**Medi-Caps University,Indore**

**Department of Computer Science and Engineering**

**B.Tech. CSE 2018 Batch Sem – VI [January-June 2021]**

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| --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Course Code** | **Courses** | L | T | P | Credit |
| 1 | CS3CO13 | Design and Analysis of Algorithms | 3 | 1 | 2 | 5 |
| 2 | CS3CO15 | Object Oriented Analysis and Design | 3 | 1 | 2 | 5 |
| 3 | CS3CO27 | Compiler Design | 3 | 0 | 2 | 4 |
| 4 | CS3EXXX | Elective-3 | 3 | 0 | 0 | 3 |
| 5 | CS3EXXX | Elective-4 | 3 | 0 | 0 | 3 |
| 6 | CS3ES14 | Software Workshop-III | 0 | 0 | 2 | 1 |
| 7 | OE000XX | Open Elective-2 | 3 | 0 | 0 | 3 |
|  |  | **Total** | 20 | 2 | 8 | **24** |
|  |  | Total Contact Hours | **30** | | |  |

**Elective-3**

Artificial Engineering Track : CS3EA06 Natural Language Processing

Data Engineering Track: CS3ED04 Big Data Engineering

Web Technology Track: CS3EL08 Programming with XML

**Elective-4**

Artificial Engineering Track : CS3EA03 Soft Computing

Data Engineering Track: CS3ED01 Data Base Applications and Tools

Web Technology Track: CS3EL06 Internet of Things

**Open Elective-2**

OE00015 Agile Development ( CSE department)

OE00016 Block chain Architecture (CSE department)

OE00051 R-Programming (CSE department)

**CSE-CTIS**

**Elective-3:** Ethical Hacking

**Elective-4:** Principles of Virtualisation

**Open Elective-2:** Cloud Web Services

**CSE-DS**

**Elective-3:** Big Data Analytics

**Elective-4:** Machine Learning

**Open Elective-2:** Exploratory Data Analytics

HOD,CSE

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| **Course Code** | **Course Name** | **Hours Per Week** | | | | |
| **CS3CO13/IT3CO06** | **Design and Analysis of Algorithms** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| **3** | **1** | **2** | **6** | **5** |

**Unit-I**: **Introduction to Algorithms**

Algorithms, Analysis, Performance issues: Time and Space complexity; Asymptotic Notations.

Mathematical preliminaries: functions & their growth rates; Recurrence relations, Methods for solving recurrences. Elementary Sorting techniques and its analysis: Selection, Bubble, Insertion sort

**Unit-II: Sorting and Divide & Conquer**

Advance sorting techniques and its analysis: Heap sort, Radix sort and Bucket sort, Divide and Conquer techniques and its analysis - Binary search, Merge Sort, Quick sort, Strassen’s Matrix multiplication.

**Unit-III: Greedy Algorithms**

Greedy problems and its complexity analysis: Optimal merge patterns, Huffman coding, Minimum spanning trees, Knapsack problem, Job sequencing with deadlines, Single source shortest path problem - Dijkstra’s Algorithm

**Unit-IV: Dynamic Programming**

Dynamic programming problems and its complexity analysis: 0/1 Knapsack, Multistage graph, Bellman Ford Algorithm, Reliability design, Floyd-Warshall algorithm, Matrix Chain Multiplication, Longest Common subsequence.

**Unit-V: Backtracking and Branch & Bound**

Backtracking Approach: N-Queen’s problem, Hamiltonian cycle, Graph coloring problem, Sum of Subset problem. Introduction to branch & bound method, examples of branch and bound method like15 puzzle traveling salesman problem, 0/1 knapsack. An introduction to P, NP, NP Complete and NP hard problems.

**Text Books:**

1. Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, Introduction toAlgorithms, Second Edition, MIT Press/McGraw-Hill
2. E. Horowitz, S. Sahni, S Rajasekaran, Computer Algorithms, Galgotia Publications

**Reference Books:**

1. Saara Base, Computer Algorithms: Introduction to Design and Analysis, Addision Wesley.
2. A V Aho, J E Hopcroft & J D Ullman, The Design and Analysis of Computer Algorithms,Addison Wesley.

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| **Course Code** | **Course Name** | **Hours Per Week** | | | |
| **CS3CO15** | **Object Oriented Analysis and Design** | **L** | **T** | **P** | **Credits** |
| **3** | **1** | **2** | **5** |

**Unit I**

Structure of Complex Systems, Object Oriented Development Methods, Characteristics of Objects, Fundamental Concepts of Object orientation, UML- Overview, RUP and its Phases

**Unit II**

Models, Concepts in UML, Structural and Behavioral Models, Use Cases and functional Requirements, Use Case Descriptions,Classes, Relationships, Association, Generalization, Realization, Dependencies, Constraints

**Unit III**

State Machine View, Activity View, Interaction View, Sequence Diagram, Collaboration Diagram, Interaction Diagrams

**Unit IV**

Physical View, Component Diagram, Deployment Diagram, Package, Dependencies on Packages, Modelling System and Subsystems, Patterns and Types of Patterns, Applying Patterns

**Unit V**

Object Oriented Testing, Types of Testing, Quality Assurance Methods, Reusability, Reverse Engineering, Case Studies

**Text Book:**

1. Grady Booch, Object Oriented Analysis and Design with Applications, Addison Wesley
2. James Rambaugh, Ivar Jacobson, Grady Booch, The Unified Modelling Language Reference Manual, Addison Wesley

**Reference Book:**

1. Design Patterns - Elements of Reusable Object-Oriented Software, Gamma, et. al., Addison-Wesley.
2. Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and IterativeDevelopment, by Craig Larman, Pearson Education.

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| **Course Code** | **Course Name** | **Hours Per Week** | | | |
| **CS3CO27** | **Compiler Design** | **L** | **T** | **P** | **Credits** |
| **3** | **0** | **2** | **4** |

**Unit I**

Basic machine, FSM, Transition graph, Transition matrix, Deterministic and non-deterministic FSM’S, Equivalence of DFA and NDFA, Regular Expressions, CFG, Chomsky Hierarchy of Language, Derivation and Parse Tree, Ambiguity

**Unit II**

Compiler structure: Pass Structure of compiler, Translators, Phases of Compilers, Lexical Analyzer: Role of Lexical Analyzer, Specification of tokens, Recognition of tokens and input Buffering, The Syntactic Specification of Programming Languages, Cross Compiler, bootstrap Compiler

**Unit III**

Basic Parsing Techniques: Top Down parsers, Recursive Descent Parsers, Predictive Parsers. Bottom Up Parsing: Operator precedence parsing, LR parsers, Construction of SLR, Canonical LR and LALR parsing tables.

**Unit IV**

Syntax Directed Definition, Translation Scheme, Synthesized and inherited attributes, dependency graph, Construction of syntax trees, S-attributed and L-attributed definitions, Three address codes, quadruples, triples and indirect triples, Translation of assignment statements.

**Unit V**

Storage organization, activation trees, activation records, allocation strategies, Parameter passing symbol table, dynamic storage allocation, Basic blocks and flow graphs, Optimization of basic blocks, Loop optimization, Global data flow analysis, Loop invariant computations.

**Text Book:**

1. K.L.P. Mishra, Theory of computer Science, Prentice Hall of India Pvt. Ltd.

2. Principle of Compiler Design, Alfred V. Aho, and J.D. Ullman, Narosa Publication.

3. John E. Hopcroft, Jeffery Ullman, Introduction to Automata theory, Langauges & computation, Narosa Publishers.

**Reference Book:**

1. Compiler design in C, A.C. Holub, PHI.

2. Compiler construction (Theory and Practice), A.Barret William and R.M. Bates, Galgotia Publication.

3. Compiler Design, Kakde.

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| **Course Code** | **Course Name** | **Hours Per Week** | | | | |
| **CS3EL08** | **Programming with XML** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| **3** | **0** | **0** | **3** | **3** |

**Unit-I: Introduction to XML**

XML overview, Markup languages, Comparison with HTML, Usage, Rules for writing XML, XML syntax, Creating notebook XML, Tree structure of XML, Elements, Attributes and values, Root element, Child element, Nesting of elements, Empty elements, Adding attributes, Elements and Attributes uses, Writing comments, Predefined entities, XML tools, XML validation.

**Unit-II: XML-DTDs (Document Type Definitions)**

Document Type Definition, DTD syntax, Creating a DTD for notebook XML, Defining elements with children, Empty element, Number of occurrences, Defining choices, Attribute definitions, Internal and external DTD’s, Validating XML with DTD, Pros and cons of using DTD.

**Unit-III: XML-Schema**

Introduction to Schema, Namespace, Schema definition, Data types, Simple and complex data types, Attributes definition, Restrictions on values, Creating schema definition for notebook XML, Link and Validate XML with schema.

**Unit-IV: XSLT**

Introduction to XSL, Layout of an XSL Document and Templates, Linking XSL to your XML Source, Transforming XML with XSLT, xsl:output, xsl:template, xsl:apply-templates, Looping over nodes using xsl:for-each, Apply conditions using xsl:if, Processing and output using xsl:value-of, Sorting nodes, Create a XSLT for notebook and XML file and generate output in different conditions.

**Unit-V: XPath and Project**

Introduction to XPath, Using XPath to navigate an XML document, Predicates.

Sample Project: Store the information of students in XML file, validate it using XML schema and display the information of students in HTML using XSLT with proper formatting and conditions like having enrollment number, name start with, having CGPA between, in sorted order, etc.

**Text Books:**

1. Introduction to XML V.1, O’Reilly Publication.

2. Deitel H.M., XML How to Program, Pearson Publication.

3. Uttam K. Roy, Web Technologies, Oxford University Press.

**References**

1. Michael J. Young, XML Step by Step, Microsoft Press; 2nd edition

2. Elliotte Rusty Harold, XML Bible Second Edition, Hungry Minds Publication.

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| **Course Code** | **Course Name** | **Hours Per Week** | | | | |
| **CS3EA03** | **Soft Computing** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| **3** | **0** | **0** | **3** | **3** |

**Unit- I:** Concept of computing systems, Introduction to soft computing, characteristics, applications of soft computing techniques.

**Unit- II**: Neural Networks: Biological Neural Network, Different ANNs architectures, Fundamentals, Neural Network Architectures, Feedforward Networks, training techniques in different ANNs, Applications of ANN to solve real world’s problems.

**Unit- III:** Fuzzy Logic:Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Fuzzy relations, rules, propositions, implications and inferences, Defuzzification techniques, Fuzzy logic controller design, Some applications of Fuzzy logic.

**Unit- IV**: Genetic Algorithms: Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques, Basic GA framework and different GA architectures, GA operators: Encoding, Crossover, Selection, Mutation, etc, Solving single-objective optimization problems using GAs.

**Unit- V:** Hybrid Systems: Genetic Algorithm based Backpropagation Network, Fuzzy – Backpropagation, Fuzzy Logic Controlled Genetic Algorithms. Case studies.Case studies in Engineering

**Text Book:**

1. Sinha, N.K. and Gupta, M. M.: “Soft Computing and Intelligent Systems - Theory and Applications”, Academic Press.
2. Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis, and Applications, S. Rajasekaran, and G. A. Vijayalakshmi Pai, Prentice Hall of India, 2007.

**Reference Books**:

1. Soft Computing, D. K. Pratihar, Narosa, 2008.
2. Jang, J-S. R., Sun,C-T, Mizutani, E.: “Neuro–Fuzzy and Soft Computing”, Prentice Hall of India.

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| **Course Code** | **Course Name** | **Hours Per Week** | | | |
| **CS3EA06/IT3EA06** | **Natural Language Processing** | **L** | **T** | **P** | **Credits** |
| **3** | **0** | **0** | **3** |

**Unit-1**

Introduction: Human languages, Main approach of NLP, Knowledge in speech and language processing, Ambiguity, Models and algorithms, Formal language and Natural Language, Regular Expression and automata.

**Unit-2**

Text Pre-processing, Tokenization, Feature Extraction from text, Morphology: Inflectional and Derivational, Finite state morphological parsing, Finite state transducer

Part of Speech Tagging: Rule based, Stochastic POS, Transformation based tagging.

**Unit-3**

Speech Processing: Speech and phonetics, Vocal organ, Phonological rules and Transducer, Probabilistic models: Spelling error, Bayesian method to spelling, Minimum edit distance, Bayesian method of pronunciation variation.

**Unit-4**

N-Grams: Simple N-Gram, perplexity, Smoothing, Backoff, Entropy, Parsing: Statistical Parsing, Probabilistic parsing, TreeBank.

**Unit-5**

Application: Sentiment analysis, Spelling correction, Word sense disambiguation, Machine translation, Text Classification, Question answering system.

**Text Book:**

1. Daniel Jurafsky and James H. Martin, “Speech and Language Processing”, Pearson Education.

2. James Allen, “Natural Language Understanding”, Pearson Education.

**Reference book:**

1. Christopher D. Manning and Hinrich Schutze, “Foundation of statistical Natural Language Processing”, MIT Press.

2. Mary Dee Harris “Introduction to Natural language Processing” ,Reston .

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| **Course Code** | **Course Name** | **Hours Per Week** | | | | |
| **CS3ED04** | **Big Data Engineering** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| **3** | **0** | **0** | **3** | **3** |

**Unit 1:** Foundations of Big Data Systems

Introduction to Big Data and its Applications Data Abstraction Linear data structures like Hashtables, Hashmaps, Bloom Filters Non-linear data structures like Binary Search Trees, KD Trees Distributed Algorithm Design Algorithm Design using MapReduce

**Unit 2:** Platforms for Big Data

Distributed Computing Environment for Big Data NoSQL databases for Big Data Storage Applications (HBase) Distributed Processing of data using MapReduce & Pig In-memory distributed processing using Apache Spark Data Storage on Cloud (Amazon S3 & Dynamo DB)

**UNIT 3:** Processing Big Data – ETL & Batch Processing

Performing ETL Operations Concepts in Data Warehousing and its relevance for Big Data Ingesting data into Big Data Platforms using Sqoop & Flume Workflow management for Hadoop using OOZIE Batch Processing on Cloud

**UNIT 4:** Processing of Real Time Data & Streaming Data

Applications of Streaming Data in Industry Sourcing Streaming data using Apache Flume Building real-time data pipelines using Apache Storm Streaming on Apache Spark

**UNIT 5:** Big Data Analytics

Regression, Clustering & Classification using Spark MLLib Building visualizations using Big Data Case Studies on applications of Big Data Analytics

**Text Books**

1. Mayank Bhushan, Big Data and Hadoop- Learn by Example, BPB Publications
2. [Erl/Khattak/Buhler](https://www.amazon.in/s/ref=dp_byline_sr_book_1?ie=UTF8&field-author=Erl%2FKhattak%2FBuhler&search-alias=stripbooks), Big Data Fundamentals: Concepts Drivers and Techniques, Prentince Hall

**References**

1. [Jeffrey Aven](https://www.amazon.in/s/ref=dp_byline_sr_book_1?ie=UTF8&field-author=Jeffrey+Aven&search-alias=stripbooks) , Hadoop in 24 Hours, Sams Teach Yourself, SAMS Publications.
2. [DT Editorial Services](https://www.amazon.in/s/ref=dp_byline_sr_book_1?ie=UTF8&field-author=DT+Editorial+Services&search-alias=stripbooks), Big Data, Black Book: Covers Hadoop 2, MapReduce, Hive, YARN, Pig, R and Data Visualization, Dream Tech Publications

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| **Course Code** | **Course Name** | **Hours Per Week** | | | | |
| CS3ED01 | Database Application and Tools | L | T | P | Hrs. | Credits |
| 3 | 0 | 0 | 3 | 3 |

**UNIT I**

**Database Environment:** Data versus information, traditional file processing, disadvantages,

database approach, range of database application, advantages of database approach. Cost and risk factors, components of database environment, evolution of database system.

**Database Development Process:** Information engineering, information architecture, enterprise data model, planning, SDLC, CASE etc. Steps of planning, strategic planning factors, corporate planning objects. Developing preliminary data model, and use of planning matrices, SDLC steps, CASE role, people in database development, three-schema architecture for database development. Examples to demonstrate the development process.

**UNIT II**

**Modeling Data in the Organization:** Modeling of the rules of organization, data names and definitions, ER model constructs entities and its types, attributes, relationships, degree, unary, binary, ternary, n-ary, cardinalities constraints, ER modeling examples.

**Enhanced ER modeling:** supertype, subtypes, specialization, generalization, specifying constraints in EER models, completeness, Disjointness, discriminators, defining super/sub type hierarchies, EER modeling examples, live demos modelling for few scenarios.

**UNIT III**

**Logical database design**: and relational model development, Relational model properties, keys, primary, secondary, composite, properties of relations. Codd’s rules, integrity constraints, creating relational tables, Transform EER diagrams into relations, seven different steps for mapping EER model into relations.

**UNIT IV**

**Introduction to normalization**: steps, functional dependencies, basic normal forms, definition of first, second, third normal form and removing anomalies from the relations. De-normalization and merging relations.

**UNIT V**

**Special Topics (Overview) :**Data Warehousing, Data Mining, Distributed Databases, Object oriented modeling, definitions, activities in phases of model development, advantages of OOM, UML class diagrams, Example of a model development.

**Text Book:**

1. Hoffer, Prescott, “Modern Database Management”, Seventh Edition, McFadden Pearson

Education.

**Reference Book(s):**

1. Thomas M. Connolly, Carolyn E. Begg, “Database Systems”, Pearson Education.

2. Raghu R and Johannes G., “Database management Systems”, Mc Hill 3rd Edition, 2002.

3. Elmasri R, Navathe S, “Fundamentals of Database Systems”, Addison Wesley 4th

Edition.

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| **Course Code** | **Course Name** | **Hours Per Week** | | | |
| **CS3EL06/IT3EL06** | **Internet of Things** | **L** | **T** | **P** | **Credits** |
| **3** | **0** | **0** | **3** |

**Unit-I**

**Introduction :**  Definition, Characteristics of IoT, IoT Architectural view, Physical design of IoT, IoT Protocols, Communication Models of IoT, IoT Communication APIs, IoT Enabling Technologies.

**Unit-II**

**IoT and M2M:** Machine-to-Machine (M2M), Difference between M2M and IoT, SDN (Software Defined Networking) and NFV (Network Function Virtualization) for IoT, Data Storage in IoT, IoT Cloud Based Services.

**Unit –III**

**IoT Platform Design Methodology**: Specifications of Purpose and Requirement, Process, Domain Model, Information Model, Service, IoT Level, Functional View, Operational View, Device and Component Integration, Application Development.

**Unit –IV**

**Security issues in IoT:** Introduction, Vulnerabilities, Security requirements and threat analysis, IoT security Tomography, layered attacker model, identity management and establishment, access control.

**Unit-V**

**Application areas of IoT**: Home Automation, smart lighting, home intrusion detection, smart cities, smart parking, environment, weather monitoring system, agriculture.

**Text Books:**

1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”,

Universities Press.

1. Rajkamal,”Internet of Things”, Tata McGraw Hill publication

**Reference Books:**

1. Olivier Hersent, David Boswarthick, Omar Elloumi , “The Internet of Things – Key applications and Protocols”, Wiley
2. Donald Norris “The Internet of Things: Do-It-Yourself at Home Projects for Arduino, Raspberry Pi and BeagleBone Black”, McGraw Hill publication.

**Open Learning Source:**

1. https://nptel.ac.in/courses/106105166/
2. <https://github.com/connectIOT/iottoolkit>

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| **Course Code** | **Course Name** | **Hours Per Week** | | | | |
| **OE00051** | **R Programming** | **L** | **T** | **P** | **Hrs.** | **Credits** |
| **3** | **0** | **0** | **3** | **3** |

**Unit 1** - R basics

Introduction: Basic features of R, advantages of using R, Limitations, R resources, Arithmetic and objects, Math, Variables, and Strings, Vectors and Factors, Vector operations.

**Unit 2** - Data structures in R

Data types, Arrays, Tables, Matrices: operations, Lists: operations, Data frames: creation, factors, reading.

**Unit 3 -** R programming fundamentals

Conditions and loops, Functions in R, Objects and Classes, Recursion, Debugging

**Unit 4 -** Working with data in R

Reading CSV and Excel Files, Reading text files, Writing and saving data objects to file in R, Reading in larger, Datasets, Exporting data. Interface to outside world.

**Unit 5 –** String & Dates in R, Graphics

String operations in R, Regular Expressions, Dates in R, Time in R, Graphics: one dimension plot, legends, function plot, box plot.

**Text Books**

1. Andrie de Vries , Joris Meys, R Programming For Dummies, Wiley Publications.
2. Roger D. Peng, R Programming for Data Science, Leanpub.

**References**

1. Emmanuel Paradis, R For Beginners, CRAN Publications.
2. [Michael J. Crawley](https://www.amazon.in/Michael-J.-Crawley/e/B001IGQIPG/ref=dp_byline_cont_book_1), The R Book, Wiley Publications.

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| **Course Code** | **Course Name** | **Hours Per Week** | | | |
| **OE00015** | **Agile Development** | **L** | **T** | **P** | **Credits** |
| **3** | **0** | **0** | **3** |

**Unit-I**

Understanding Agile: Introduction to Agile Project Management, Agile Manifesto, Agile Principles, Agile Benefits: Product Development and customers, Development teams etc.

**Unit-II**

Agile Frameworks: Agile approaches, reviewing the big three: Lean, Extreme programming and Scrum. Putting Agile in action: Environment, Behaviors- Agile roles, New values, Team philosophy.

**Unit-III**

Working in Agile: Planning in Agile, product vision, creating the product roadmap, refining requirement and estimates, release planning and Sprint planning.

**Unit-IV**

Managing in Agile: Managing Scope and procurement, managing time and cost, team dynamics and communication, managing quality and risk

**Unit-V**

Ensuring Agile Success: Building a foundation- Commitment, choosing the right project team members-Development team, scrum master etc. Being a change agent, Key benefits and key resources for agile project management.

**Text Books:**

1. Mark C. Layton, Agile Project Management For Dummies, Wiley publishers
2. Jim Robert Highsmith, Agile Project Management: Creating Innovative Products, Pearson education
3. Hitzler, Markus, Rudolph , Foundations of Semantic Web Technologies, Chapman & Hall/CRC
4. Allemang , Hendler , Semantic Web for the working Ontologist, Elsevier Pub

**Reference Books:**

1. Charles G. Cobb, Making Sense of Agile Project Management: Balancing Control and Agility, Wiley
2. Mike Cohn, Agile Estimating and Planning, Pearson
3. Liz Sedley and Rachel Davies, Agile Coaching, The Pragmetic Bookshelf

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| **Course Code** | **Course Name** | **Hours Per Week** | | | | |
| **OE00016** | **Blockchain Architecture** | L | T | P | Hrs. | Credits |
| 3 | 0 | 0 | 3 | 3 |

**Unit I: Cryptocurrency:** History, electronic cash, double spending problem, Bitcoin protocols, Mining strategy and rewards, Types of crypto currency wallets, Legal aspects of crypto currency, Crypto currency exchanges.

**Unit II: Introduction to Blockchain:** History of blockchain, Hash functions, SHA-256, Symmetric cryptography, Asymmetric cryptography, Keys & Digital signatures, benefits and limitation of block chain, features of blockchain.

**Unit III: Consensus:** Nakamoto consensus, Proof of work, Proof of stake, Proof of burn, Difficulty Level, Sybil attack, Energy utilization, collision of energy utilization, Introduction to ethereum.

**Unit IV: Blockchain Architectures:** Blockchain network, Merkle patricia Tree, Soft & hard fork, Private and public blockchain, Tokenized blockchain.

**Unit V: Blockchain Applications:** Financial Sector, Medical record management system, domain name service and future of block chain, case study: Government on blockchain. Introduction to hashgraph and tangle.

**Text Books:**

1. Andreas Antonopoulos “Mastering Bitcoin Unlocking Digital Cryptocurrencies” O’Reilly publication.
2. Imran Bashir “Mastering Blockchain: Distributed ledger technology, decentralization, Packt publishing”.

**Reference Books:**

1. Wattenhofer, The Science of the Blockchain

2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction” Princeton University.