Propagation Network, Learning Factors of Back-Propagation Network, Radial Basis Function Network. Feedback network -Hopfield Nets: architecture, energy functions, training algorithms, competitive learning, self-organizing maps. Introduction to CNN and RNN network.

**Module -III:** **(8 Hrs.)**

Fuzzy Systems: fuzzy set theory, fuzzy sets and operations, membership functions, concept of fuzzy relations and their composition, concept of fuzzy Measures. Fuzzy logic: fuzzy rules, inferencing, Features of the Membership Functions, Fuzzyfication, De-fuzzification: Lambda-Cuts for Fuzzy sets, Lambda-Cuts for Fuzzy Relations, De-fuzzification Methods, applications of fuzzy system.

**Module -IV:** **(10 Hrs.)**

Fundamentals of Genetic Algorithms: Genetic Algorithms: History, Basic Concepts, Creation of Offspring's, Working Principle, Encoding, Fitness Function, And Reproduction. Genetic Modelling: Inheritance Operators, Cross Over, Inversion, And Deletion, Mutation Operator, Bit-Wise Operators, Bit-Wise Operators used in GA, Generational Cycle, Convergence of Genetic Algorithms.

**Course outcomes:**

1. Learn about soft computing techniques and their applications

2. Analyze various neural network architectures

3. Understand perceptron and counter propagation networks.

4. Define the fuzzy systems and Analyze the genetic algorithms and their applications

**Books Recommended**

1. S.N. Sivanandam & S.N. Deepa, Principles of Soft Computing, Wiley Publications

2. S, Rajasekaran & G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic & Genetic Algorithms, Synthesis & applications, PHI Publication

3. Bose, Neural Network fundamental with Graph , Algo.& Appl, TMH Kosko: Neural Network & Fuzzy System, PHI Publication

4. Klir & Yuan ,Fuzzy sets & Fuzzy Logic: Theory & Appli.,PHI Pub. Hagen, Neural Network Design, Cengage Learning

| MCA-600L | Design and Analysis of Algorithms Lab | 1 Credits |
|---|---|---|

**Lab Assignments:**

1. Insertion Sort/ Selection Sort
2. Divide and Conquer: Fibonacci search/Binary search
3. Divide and Conquer: Merge Sort/Quicksort/Heap Sort
4. Divide and Conquer: Convex hull/Finding closet pair
5. Dynamic Programming: MCM/LCS
6. Dynamic Programming: Rod Cutting problem /Assembly line Scheduling
7. Greedy method: Activity Selection/Huffman Coding
8. Graph Search: BFS/DFS
9. Graph Greedy MST: Kruskal/Prim's
10. Graph Greedy Shortest Path: Bellman ford/Dijkstra
11. Rabin Karp string matching algorithm/Subset Sum problem using Branch and Bound

Prerequisite: Each student should have a good knowledge on basic data structures like Stack, Queue, List, Heap, Matrix

| MCA-602L | Python Programming Lab | 1 Credits |
|---|---|---|

**Lab Assignments:**

1. Basic Syntax and Operators
2. Conditional Statements
3. Loops and Patterns
4. Lists and Tuples
5. Strings and String Functions
6. Dictionaries and Sets
7. Functions and Recursion
8. Object-Oriented Programming
9. File Handling
10. Exception Handling
11. Python Database Connectivity

## FOURTH SEMESTER DETAIL SYLLABUS

| MCA-604 | Machine Learning | 4 Credits |
|---|---|---|

**Course Objective:**

1. Understand Fundamental Concepts and the basic principles of machine learning.
2. Apply Machine Learning Algorithms such as regression, classification, clustering, and dimensionality reduction.
3. Develop Data-Driven Models using appropriate ML techniques and tools.
4. Build ML Applications for solving real-world problems.

**Module-I:** **(12 Hrs.)**

Introduction to Machine Learning, Model Preparation, Modeling and Evaluation, Human learning versus machine learning, types of machine learning, applications of machine learning, tools for machine learning, Data Pre- processing, selecting a model, training a model, model representation and interpretability, evaluating performance of a model, improving performance of a model, Learning theory, Hypothesis and target class, Hilbert space, Inductive bias and bias-variance tradeoff. Feature Engineering, Bayesian Concept Learning, Introduction to feature engineering, feature transformation, feature subset selection,

**Module-II:** **(10 Hrs.)**

Supervised Learning –Classification, Regression, Common regression algorithms, classification model, classification learning steps, common classification algorithms – KNN, Decision trees random forest, SVM, concepts of Bayes' theorem, concept learning through Bayes' theorem, Bayesian Belief Network.

**Module-III:** **(8 Hrs.)**

Unsupervised Learning –Clustering, pattern finding using association rules, Unsupervised learning versus supervised learning, applications of unsupervised learning, clustering and its types, Apriori algorithm for association rule learning.

**Module-IV:** **(8 Hrs.)**

Neural Network: Understanding the biological neuron, exploring artificial neuron, types of activation functions, early implementation of artificial neural network, architectures of neural network, learning process in artificial neural network, back propagation, Overview of Deep Learning.

**Course Outcome:**

1. Equip students with knowledge of fundamentals concepts in machine learning.
2. Ability to analyse and validate different learning algorithms.
3. Fine tune machine learning algorithms and evaluate models generated from data.

4. Solving real-world problems using ML Applications.

**Textbooks:**

1. Saikat Dutt, Subramanian Chandramouli, Amit Kumar Das, "Machine Learning", Pearson Education
2. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2010.

**Reference Books:**

3. J. Friedman, T. Hastie, and R. Tibshirani.The elements of statistical learning.Vol. 1, no. 10. New York: Springer series in statistics, 2001.
4. S. Shalev-Shwartz, and S. Ben-David. Understanding machine learning: From theory to algorithms. Cambridge university press, 2014.

**Digital Learning Resources**

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|---|---|
| Course Name | Introduction to Machine Learning |
| Course Link | https://nptel.ac.in/courses/106/106/106106139/ |

| MCA-605 | Internet & Web Technology | 4 Credits |
|---|---|---|

**Course Objective:**

1. Develop dynamic web pages using HTML, CSS and Java Script.
2. Develop applications using JDBC.
3. Develop a small web site using Servlets and , JSP and database.
4. Understanding the requirement of various frameworks Spring and Hibernate.

**Module-I** **(10 Hrs)**

Introduction to Web Application: Introduction and overview of networking concept and Client Server Architectural Model, 3 Tier Architecture, Internet and World Wide Web, Web Browsers, Web Servers, URLs, HTTP, Web applications.

Web Programming: Basics of HTML Programming: HTML Tags, images, hyperlinks Tables, List, Forms, Frames, CSS, Basic JavaScript Programming: DOM, Loops, function, arrays, form validation, Event handling, XML: Document structure, DTD, XML Schema and Parsing XML documents.

**Module-II** **(8 Hrs)**

Basics of JDBC: Architecture of JDBC, Various types of JDBC drivers, Programming with JDBC, creating a database using MySQL, Loading the Driver, Establishing the Connection, Creating Statements (Statement/Prepared Statement/Callable Statement), Executing a SQL Query, manipulating various SQL Queries, Result, Set, Creating Database Connectivity Applications

**Module-III** **(10 Hrs)**

Enterprise Java Programming: Java Servlet Technology: Introduction to Servlet, Web Servers and its Containers, Lifecycle of a Servelet, Servelet API, Servlet Packages, Types of servlets, Servlet Config, Servlet Context, sendRedirect(), Request Dispatcher forward(), Session tracking in Servlet, Cookies ,Servlet Filters, Servlet code for mailing using Mail API.

Database Programming: Servlet to DBMS communication using type-4 connection, Servlet communication with other servlets (Servlet Chaining), Servlet communication with JSP or HTML page, Database Access using Servlet.

**Module-IV** **(10 Hrs)**

JSP Technology: - Architecture & Anatomy of JSP Page, JSP life cycle, JSP with MVC Architecture, Dynamic webpage Creation, Significance of JSP Engine, Built in objects of JSP, Scripting Elements, Directive tags, Action tags ,Session Tracking, Database access using JSP page, JSTL, Concept of Ajax. Introduction to Java Server Faces (JSF) Technology. Enterprise JavaBeans Technology: EJB Component Architecture, Role of EJB & its life cycle, Types of Beans, Stateless and stateful beans.

**Course Outcome:**

1. Design and implementation of Web pages using HTML, Java Script and CSS.
2. Develop JDBC applications.
3. Implement server-side script using Servest's.

4. Develop dynamic web pages using JSP, develop a web site using JSP, Servlet and Database. Analyze the benefits of various frameworks like Spring, Hibernate.

**Suggested Books and Reading Materials:**

1. Java Server Programming Java EE6 (J2EE 1.6) Black Book, Kogent Solution Inc.
2. Head First Servlets and JSP 3rd Edition by Bert Bates (Author), Kathy Sierra (Author), Bryan Basham
3. Web Enabled Commercial Application Using HTML, DHTML, JAVA SCRIPT, PERL, CGI ,Ivan Bayross BPB Publication.

| | |
|---|---|
| Course Name | JDBC Servlets and JSP - Java Web Development Fundamentals |
| Course Link | https://www.udemy.com/jdbcservletsandjsp/ |
| Course Instructor | Create Java Web Applications from scratch in easy steps by Bharath Thippi Reddy |

**ELECTIVE-II**

| MCA-631A | Internet of Things (IoT) | 3 Credits |
|---|---|---|

**Course Objective**

1. To learn the basic issues, policy and challenges in the Internet.
2. To get an idea of the application areas where Internet of Things can be applied.
3. To understand the cloud and internet environment and various modes of communications with Internet.
4. To understand the various modes of communications with Internet.

**Module-I:** **(10 Hrs)**

Introduction & Concepts: Introduction to Internet of Things, Physical Design of IOT, Logical Design of IOT, IOT Enabling Technologies, IOT Levels. Domain Specific IOTs: Home Automation, Cities, Environment, Energy, Agriculture, IIOT 4.0 Health & Life Style, Challenges and Issues.

**Module-II:** **(10 Hrs)**

M2M & System Management with NETCONF-YANG: M2M, Difference between IOT and M2M, SDN and NFV for IOT, Software defined Networking, Network Function Virtualization, Need for IOT Systems Management, Simple Network Management Protocol, Limitations of SNMP, Network Operator Requirements, NETCONF, YANG, IOT Systems management with NETCONF-YANG.

**Module-III:** **(10 Hrs)**

IoT Protocols: Protocol Standardization for IoT and WSN Protocols-SCADA and RFID Protocols-Issues with IoT Standardization Protocols IEEE802.15.4-BACNet Protocol- , Architecture - Network layer – APS Layer – Security.

**Module-IV:** **(10 Hrs)**

Data Analytics for IoT; Introduction Appache Hadoop, using Hadoop Map Reduce for Batch Data Analysis, Ethics: Characterizing the IoT, Privacy, Control, Distributing Control and Crowd Sourcing, Environment, Physical Thing (Prototypes, Design environment, ARDINO & Raspberry PI, Prototype board), Electronics, Internet Service, Solutions, Internet of Things as Part of Solution, Cautious Optimizing, The Open IoT definition.

**Course Outcome:**

1. Understand the definition and significance of the Internet of Things
2. Discuss the architecture, operation, and business benefits of an IoT solution
3. Examine the potential business opportunities that IoT can uncover
4. Explore the relationship between IoT, cloud computing, and big data

**Text Book:**

1. VijayMadisetti, Arshdeep Bahga," Internet of ThingsA Hands-On- Approach",2014, ISBN:978 0996025515
2. Honbo Zhou, "The Internet of Things in the Cloud:A Middleware Perspective" — CRC Press-2012.

3. Arshdeep Bahga, Vijay Madisetti, “Internet of Things (A Hands-On-Approach)”, VPT, 2014.

**Suggested Book:**

1. Atzori, L., Iera, A., & Morabito, G. (2010). The internet of things: A survey. *Computer networks*, *54*(15), 2787-2805.

2. Hersent, O., Boswarthick, D., & Elloumi, O. (2011). *The internet of things: Key applications and protocols*. John Wiley & Sons.

3. Tan, L., & Wang, N. (2010, August). Future internet: The internet of things. In *2010 3rd international conference on advanced computer theory and engineering (ICACTE)* (Vol. 5, pp. V5-376). IEEE.

4. Uckelmann, D., Harrison, M., & Michahelles, F. (Eds.). (2011). *Architecting the internet of things*. Springer Science & Business Media.

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|---|---|
| Course Name | INTRODUCTION TO INTERNET OF THINGS |
| Course Link | https://nptel.ac.in/courses/106/105/106105166/ |
| Course Instructor | PROF. SUDIP MISRA<br>Department of Computer Science and Engineering,<br>IIT Kharagpur |

| MCA-631B | Computer Network Security | 3 Credits |
|---|---|---|

**Course Objective:**

1. To understand basics of Cryptography and Network Security.
2. To be able to secure a message over insecure channel by various means.
3. To learn about how to maintain the Confidentiality, Integrity and Availability of a data.
4. To understand various protocols for network security to protect against the threats in the networks

**Module-I** **(10 Hrs)**

Introduction to Security: What is security? Why we need Security? Security concerns, Security Goals: Confidentiality, Integrity, Availability, Authenticity and Accountability, Computer security challenges, Security Breach Impact levels: Low, Moderate and High, Security threats/attacks: passive and active, Security Policy, Security issues, Brief History of Malware, Types of Malware, Network Security Audit, The Orange Book, Legal Issues.

TCP/IP Security Attacks: TCP Segment Format, TCP Connection Setup, TCP Disconnection, IP Address Spoofing, Covert Channel, IP Fragment Attacks, TCP Flags, Syn Flood, Ping of Death, Smurf, Fin, UDP Flood Attack, Connection Hijacking, ARP Spoofing, DNS Spoofing, E-Mail Spoofing, Web Spoofing.

**Module-II** **(8 Hrs)**

Introduction to Cryptography, Symmetric-Key Cryptography: Traditional Ciphers, Simple Modern Ciphers, Modern Round Ciphers, Mode of Operations. Asymmetric-key Cryptography: RSA and Diffie-Hellman. Network Security: Security Services, Message Confidentiality, Message Integrity, Message Authentication: MAC and HMAC, Digital Signature, Key Management: Symmetric-key Distribution: KDC, Session Keys, Kerberos, Public-key Distribution: Certification Authority, X.509, PKI.

**Module-III** **(10 Hrs)**

Authentication, Authentication methods, Passwords, Challenge-Response, Biometrics, Something you have, Two-factor authentication., Single Sign-On and Web Cookies. Authorization, A brief history of authorization, Access control matrix, Compartments, Covert Channel, Inference Control, CAPTCHA, Firewalls and Proxies, Defense in depth, Computer Networks security zones, Concept of Demilitarized Zones (DMZ) in designing Corporate Networks, Analysis of Network Infrastructure, DMZ: Mail server, WWW Server, DNS Server. Network flooding, Anticipating attacks, IDS.

**Module-IV** **(12 Hrs)**

Simple Security Protocols, Authentication Protocols: authentication using symmetric keys, authentication using public keys, session keys, perfect forward secrecy, mutual authentication, session keys, and PFS, Timestamps, Authentication and TCP, Zero knowledge proofs. SSH, SSL/TSL: SSL and Man-in-the-Middle, SSL connections, SSL Versus IPSec, , IPSec: IKE Phase I: Digital Signature, Symmetric Key, Public Key Encryption, IPSec Cookies, IKE. Phase II, IPSec and IP Datagrams, Transport and Tunnel Modes, ESP and AH, Application Layer Security: Pretty Good Privacy (PGP). Introduction to Blockchain & Distributed Ledger technology (DLT):

Bitcoin, Blockchain Architecture, Key Characteristics of Blockchain, Taxonomy of Blockchain systems,

**Course Outcome:**

The learners would be able to

1. Provide security of the data over the network.
2. Do research in the emerging areas of cryptography and network security.
3. Implement various networking protocols.
4. Protect any network from the threats in the world.

**Text Books:**

1. William Stallings, "Crpyptography and Network security Principles and Practices",Pearson/PHI.
2. Wade Trappe, Lawrence C Washington, " Introduction to Cryptography with codingtheory", Pearson.

**Reference Books:**

1. W. Mao, "Modern Cryptography –Theory and Practice", Pearson Education. Charles P. Pfleeger, Shari Lawrence Pfleeger –Security in computing –Prentice Hall of India.

| MCA-631C | Web application Development | 3 Credits |
|---|---|---|

**Course Objectives:**

1. Understand the basics in Web Design
2. Define the basic concept of HTML
3. Introduce basics concept of CSS
4. Develop and Publish Web-Apps

**Module-I** **(10 Hrs)**

Web Design Principles:

Basic principles involved in developing a web site, Planning process, Five Golden rules of web designing, Designing navigation bar, Page design, Home Page Layout, Design Concept. Basics in Web Design, Brief History of Internet, The World Wide Web, To create a web site, Web Standards, Audience requirement.

**Module-II** **(10 Hrs)**

Introduction to HTML, HTML Basics, HTML Documents, Basic structure of an HTML document, Creating an HTML document, Mark up Tags, Heading-Paragraphs, Line Breaks, HTML Tags. Elements of HTML, Introduction to elements of HTML, Working with Text, Working with Lists, Tables and Frames, Working with Hyperlinks, Images and Multimedia, Working with Forms and controls.

**Module-III** **(10 Hrs)**

Introduction to Cascading Style Sheets, Concept of CSS, Creating Style Sheet, CSS Properties, CSS Styling(Background, Text Format, Controlling Fonts), Working with block elements and objects, Working with Lists and Tables, CSS Id and Class, Box Model(Introduction, Border properties, Padding Properties, Margin properties), CSS Advanced(Grouping, Dimension, Display, Positioning, Floating, Align, Pseudo class, Navigation Bar, Image Sprites, Attribute sector), CSS Color Creating page Layout and Site Designs

**Module-IV** **(8 Hrs)**

Introduction to Web Publishing or Hosting, Creating the Web Site, Working on the web site, Creating web site structure, 6.5 Creating Titles for web pages, 6.6 Themes-Publishing web sites.

| MCA-631D | Cloud Computing | 3 Credits |
|---|---|---|

**Course Objective:**

1. To understand the concepts of Cloud Computing and Virtualization Techniques.
2. To learn Cloud Computing Architecture.
3. To acquire knowledge on Aneka Cloud Application Platform.
4. To learn Industry Cloud Platforms.

**Module-I** **(10 Hrs)**

Introduction to Cloud: Cloud Computing at a Glance, The Vision of Cloud Computing, Defining a Cloud, A Closer Look, Cloud Computing Reference Model. Characteristics and Benefits, Challenges Ahead, Historical Developments. Virtualization: Introduction, Characteristics of Virtualized Environment, Taxonomy of Virtualization Techniques, Virtualization and Cloud computing, Pros and Cons of Virtualization, Technology Examples- VMware and Microsoft Hyper- Before the Move into the Cloud: Know Your Software Licenses, The Shift to a Cloud Cost Model, Service Levels for Cloud Applications..

**Module-II** **(10 Hrs)**

Cloud Computing Architecture : Introduction, Cloud Reference Model, Architecture, Infrastructure / Hardware as a Service, Platform as a Service, Software as a Service, Types of Clouds, Public Clouds, Private Clouds, Hybrid Clouds, Community Clouds, Economics of the Cloud, Open Challenges, Cloud Interoperability and Standards, Scalability and Fault Tolerance. Ready for the Cloud: Web Application Design, Machine Image Design, Privacy Design, Database Management, Data Security, Network Security, Host Security, Compromise Response.

**Module-III** **(10 Hrs)**

Defining the Clouds for Enterprise: Storage as a service, Database as a service, Process as a service, Information as a service, Integration as a service and Testing as a service. Scaling a cloud infrastructure - Capacity Planning, Cloud Scale. Disaster Recovery: Disaster Recovery Planning, Disasters in the Cloud, Disaster Management. Aneka: Cloud Application Platform Framework Overview, Anatomy of the Aneka Container, From the Ground Up: Platform Abstraction Layer, Fabric Services, Foundation Services, Application Services, Building Aneka Clouds, Infrastructure Organization, Logical Organization, Private Cloud Deployment Mode, Public Cloud Deployment Mode, Hybrid Cloud Deployment Mode, Cloud Programming and Management, Aneka SDK, Management Tools.

**Module-IV** **(8 Hrs)**

Cloud Applications: Scientific Applications – Health care, Geoscience and Biology. Business and Consumer Applications- CRM and ERP, Social Networking, Media Applications and Multiplayer Online Gaming. Cloud Platforms in Industry: Amazon Web Services- Compute Services, Storage Services, Communication Services and Additional Services. Google App Engine-Architecture and Core Concepts, Application Life-Cycle, cost model. Microsoft Azure- Azure Core Concepts, SQL Azure.

**Textbook:**

1. Mastering Cloud Computing by Rajkumar Buyya, Christian Vecchiola, S.Thamarai Selvi from TMH 2013.
2. George Reese Cloud Application Architectures, First Edition, O‟Reilly Media 2009.

**Reference Book:**

1. Cloud Computing and SOA Convergence in Your Enterprise A Step-by-Step Guide by David S. Linthicum from Pearson 2010.
2. Cloud Computing 2 nd Edition by Dr. Kumar Saurabh from Wiley India 2012.
3. Cloud Computing – web based Applications that change the way you work and collaborate Online – Micheal Miller.Pearson Education.

| MCA-631E | Data Science | 3 Credits |
|---|---|---|

**Course Objectives:**

1. Introduce R as a programming language
2. Introduce the mathematical foundations required for datascience
3. Introduce the first level data science algorithms
4. Introduce a data analytics problem solving framework
5. Introduce a practical capstone case study

**Module-I** **(10 Hrs)**

Introduction: Introduction to Data Science, Data Science Venn Diagram, Relation to data mining, machine learning, big data and statistics, Business Intelligence (BI) vs. Data Science. Types of Data: Structured v/s unstructured data, Examples of data pre-processing, Quantitative vs qualitative data, Four levels of data. Stages of a data science project: Defining the goal, Data collection and management, Explore the data, Modeling, Model evaluation and critique, Presentation and documentation.

**Module-II** **(10 Hrs)**

Introduction to Linear algebra for data science: Vectors and matrices. Introduction to Probability: Bayesian versus Frequentist, Frequentist approach, The law of large numbers, Compound events, Conditional probability, Bayesian ideas revisited, Bayes theorem , More applications of Bayes theorem, Random variables, Discrete random variables. Basic Statistics: Obtaining data (Observational, Experimental), Sampling data, Probability sampling, Random sampling, Unequal probability sampling, measurement of statistics , Measures of center (Mean, Median, Mode, Skewness, Quantile, Percentile), Measures of variation, Measures of relative standing, Correlations in data, The Empirical rule.

**Module-III** **(10 Hrs)**

Data Visualization: Basic principles, ideas and tools for data visualization, Identify effective and ineffective visualization (Scatter plots, Line graphs, Bar charts, Histograms, Box plots), Correlation versus causation, Simpson's paradox, Verbal communication. Machine Learning Essentials: Machine learning, Working principles, Types of machine learning (Supervised learning, Unsupervised learning, Reinforcement learning), How does statistical modeling fit. Some Basic Algorithms like Linear Regression, k-Nearest Neighbors (k-NN), k-Means, Decision Tree. Feature Extraction, Eigen vectors and Eigen values, Principal Component Analysis (PCA).

**Module-IV** **(10 Hrs)**

Beyond the Essentials: The bias variance tradeoff (Error due to bias, Error due to variance, Two extreme cases of bias/variance tradeoff, How bias/variance play into error functions), K folds cross-validation, Grid searching (Visualizing training error versus cross-validation error), Ensembling techniques (Random forests, Comparing Random forests with decision trees), Introduction to structure of Neural networks.

**Module-V** **(10 Hrs)**

Hands on laboratory using R Language for example like Data Visualization (Scatter plots, Line

graphs, Bar charts, Histograms, Box plots), Some Basic Algorithms like Linear Regression, k-Nearest Neighbors (k-NN), k-Means, Decision Tree. Principal Component Analysis (PCA), Random Forests, Neural Networks.

**Course Outcomes:**

1. Describe a flow process for data science problems (Remembering)
2. Classify data science problems into standard typology (Comprehension)
3. Develop R codes for data science solutions (Application)
4. Correlate results to the solution approach followed (Analysis)
5. Assess the solution approach (Evaluation)
6. Construct use cases to validate approach and identify modifications required

**Text Books:**


1. Principles of Data Science, Sinan Ozdemir, Packt Publishing Ltd 2016.
2. Doing Data Science, Straight Talk From The Frontline, Cathy O'Neil and Rachel Schutt., O'Reilly. 2014.
3. An Introduction to Statistical Learning with Applications in R. James G, Witten D, Hastie Tibshirani R, Springer, 2013.
4. Hands-On Data Science with R: Techniques to perform data manipulation and ...,Vitor Bianchi Lanzetta, Nataraj Dasgupta, Ricardo Anjoleto Farias, Packt publishing ltd, 2018.
5. Data Science for Engineers : https://swayam.gov.in/nd1_noc19_cs60/preview (Prof. Raghunathan Rengasamy & Prof. Shankar Narasimhan, IIT Madras).
6. https://www.udemy.com/course/data-science-and-machine-learning-bootcamp-with-r/ (Created by Jose Portilla)
7. https://www.udemy.com/machinelearning/ Machine Learning A-Z™: Hands-On Python & R In Data Science By: Kirill Eremenko, Hadelin de Ponteves

| MCA-631F | Software Testing and Quality Assurance | 3 Credits |
|---|---|---|

**Course Objective:**

1. Introduce basic concepts of software testing
2. Understand white box, block box, object oriented, web based and cloud testing
3. Know in details automation testing and tools used for automation testing
4. Understand the importance of software quality and assurance software systems development.

**Module-I** **(10 Hrs)**

Quality Revolution, Software Quality, Role of Testing, Verification and Validation, Failure, Error, Fault and Defect, Notion of Software Reliability, Objective of Testing, What is a Test Case?, Expected Outcome, Concept of Complete Testing, Testing Activities, Test Oracle, Testing Levels, Regression Testing, White-Box and Black Testing, Test Planning and Design, Monitoring and Measuring Test Execution, Test Tools and Automation Unit Testing: Concept of Unit Testing, Static and Dynamic unit Testing, Mutation Testing, Debugging, Unit Testing in eXtreme Programming.

**Module-II** **(10 Hrs)**

Control Flow Testing: Outline of Control Flow Testing, Control Flow Graph, Path in a CFG, Path selection Criteria, All-Path Coverage Criterion, Statement Coverage Criterion, Branch Coverage Criterion, Generation of Test Input, Example of Test Data Selection. Data Flow Testing:Data Flow Anomaly, Overview of Dynamic Data Flow Testing, Data Flow Graph, Data Flow Terms, Data Flow Testing Criteria, Comparison of Data Flow Test Selection Criteria, Feasible Paths and Test Selection Criteria, Comparison of Testing Techniques. System Integration Testing:Concept of Integration Testing, Different Types of Interfaces and Interface Errors, Granularity of System Integration Testing, System Integration Techniques, Software and Hardware Integration, Test Plan for System Integration, Off-the-Shelf Component Integration, Off-the-Shelf Component Testing, Built-in Testing

**Module-III** **(10 Hrs)**

System Test Categories:Basic Tests, Functionality Tests, Robustness Tests, Interoperability Tests, Performance Tests, Scalability Tests, Stress Tests, Load and Stability Tests, Reliability Tests, Regression Tests, Documentation Tests. Functional Testing:Equivalence Class Partitioning, Boundary Value Analysis, Decision Tables, Random Testing, Error Guessing, Category Partition.
System Test Planning and Automation:Structure of a System Test Plan, Introduction and Feature Description, Assumptions, Test Approach, Test Suite Structure, Test Environment, Test Execution Strategy, Test Effort Estimation, Scheduling and Test Milestones, System Test Automation, Evaluation and Selection of Test Automation Tools, Test Selection Guidelines for Automation, Characteristics of Automated Test Cases, Structure of an Automated Test Case, Test Automation Infrastructure. Acceptance Testing:Types of Acceptance Testing, Acceptance Criteria, Selection of Acceptance Criteria, Acceptance Test Plan, Acceptance Test Execution, Acceptance Test Report, Acceptance Testing in eXtreme Programming.

**Module-IV** **(10 Hrs)**

Software Reliability: Definition, Factors Influencing Software Reliability, Application of Software Reliability, Operational Profiles. Software Quality:Five Views of Software Quality, McCall's Quality Factors and Criteria, Quality Factors Quality Criteria, Relationship between Quality Factors and Criteria, Quality Metrics, ISO 9126 Quality Characteristics, ISO 9000:2000 Software Quality Standard ISO 9000:2000 Fundamentals, ISO 9001:2000 Requirements. Maturity Models: Basic Idea in Software Process, Capability Model(CMM) Model, Architecture, Five Levels of Maturity and Key Process Areas, Common Features of Key Practices, Application of CMM, CMMI, Test Process Improvement (TPI), Testing Maturity Model (TMM).

**Textbook:**

1. Software Testing and Quality Assurance: Theory and Practice, Kshirasagar (Sagar) Naik, University of Waterloo, Priyadarshi (Piyu) Tripathy, NEC, Wiley , 2008.

Reference Book:

Software Quality Assurance, Daniel Galin, Pearson Education

| MCA-631G | Block-Chain Technology | 3 Credits |
|---|---|---|

**Course Objective:**

1: Understand how block-chain systems (mainly Bitcoin and Ethereum) work,
2: To securely interact with them,
3: Design, build, and deploy smart contracts and distributed applications,
4: Integrate ideas from block-chain technology into their own projects

**Module-I** **(10 Hrs)**

Basics: Distributed Database, Two General Problem, Byzantine General problem and Fault Tolerance, Hadoop Distributed File System, Distributed Hash Table, ASIC resistance, Turing Complete. Cryptography: Hash function, Digital Signature - ECDSA, Memory Hard Algorithm, Zero Knowledge Proof.

**Module-II** **(10 Hrs)**

Introduction, Advantage over conventional distributed database, Block-chain Network, Mining Mechanism, Distributed Consensus, Merkle Patricia Tree, Gas Limit, Transactions and Fee, Anonymity, Reward, Chain Policy, Life of Block-chain application, Soft & Hard Fork, Private and Public Block-chain

**Module-III** **(10 Hrs)**

Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn, Difficulty Level, Sybil Attack, Energy utilization and alternate,

**Module-IV** **(10 Hrs)**

Cryptocurrency: History, Distributed Ledger, Bitcoin protocols - Mining strategy and rewards, Ethereum -Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin Cryptocurrency Regulation: Stakeholders, Roots of Bit coin, Legal Aspects-Crypto currency Exchange, Black Market and Global Economy.
Applications: Internet of Things, Medical Record Management System, Domain Name Service

**Course Outcome:**

1. Explain design principles of Bitcoin and Ethereum, Explain Nakamoto consensus, Explain the Simplified Payment Verification protocol.
2. List and describe differences between proof-of-work and proof-of-stake consensus.
3. Interact with a blockchain system by sending and reading transactions. Design, build, and deploy a distributed application.
4. Evaluate security, privacy, and efficiency of a given blockchain system

**Textbooks:**

1. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder, Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction, Princeton University Press (July 19, 2016).

Reference Books
1. Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies
2. Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System
3. DR. Gavin Wood, “ETHEREUM: A Secure Decentralized Transaction Ledger,”Yellow paper.2014.
4. Nicola Atzei, Massimo Bartoletti, and TizianaCimoli, A survey of attacks on Ethereum smart contracts

| MCA-604L | Machine Learning Laboratory | 1 Credits |
|---|---|---|

**Course Objective:**

1. Make use of Data sets in implementing the machine learning algorithms
2. Implement the machine learning concepts and algorithms in any suitable language of choice.

**Laboratory Experiments**

1. Build a multivariate logistic regression model to classify glass type of glass given different glass mixture features using the Glass Identification Dataset from UCI Machine Learning Repository.
2. Implement supervised machine learning algorithm (Classification – K Nearest Neighbourhood) in python to classify breast tumour data into malignant breast tumour or benign breast tumour and obtain its accuracy level.
3. Implement supervised machine learning algorithm (Classification – K Nearest Neighbourhood) in python to classify iris data into setosa, virginica, versicolor using iris dataset and obtain its accuracy level.
4. Implement supervised machine learning algorithm (Classification – Naïve Bayes algorithm) in python on Pima Indians Diabetes dataset and obtain its accuracy level.
5. Implement supervised machine learning algorithm (Classification – Support Vector Machine) in python to classify breast tumour data into malignant breast tumour or benign breast tumour (use breast tumour dataset) and obtain its accuracy level.
6. Write a python program to build an email spam classifier using support vector machines for the Spam base dataset from UCI machine learning repository.
7. Implement unsupervised machine learning algorithm (Clustering – K Means) in python on Titanic/Iris dataset to cluster data by removing the class label.
8. Implement unsupervised machine learning algorithm (Clustering – K Means) in python on Breast Tumour dataset to cluster data by removing the class label.
9. Implement unsupervised machine learning algorithm (Clustering –Hierarchical) in python on Titanic dataset to cluster data (use Titanic dataset).
10. Implement text classification using neural network in python on Twenty Newsgroup dataset from UCI machine learning repository.

**References:**


**1.** Peter Harrington, “Machine Learning in Action”, DreamTech

**2.** Michael Bowles, “Machine Learning in Python”, Wiley

**3.** Gavin Hackeling, Mastering Machine Learning with Scikit-learn, Packt

**4.** Giuseppe Bonaccorso, Machine Learning Algorithms - Second Edition, Packt


**Course Outcome:**

1. Understand the implementation procedures for the machine learning algorithms
2. Design Java/Python programs for various Learning algorithms.
3. Apply appropriate data sets to the Machine Learning algorithms
4. Identify and apply Machine Learning algorithms to solve real world problems

| MCA-605L | Internet & Web Technology Laboratory | 1 Credits |
|---|---|---|

**Course Objective:**

1. Develop dynamic web pages using HTML, CSS and Java Script.
2. Develop applications using JDBC.
3. Develop a small web site using Servlets and ,JSP and database.
4. Understanding the requirement of various frameworks Spring and Hibernate.

**Laboratory Experiments**

01. HTML & XHTML Programming: basic tags, text formatting tags, creating hyperlinks.
02. HTML & XHTML Programming: tables, lists, frames, forms, maps, Creating CSS.
03. JavaScript Programming: Data types, loops, functions.
04. JavaScript Programming: DOM, arrays, forms, frame, GUI design.
05. XML Programming: page creation, making a DTD, Parsing XML files.
06. Creating, installation and running a web server (e.g. Apache Tomcat/ GlassFish).
07. Creating, Compiling and Running a Servlet. Program (both http & generic servlet).
08. Implementing session tracking mechanisms in servlets.
09. Generating Dynamic Web content using Servlet basing upon request response model.
10. Creating, Compiling and Running a JSP Program.
11. Implementing Session tracking through JSP Program.
12. Access to a database using Servlet/JSP program.
13. Creating a simple Java Bean Application programs using BDK. Tools.
14. Deploying of beans, implementing entity beans and session beans of EJB.
15. Creating manifest file, jar file and Deploying a web application.
16. Designing a simple Program using JDBC, beans and JSP implementing MVC Model.
17. A Web based Capstone project university management system using JSP/Servlet and Database.

**Course Outcome:**

1. Design and implementation of Web pages using HTML, Java Script and CSS.
2. Develop JDBC applications.
3. Implement server-side script using Servest's.
4. Develop dynamic web pages using JSP, develop a web site using JSP, Servlet and atabase. Analyze the benefits of various frameworks like Spring, Hibernate.

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| **22MC410** | **Major Project/ Industrial Training (0-0-24)** | **12 Credits** |