ICFAI TECH SCHOOL

M.TECH (COMPUTER SCIENCE & ENGINEERING)

**CURRICULUM 2016-2018**

**I Year I Semester**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **L** | **T** | **P** | **Credit** |
| CST 5101 | Design and Analysis of Advanced Algorithm | 3 | 1 | 0 | 4 |
| CST 5102 | Advanced Computing Network | 3 | 1 | 0 | 4 |
| CST 5103 | Advanced Computer Architecture | 3 | 1 | 0 | 4 |
|  | Elective I |  |  |  | 4 |
| CST/CSL 5105 | Advanced Programming | 3 | 0 | 2 | 4 |
| MAT 5101 | Advanced Engineering Mathematics | 3 | 1 | 0 | 4 |
| **Total** | |  |  |  | **24** |

**I Year II Semester**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **L** | **T** | **P** | **Credit** |
| CST 5201 | Cryptography and Network Security | 3 | 1 | 0 | 4 |
| CST 5202 | Machine Learning | 3 | 1 | 0 | 4 |
| CST/CSL 5203 | Modelling & Simulation | 3 | 0 | 2 | 4 |
| CST 5204 | Cloud Computing | 3 | 1 | 0 | 4 |
|  | Elective II |  |  |  | 4 |
|  | Elective III |  |  |  | 4 |
| **Total** | |  |  |  | **24** |

ICFAI TECH SCHOOL

M.TECH (COMPUTER SCIENCE & ENGINEERING)

**CURRICULUM 2016-2018**

**II Year III Semester**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **L** | **T** | **P** | **Credit** |
|  | Elective IV |  |  |  | 4 |
|  | Elective V |  |  |  | 4 |
| TS 6102 | Seminar Phase-I |  |  |  | 2 |
| TS 6101 | Dissertation Phase-I |  |  |  | 10 |
| **Total** | |  |  |  | **20** |

**II Year IV Semester**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **L** | **T** | **P** | **Credit** |
| TS 6202 | Seminar Phase-II |  |  |  | 2 |
| TS 6201 | Dissertation Phase-II |  |  |  | 22 |
| **Total** | |  |  |  | **24** |

**Credit Allocation in M.Tech (CSE)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Semester** | | **Credit** |
| **M.Tech 1st Year** | **Semester I** | **24 Credits** | **48 Credits** |
| **Semester II** | **24 Credits** |
| **M.Tech 2nd Year** | **Semester III** | **20 Credits** | **44 Credits** |
| **Semester IV** | **24 Credits** |
|  |  |  | **Total : 92 Credits** |

**List of Elective Subjects for II & III Semester**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Elective Subjects Semester I /II/III** | | | **L** | **T** | **P** | **Credit** |
| **Course Code** | **Course** | **Pre-requisite** |  |  |  |  |
| CS-E01 | Big Data Analytics | Data Base Management System | 3 | 0 | 2 | 4 |
| CS-E02 | Advanced Database Management System | Data Base Management System | 3 | 0 | 2 | 4 |
| CS-E03 | Internet of Things (IoT) | Computer Network | 3 | 0 | 2 | 4 |
| CS-E04 | Wireless Sensor Network | Computer networks | 3 | 0 | 2 | 4 |
| CS-E05 | Embedded System | Digital Electronics | 3 | 1 | 0 | 4 |
| CS-E06 | Natural Language Processing | Artificial Intelligence | 3 | 1 | 0 | 4 |
| CS-E07 | Mobile Computing | Computer Networks | 3 | 1 | 0 | 4 |
| CS-E08 | Software metrics | Software Engineering | 3 | 1 | 0 | 4 |
| CS-E09 | Advanced Software Engineering | Software Engineering | 3 | 1 | 0 | 4 |
| CS-E10 | Service Oriented Architecture | Basics of Java | 3 | 1 | 0 | 4 |

ICFAI TECH SCHOOL

M.TECH (COMPUTER SCIENCE & ENGINEERING)

**CURRICULUM 2016-2018**

**I Year I Semester**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **L** | **T** | **P** | **Credit** |
| CST 5101 | Design and Analysis of Advanced Algorithm | 3 | 1 | 0 | 4 |
| CST 5102 | Advanced Computing Network | 3 | 1 | 0 | 4 |
| CST 5103 | Advanced Computer Architecture | 3 | 1 | 0 | 4 |
| CST 5104 | Advanced Software Engineering | 3 | 1 | 0 | 4 |
| CST/CSL 5105 | Advanced Programming | 3 | 0 | 2 | 4 |
| MAT 5101 | Advanced Engineering Mathematics | 3 | 1 | 0 | 4 |
| **Total** | |  |  |  | **24** |

|  |  |  |  |
| --- | --- | --- | --- |
| Course: Design and Analysis of Advanced Algorithm | | | Semester: I |
| Course Code: CST 5101 | L T P | 3 1 0 | Credits: 4 |

**Objective:** The aim of this course is to learn how to develop efficient algorithms for simple computational tasks and reasoning about the correctness of them.

**Syllabus**

**Introduction 6**

Basics of Algorithms and Mathematics, Characteristics of algorithm, Mathematics for Algorithmic Sets, Functions and Relations, Vectors and Matrices, Linear Inequalities and Linear Equations.

**Analysis of Algorithm 6**

The efficient algorithm, Average, Best and worst case analysis, Amortized analysis , Asymptotic Notations, Analyzing control statement, Loop invariant and the correctness of the algorithm, Sorting Algorithms and analysis: Bubble sort, Selection sort, Insertion sort, Shell sort Heap sort, Sorting in linear time : Bucket sort, Radix sort and Counting sort.

**Divide and Conquer Algorithm 6**

Recurrence and different methods to solve recurrence, Multiplying large Integers Problem, Problem Solving using divide and conquer algorithm, Binary Search, Max-Min problem, Sorting (Merge Sort, Quick Sort), Matrix Multiplication, Exponential.

**Dynamic Programming 6**

The Principle of Optimality, Problem Solving using Dynamic Programming, Calculating the Binomial Coefficient, Making Change Problem, Assembly Line-Scheduling, Knapsack problem, All Points Shortest path, Matrix chain multiplication, Longest Common Subsequence.

**Greedy Algorithm 6**

General Characteristics of greedy algorithms, Problem solving using Greedy Algorithm, Activity selection problem, Elements of Greedy Strategy, Minimum Spanning trees (Kruskal’s algorithm, Prim’s algorithm), Graphs: Shortest paths, The Knapsack Problem, Job Scheduling Problem, Huffman code.

**Exploring Graphs 6**

An introduction using graphs and games, Undirected Graph, Directed Graph, Traversing Graphs, Depth First Search, Breath First Search, Topological sort, connected components.

**Introduction to NP-Completeness 4**

The class P and NP, Polynomial reduction, NP- Completeness Problem, NP-Hard Problems. Travelling Salesman problem, Hamiltonian problem, Approximation algorithms

**Suggested Readings**

1. Cormen Thomas H., Leiserson Charles E., Ronald L. Rivest, and Clifford Stein, *Introduction to Algorithms* ,The MIT Press; 3rd edition (July 31, 2009)
2. Anany Levitin, *Introduction to the Design and Analysis of Algorithms*, Pearson Education, 2007
3. Kleinberg Jon and Tardos Eva, *Algorithm Design*, Third Edition

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| --- | --- | --- | --- |
| Course: Advanced Computing Network | | | Semester: I |
| Course Code: CST 5102 | L T P | 3 1 0 | Credits: 4 |

**Objective**: To introduce basic concept of TCP/IP and its importance in internetworking.

**Syllabus**

**Introduction 8**

Network Technologies-Introduction, Ethernet technology, FDDI, Network predecessors

Internet addressing, Address Resolution Protocol

**Addressing 8**

Address Resolution Protocol, Reverse Address Resolution Protocol, and Routing IP datagrams

Reliable stream transport service (TCP)-properties, Sliding window protocol ,segments –Basics

**TCP 8**

TCP-Timeout and Retransmission, karn’s algorithm, Tail Drop policy **,** TCP - RED Algorithm, congestion, silly window syndrome

**TCP/IP 8**

TCP/IP over ATM networks – Basics, AAL types, Packet format, Internet Applications –Email, TELNET File Transfer Protocol, TFTP

**NFS 8**

NFS, Internet traffic management

**Suggested Reading :**

1. [Comer](http://www.amazon.in/s/ref=dp_byline_sr_book_1?ie=UTF8&field-author=Comer&search-alias=stripbooks) , *Internet Working With Tcp/Ip, Pearson Education*, 2008
2. [Douglas E. Comer](http://www.amazon.in/Douglas-E.-Comer/e/B000AQ4HHG/ref=dp_byline_cont_book_1)  , *Internetworking with TCP/IP Vol. I: Principles, Protocols, and Architecture*, PHI

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| --- | --- | --- | --- |
| Course: Advanced Computer Architecture | | | Semester: I |
| Course Code: CST 5103 | L T P | 3 1 0 | Credits: 4 |

**Objectives:**

To understand the micro architectural design of processors. Learn about the various techniques used to obtain performance improvement and power savings in current processors.

**Syllabus**

**Fundamentals of Computer Design 8**

Review of Fundamentals of CPU, Memory and IO – Trends in technology, power, energy and cost, Dependability, Performance Evaluation

**instruction level parallelism 8**

ILP concepts Pipelining overview Compiler, Techniques for Exposing ILP, Dynamic Branch Prediction, Dynamic Scheduling, Multiple instructions Issue, Hardware Based Speculation, Static scheduling Multithreading, Limitations of ILP

**Data level Parallelism 8**

Vector architecture, SIMD extensions, Graphics Processing units , Loop level parallelism.

**Thread level Parallelism 8**

Symmetric and Distributed Shared Memory Architectures , Performance Issues Synchronization, Models of Memory Consistency , Case studies: Intel i7 Processor, SMT & CMP Processors

**Memory and I/O 8**

Cache Performance, Reducing Cache Miss Penalty and Miss Rate, Reducing Hit Time, Main Memory and Performance, Memory Technology. Types of Storage Devices , Buses , RAID, Reliability, Availability and Dependability I/O Performance Measures.

**Suggested Reading**

1. Hwang Kai and Faye Briggs, “Computer Architecture and Parallel Processing”, Mc GrawHill

International , Edition, 2000.

1. Sima D, Fountain T and Kacsuk P, ”Advanced Computer Architectures: A Design Space Approach”, Addison Wesley, 2000.
2. John L Hennessey and David A Patterson, “Computer Architecture A Quantitative Approach”,

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| --- | --- | --- | --- |
| Course: Advanced Software Engineering | | | Semester: I |
| Course Code: CST 5104 | L T P | 3 1 0 | Credits: 4 |

**Objective:** To understand the advances of software engineering and its implication in software industry.

**Software Project Management: 8**

Software Project Planning and its characteristics, Types of metrics, Effort Estimation- FP, LOC, FP vs. LOC, Schedule & Cost Estimation Models- Activity Networks-PERT/CPM, COCOMO-I, COCOMO-II, Risk Assessment- Probability Matrix, Risk Management, Agile Methodology- Scrum and XP.

**Formal Methods: 8**

Basic concepts, mathematical preliminaries, Applying mathematical notions for formal specification, Formal specification languages, using Z to represent an example software component, the ten commandments of formal methods, Formal methods- the road ahead.

**Component-Based Software Engineering: 2**

CBSE process, Domain engineering, Component based development, Classifying and retrieving components and economics of CBSE.

**Client/Server Software Engineering: 4**

Structure of client/server systems, Software engineering for Client/Server systems, Analysis modeling issues, Design for Client/Server systems, testing issues

**Web Engineering: 4**

Attributes Of web-based applications, the WebE process, framework for WebE. Formulating, analyzing web-based systems, design and testing for web-based applications, Management issues.

**Reengineering: 4**

Business process reengineering, Software reengineering, Reverse reengineering, Restructuring, Forward reengineering, economics of reengineering.

**Software Quality: 4**

CASE tools, metrics, Standards, Certification and Assessment. TQM, Bootstrap methodology, The SPICE project, ISO-IEC 15504, Six Sigma Concept for Software Quality.

**Computer-Aided Software Engineering: 4**

Building Blocks for CASE, taxonomy Of CASE tools, integrated CASE environments, Integration architecture, and CASE repository

**Suggested Readings:**

1. Software Engineering a Practitioners Approach, Roger S. Pressman, McGraw-Hill 8thEdition, 2014

2. Formal Specification and Documentation testing - A Case Study Approach, J.Bowan , International Thomson Computer Press, 2003

3. Software Engineering for Embedded Systems: Methods, Practical and Applications, Robert Oshana, Mark Kraeling, Newnes Publisher, 2013

4. Software engineering an engineering approach, James S. Peters, WitoldPedrycz, Wiley India, 2011. 5. Software Engineering Principles and Practice, Hans Van Vliet, Yded, 2015

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| --- | --- | --- | --- |
| Course: Advanced Programming | | | Semester: I |
| Course Code: CST/CSL 5105 | L T P | 3 0 2 | Credits: 4 |

**List of experiments in Advanced Java**

1. Introduction to C# and .NET Farme-work lab (Simple C# programming).
2. Implementation of the Login\_Id Form using .NET & C# programming.
3. Implementation of inheritance, abstract classes and interfaces in C# programming.
4. Implementation of delegates, events and exceptions in C# programming.
5. Implementation of SQL commands using JDBC.
6. Implementation of a table creation using JDBC.
7. Implementation of Servlets to create dynamic HTML form to accept and display username and password with the help of get() and post() methods.
8. Implementation of Servlets to store only valid data in the database with support of JDBC-ODBC connectivity.
9. Implementation of Servlets to demonstration of Cookies.
10. Implementation of form validation using JSP.
11. Implementation of JSP for creation and accessing JAVA BEANS.
12. Implementation of Java Swing components namely Buttons and Boxes.
13. Implementation of Java Swing components namely Lists and Menus.

**Suggested Readings :**

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| --- |
| 1. *Core and advance Java Black Book*  Dreamtech Publication  2. Cay S. Horstmann, *Core Java, Volume II: Advanced Features* 9th Edition, Pearson. |

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| --- | --- | --- | --- |
| Course: Advanced Engineering Mathematics | | | Semester: I |
| Course Code: MAT 5101 | L T P | 3 1 0 | Credits: 4 |

**Objective:** To familiarize the students with Complex analysis, statistical theory, finite element methods and calculus of variation.

**Syllabus**

**Complex Integration 14**

Cauchy-Goursat Theorem (for convex region), Cauchy's integral formula, Higher order derivatives, Morera's Theorem, Cauchy's inequality and Liouville's theorem, Fundamental theorem of algebra, Maximum modulus principle, Taylor’s theorem, Schwarz lemma.Laurent's series, Isolated singularities, Meromorphic functions, Rouche's theorem, Residues, Cauchy's residue theorem, Evaluation of integrals, Riemann surfaces.

**Probability and Statistics 10**

Basic Probability Concepts, Discrete Random Variable, Expected Value and Variance of a Discrete Random Variable, Measure of Probability Function, Continuous Random Variable, Exponential Distribution, Mean and Variance of Continuous Distribution, Normal Distribution.

**Finite Element Method 10**

Finite element formulation of boundary value problems, one and two dimensional finite element analysis.

**Calculus of Variation 10**

Functionals and their differentiation, Euler-Lagrange equation, Boundary value problems, Variational principles, Rayleigh-Ritz Methods

**Suggested Readings:**

1. E.Kreyszig, *Advanced Engineering Mathematics*, 9th ed., John Wiley (2005).

2. J. H. Mathews, and R. Howell, *Complex analysis for Mathematics and Engineering*,

Narosa, 2005

3. V. Sundarapandian, *Numerial Linear Aalgebr*a, Prentice-Hall, 2008.

4. R. L.Burden and J. D. Faires, *Numerical Analysis*, Brooks/Cole, 2001

5. I. M. Gelfand and S. V. Fomin, *Calculus of Variations*, Prentice Hall, 1963

6. A. S. Gupta, *Calculus of Variations with Applications*, Prentice Hall, 1997

7. R. K. Jain, and S. R. K Iyengar, *Advanced Engineering Mathematics*, Narosa (2005).

8. M. D. Greenberg, *Advanced Engineering Mathematics*, Pearson Education (2007).

9. R. V. Churchill and J. W. Brown. *Complex Variables and Applications*, 6thed., McGraw-

Hill (2004)

**I Year II Semester**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Course Code** | **Course Title** | **L** | **T** | **P** | **Credit** |
| CST 5201 | Cryptography and Network Security | 3 | 1 | 0 | 4 |
| CST 5202 | Machine Learning | 3 | 1 | 0 | 4 |
| CST/CSL 5203 | Modelling & Simulation | 3 | 0 | 2 | 4 |
| CST 5204 | Cloud Computing | 3 | 1 | 0 | 4 |
| CST 5205 | Service Oriented Architecture | 3 | 1 | 0 | 4 |
|  | Elective I |  |  |  | 4 |
| **Total** | |  |  |  | **26** |

|  |  |  |  |
| --- | --- | --- | --- |
| Course: Cryptography and Network Security | | | Semester: II |
| Course Code: CST 5201 | L T P | 3 1 0 | Credits: 4 |

**Objective:** This course aims at providing a sound conceptual foundation in the area of Cryptography and Network Security with emphasis on the design aspects while adopting combination of the systems approach.

**Syllabus**

**Introduction 8**

Introduction to Cryptography and Network Security, Need for Security, Security Approaches, Security Attacks, Security Services, Network Security Model.Cryptography techniques, Symmetric cipher model, Substitution Technique, Transposition Technique, Steganography.Symmetric encryption, The data encryption standard(DES), Advanced encryption standard (AES)

**Public Key Cryptography 12**

Public Key Cryptography, Message Authentication, Secure Hash Functions, Message Authentication Codes(MAC),Public-Key Cryptography Algorithms, The RSA Algorithm, Diffie-Hellman Key Exchange, Digital Signature and authentication protocols, Digital signature standards. Symmetric Key Distribution Using Symmetric Encryption, Kerberos, Key Distribution Using Asymmetric Encryption

**Transport Level Security 8**

Transport-level security, Web Security, Secure Socket Layer(SSL),Transport Layer Security(TLS), HTTPS, Secure electronic transaction (SET), Secure Shell (SSH)

**Wireless network security 8**

Wireless network security, IEEE 802.11 Wireless LAN, IEEE 802.11i Wireless LAN Security, Wireless Application Protocol, Wireless Transport Layer Security, WAP End-to-End Security

Electronic mail security, Pretty Good Privacy, S/MIME, Domain Keys Identified Mail, IP Security, IP Security policy , Encapsulating Security Payload, Internet Key Exchange

**System Security 6**

System Security, Intruders, Intrusion Detection, Password Management Malicious software, Types Of Malicious Software, Viruses, Virus Countermeasures, Worms, Distributed Denial Of Service Attacks, Firewalls, The Need for Firewalls, Firewall Characteristics, Types of Firewalls, Firewall Basing, Firewall Location and Configurations, Virtual private network

**Suggested Readings**

1. Network Security Essentials Applications and standards, William Stallings,

4th Edition, Prentice-Hall Pearson Education.

2. Cryptography and Network Security, William Stallings, 5th Edition, Prentice-all

Pearson Education.

3. Cryptography and Network Security, Atul Kahate, 3rd Edition, McGraw

Hill Education.

|  |  |  |  |
| --- | --- | --- | --- |
| Course: Machine Learning | | | Semester: II |
| Course Code: CST 5202 | L T P | 3 1 0 | Credits: 4 |

**Objective:** To be familiar with the basic concept of GA and machine learning, To learn and analyze the mathematical foundations for Genetic algorithm.

**Syllabus**

**Introduction to genetic algorithm and machine learning: 8** Robustness of Traditional Optimization and Search methods, Goals of optimization, GA versus Traditional methods, Simple GA; Machine learning explanation, machine learning vs. artificial intelligence, supervised and unsupervised machine learning, examples of machine learning.

**Mathematical foundations of genetic algorithm: 8**

The fundamental theorem, Schema processing at work, The 2-armed & k armed Bandit problem, The building Block Hypothesis, Minimal deceptive problem.

**GA operators: 8**

Data structures, Reproduction, Roulette-wheel Selection, Boltzmann Selection, Tournament Selection Rank Selection, Steady state selection, Crossover & mutation, Mapping objective functions to fitness forum, Fitness scaling.

**Applications of GA: 8** The rise of GA, GA application of Historical Interaction, Dejung & Function optimization, Current applications of GA, Advanced operators & techniques in genetic search, Dominance, Diploidy & abeyance.

**Applications of genetics based machine learning: 8** The Rise of GBML, Learning classifier system, Development of CS-1, the first classifier system. Smitch’s Poker player, GBML for sub problems of learning, Other Early GBML efforts, Current Applications.

**Suggested Readings:**

**1.** David E. Gold Berg, *Genetic Algorithms in Search, Optimization & Machine Learning;* Pearson

Education, 2013.

**2.** Rajasekaran S., Vijayalakshmi Pai G.A., *Neural Networks, Fuzzy Logic and Genetic Algorithms*;

PHI, 2003.

**3.** Kalyanmoy Deb, *Optimization for Engineering Design, algorithms and examples*, PHI 1995.

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| --- | --- | --- | --- |
| Course: Modelling & Simulation | | | Semester: II |
| Course Code: CST/CSL 5203 | L T P | 3 1 0 | Credits: 4 |

**Objective:** The objective of this course is to teach different components of Modeling & Simulation with its usages in Different field of Engineering.

**Syllabus**

**System definition and components 8**

System definition and components, stochastic activities, continuous 8 and discrete systems, System modeling, Types of models, static and dynamic physical models, static and dynamic mathematical models, full corporate model, types of system study

**System simulation 8**

System simulation, Need of simulation, Basic nature of simulation, 8 techniques of simulation, comparison of simulation and analytical methods, types of system Simulation, real time simulation, hybrid simulation, simulation of pursuit problem, single-server queuing system and an inventory problem, Monte-Carlo simulation, Distributed Lag model, Cobweb model

**Simulation of continuous Systems 8**

Simulation of continuous Systems, analog vs digital simulation, 8 simulation of water reservoir system, simulation of a servo system, simulation of an auto-pilot. Discrete system simulation, fixed time step vs event-to-event model, generation of random numbers, test of randomness, Monte-Carlo computation vs stochastic simulation.

**System Dynamics 8**

System dynamics ,exponential growth models, exponential decay 8 models, logistic curves, system dynamics diagrams, world model

**Simulation of PERT networks 8**

Simulation of PERT networks, critical path computation, uncertaintities in activity duration, resource allocation and consideration, Simulation languages, object oriented simulation.

Textbooks:

1) Geoftrey Gordon, “System Simulation”, PHI

2) Narsingh Deo, “System Simulation with digital computer”, PHI.

3) Averill M. Law, W. David Kelton, “Simulation Modelling and Analysis”,TMH.

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| Course: Cloud Computing | | | Semester: II |
| Course Code: CST 5204 | L T P | 3 1 0 | Credits: 4 |

**Objective:** To understand the basics of cloud computing and its usage in industry.

**Introduction: 8**

Cloud Computing definition, Cloud Types- Private, Public and Hybrid cloud. Cloud Services: Software as a Service (SaaS)- Understanding the Multitenant Nature of SaaS Solutions, Understanding SOA. Platform as a Service (PaaS)-IT Evolution Leading to the Cloud, Pros and Cons of PaaS Solutions. Infrastructure as a Service (IaaS)- Understanding IaaS, Improving Performance through Load Balancing, System and Storage Redundancy, Utilizing Cloud-Based NAS Devices, Advantages, Server Types. Benefits and challenges of cloud computing.

**Virtualization: 2**

Definition, Type of Virtualization, Benefits, Limitations, Virtualization and Cloud, Virtual Appliance.

**Cloud based Data Storage: 6**

Introduction to MapReduce for Simplified data processing on Large clusters, Design of data applications based on MapReduce in Apache Hadoop , Task Partitioning, Data partitioning, Data Synchronization, Distributed File system, Data Replication

**Cloud Services: 4**

Introduction, Contrast traditional software development and development for the cloud. Technologies and the processes required when deploying web services; deploying a web service from inside and outside a cloud architecture, advantages and disadvantages, Public vs Private cloud apps

**Management of Cloud Services: 8**

Reliability, availability and security of services deployed from the cloud. Performance and scalability of services, tools and technologies used to manage cloud services deployment; Cloud Economics-Cloud Computing infrastructures available for implementing cloud based services. Economics of choosing a Cloud platform for an organization application requirements, economic constraints and business needs (e.g Amazon, Microsoft and Google,Salesforce.com, Ubuntu and Redhat)

**Open Source Cloud Computing and Testing: 8**

OpenStack, OpenNebula-underlying technologies, Cloud Monitoring-Ganglia; Physical and virtual machine memory, CPU management and abstractiontechniques using a hypervisor. Software Testing in the Cloud - SMART-T- Migrating Testing to the Cloud, HadoopUnit- Test Execution in the Cloud.

**Advances in Cloud Computing: 4**

Mobile Cloud Computing, Big-Data and Internet of Things (IoT): Definition of BigData, Structured and Unstructured Data, V’s of Big-Data, Hadoop, Definition of IoT, Characteristics of IoT, Combining Big-Data, IoT and Cloud Computing

**Suggested Readings:**

1. Cloud Computing: A Practical Approach by Anthony T. Velte Toby J. Velte, Robert Elsenpeter, 2010 by The McGraw-Hill.

2. Cloud Computing: SaaS, PaaS, IaaS, Virtualization and more. by Dr. Kris Jamsa.

3. Enterprise Cloud Computing Technology Architecture Applications by Gautam Shroff, Cambridge University Press; 1 edition, 2010.

4. Cloud Computing Strategies by Dimitris N. Chorafas, CRC Press; 1 edition,2010.

5. OpenStack Cloud computing Cookbook, Second Edition,by Kevin Jackson, Cody Bunch, Packt Publishing, 2013. 6. Software Testing in the Cloud Migration and Execution by Scott Tilley, Tauhida Parveen Springer, 2012.

7. OpenNebula 3 Cloud Computing by Giovanni Toraldo, , Packt Publishing, 2012.

8. Big Data for Dummies by Alan Nugent, Fern Halper, Judith Hurwitz and Marcia Kaufman, Wiley India, ISBN-13: 978-8-12-654328-1, April, 2013.

9. Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions by Jayavardhana Gubbi, Rajkumar Buyya, Slaven Marusic and Marimuthu Palaniswami, Future Generation Computer Systems, vol. 29, no. 7, pp. 1645-1660, September, 2013.

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| Course: Service Oriented Architecture | | | Semester: II |
| Course Code: CST 5205 | L T P | 3 1 0 | Credits: 4 |

**Introduction: 8**

Characteristics and Anatomy of SOA, Comparing SOA to client-server and distributed internet architectures, SOA component interrelation, Principles of service orientation. Major components of the architecture SOAP, XML, HTTP, Cookies, WSDL, XML schema, UDDI

**Introduction to Web services: 8**

Service descriptions , Messaging with SOAP ,Message exchange Patterns , Coordination ,Atomic Transactions , Business activities , Orchestration ,Choreography ,Service layer abstraction , Application Service Layer , Business Service Layer , Orchestration Service Layer

**Analysis: 4**

Service oriented analysis ,Business-centric SOA , Deriving business services , service modeling ,Service Oriented Design , WSDL basics , SOAP basics , SOA composition guidelines ,Entity-centric business service design , Application service design , Task centric business service design

**SOA platform basics: 8**

SOA support in J2EE ,Java API for XML-based web services (JAX-WS), Java architecture for XML binding (JAXB) ,Java API for XML Registries (JAXR) ,Java API for XML based RPC (JAX-RPC),Web Services Interoperability Technologies (WSIT) , SOA support in .NET , Common Language Runtime , ASP.NET web forms , ASP.NET web services , Web Services Enhancements (WSE)

**Security: 4**

WS-BPEL , WS-Coordination , WS-Choreography, WS-Policy, WS-Security.

Suggested Reading:

1. Service-Oriented Architecture: Concepts, Technology, and Design, Thomas Erl, Pearson Education, 2005

2. Achieving Service-Oriented Architecture: Applying an Enterprise Architecture Approach, Rick Sweeney, 2010

**List of Elective Subjects for II & III Semester**

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| --- | --- | --- | --- | --- | --- | --- |
| **Elective Subjects Semester II/III** | | | **L** | **T** | **P** | **Credit** |
| **Course Code** | **Course** | **Pre-requisite** |  |  |  |  |
| CS-E01 | Big Data Analytics | Data Base Management System | 3 | 0 | 2 | 4 |
| CS-E02 | Advanced Database Management System | Data Base Management System | 3 | 0 | 2 | 4 |
| CS-E03 | Internet of Things (IoT) | Computer Network | 3 | 0 | 2 | 4 |
| CS-E04 | Wireless Sensor Network | Computer networks | 3 | 0 | 2 | 4 |
| CS-E05 | Embedded System | Digital Electronics | 3 | 1 | 0 | 4 |
| CS-E06 | Natural Language Processing | Artificial Intelligence | 3 | 1 | 0 | 4 |
| CS-E07 | Mobile Computing | Computer Networks | 3 | 1 | 0 | 4 |
| CS-E08 | Software metrics | Software Engineering | 3 | 1 | 0 | 4 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Course: Big Data Analytics** | | | **Semester:** |
| **Course Code: CS-E01** | **L T P** | **3 0 2** | **Credits: 4** |

**Objective:** The course provides grounding in basic and advanced methods to big data technology and tools, including MapReduce, SPARK and Hadoop.

**Syllabus**

**Introduction to Big Data: 6**

Distributed file system–Big Data and its importance, Four Vs, Drivers for Big data, Big data analytics, Big data applications. Algorithms using map reduce

**Introduction to Hadoop and Hadoop architecture: 8**

Big Data – Apache Hadoop & Hadoop EcoSystem, Moving Data in and out of Hadoop – Understanding inputs and outputs of MapReduce -, Data Serialization.

**HDFS, HIVE and HIVEQL, HBASE 8**

HDFS-Overview, Installation and Shell, Java API; Hive Architecture and Installation, Comparison with Traditional Database, HiveQL Querying Data, Sorting And Aggregating, Map Reduce Scripts, Joins & Sub queries, HBase concepts, Advanced Usage, Schema Design, Advance Indexing, PIG, Zookeeper , how it helps in monitoring a cluster, HBase uses Zookeeper and how to Build Applications with Zookeeper.

**SPARK: 8**

Introduction to Data Analysis with Spark, Downloading Spark and Getting Started, Programming with RDDs, Machine Learning with MLlib.

**NoSQL 10**

Introduction to NoSQL, Types of NoSQL databases, Advantages of NoSQL, Use of NoSQL in Industry, SQL vs NoSQL, NewSQL, Data Base for the Modern Web: Introduction to MongoDB key features, Core Server tools, MongoDB through the JavaScript’s Shell, Creating and Querying through Indexes, Document-Oriented, principles of schema design, constructing queries on Databases, collections and Documents, MongoDB Query Language.

**Suggested Readings:**

**1.** Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, *Professional Hadoop Solutions*, Wiley,

2015.

**2.** Chris Eaton,Dirk derooset al. , *Understanding Big data* , McGraw Hill, 2012.

**3**. Sima Acharya, Subhashini Chhellappan , *BIG Data and Analytics*, Willey.

**4.** Kyle Banker,Piter Bakkum , Shaun Verch, *MongoDB in Action,* Dream tech Press.

**5.** Tom White, *HADOOP: The definitive Guide*, O Reilly 2012.

**6.** Vignesh Prajapati, *Big Data Analytics with R and Haoop*, Packet Publishing 2013.

**List of Experiments:**

1. To understand the overall programming architecture using Map Reduce API.

2. Store the basic information about students such as roll no, name, date of birth, and address of

student using various collection types such as List, Set and Map.

3. Basic CRUD operations in MongoDB.

4. Retrieve various types of documents from student’s collection.

5. To find documents from Students collection.

6. Develop Map Reduce Work Application.

7. Creating the HDFS tables and loading them in Hive and learn joining of tables in Hive.

**Design based Problems (DP)/Open Ended Problem:**

**1.** Create a system which can use of Web search, web crawlers and web information retrieval.

**2.** Analyse and implement a system with Web graph mining.

**3.** Implement and Subscribe RSS News feeds to get latest news in India.

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| **Course: Advanced Database Management System** | | | **Semester:** |
| **Course Code: CS-E02** | **L T P** | **3 0 2** | **Credits: 4** |

**Objective:** This course will provide a comprehensive study of Relational, Distributed and Advanced Database technologies.The objective of this course is to learn about ER diagrams, their representation in RDBMS, and various storage structures for Database.

**Syllabus**

**Database concepts 6**

Overview of file systems and database systems-Software architecture of a typical DBMS-Data Models, Schemas and Instances- ER and EER diagrams and Data Flow Diagrams. Database administration and control.

**Relational concepts:**  **6** Introduction to Relational Model, Relational Algebra, Commercial query languages-Case studies- Normalization Techniques.

**Database storage and system design: 6**

Storage Structures, Indexing and multi-dimensional indexes, Query Processing Algorithms, External Sorting, and Query Optimization- Heuristic based optimization- cost based optimization, Buffer Management, Concurrency Control, Recovery.

**Distributed Databases: 6**

Query processing, semi-joins, query optimization, distributed and client/server architecture-distributed transactions – Locking and commit protocols- Concurrency control, transaction and recovery Heterogeneity issues Parallel databases - Parallel Architectures, performance measures, shared nothing/shared disk/shared memory based architectures

**Advanced database systems: 8**

Semi-structured and Web databases, The World Wide Web, HTML , Architecture -XML, ML/QL - Database Connectivity, OODBMS, ORDBMS, Deductive databases, data mining and warehousing-temporal and spatial databases-mobile databases.

**Database security: 8**

Security and integrity threats, Defense mechanisms, Statistical database auditing & control. Security issue based on granting/revoking of privileges, Introduction to statistical database security. PL/SQL Security – Locks – Implicit locking, types and levels of locks, explicit locking, Oracles’ named Exception Handlers.

**Suggested Readings:**

**1.** Silberschatz A., Korth H., and Sudarshan S., *Database System Concepts,* McGraw-Hill (6th Ed), 2010.

**2.** Morrison, Joline, Morrison, Mike, Conrad, Rocky, *Guide to Oracle 10g*, Thompson Course

Technology, 5th Edition 2003.

**3.** Date C. J., *An Introduction to Database Systems*, Addison Wesley Longman ( 8th Ed), 2003.

**List of programs in Advanced Database Management System:-**

1. Create Table, SQL for Insertion, Deletion, Update and Retrival using aggregating functions.

2. Write Programs in PL/SQL, Understanding the concept of Cursors.

3. Write Program for Join, Union & intersection etc.

4. Creating Views, Writing Assertions, Triggers.

5. Creating Forms, Reports etc. 6. Writing codes for generating read and update operator in a transaction using different situations.

7. Implement of 2PL concerning central algorithm.

8. Developing code for understanding of distributed transaction processing.

Students are advised to use Developer & Oracle for above experiments. However, depending on the availability of Software’s students may use power builder/SQL Server/DB2 etc. for implementation.

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| **Course: Internet of Things (IoT)** | | | **Semester:** |
| **Course Code: CS-E03** | **L T P** | **3 0 2** | **Credits: 4** |

**Objective:** The Internet of Every Things is a course about the new paradigm of objects interacting with people, with information systems, and with other objects. The course will focus on creative thinking and on hands-on project development. The students will learn: IoT concepts, IoT technologies, Security issues and requirements related to IoT.

**Syllabus**

**Introduction 8**

IoT, Concepts behind the Internet of Things, The IoT paradigm , Smart objects , Bits and atoms, Goal orientation, Convergence of technologies.

**Technologies behind the Internet of Things 8**

RFID + NFC, Wireless networks + WSN, RTLS + GPS, Agents + Multiagent systems.

**IoT Data Link Protocol 8** IEEE 802.15.4e, IEEE 802.11 ah, WirelessHAR, Z-Wave, Bluetooth Low Energy.

**Network Layer Routing Protocols 8** RPL, CORPL, CARP, Network Layer Encapsulation Protocols, 6LoWPAN, 6TiSCH, 6Lo, IPv6 over G.9959, IPv6 over Bluetooth Low Energy.

**IoT Management Protocol and Security 8** IoT Management Protocol, Interconnection of Heterogeneous Datalink, Smart Transducer Interface, Security Issues and Security requirements in IoT.

**Suggested Readings:**

**1.** Boston, Mass, *Computer networking: A Top-Down Approach;* 5th ed., Pearson, cop. 2010.

**2.** Ovidiu, Vermesan, Peter Friess, *Internet of Things- From Research and Innovation to market deployment;* River publishers.

**3.** Luigi Atzori, Antonio Iera, Giacomo Morabito, *The Internet of Things: A survey Computer Networks;* 2010 - Elsevier 54 (2010) 2787–2805.

**List of Experiments in IoT:**

1. Define and Explain Eclipse IoT Project.

2. List and summarize few Eclipse IoT Projects.

3. Sketch the architecture of IoT Toolkit and explain each entity in brief.

4. Demonstrate a smart object API gateway service reference implementation in IoT toolkit.

5. Write and explain working of an HTTP- to-CoAP semantic mapping proxy in IoT toolkit.

6. Describe gateway-as-a-service deployment in IoT toolkit.

7. Explain application framework and embedded software agents for IoT toolkit.

8. Explain working of Raspberry Pi.

9. Connect Raspberry Pi with your existing system components.

10. Give overview of Zetta.

**Design based Problems (DP)/Open Ended Problem:**

1. How do you connect and display your Raspberry Pi on a Monitor Or TV?

2. Create any circuitry project using Arduino.

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| **Course: Wireless Sensor Networks** | | | **Semester:** |
| **Course Code: CS-E04** | **L T P** | **3 0 2** | **Credits: 4** |

**Objective:** To learn the fundamentals of Wireless Sensor Network (WSN) and its architecture with modern era usages. This course will also help the learner to know different routing algorithms of WSN.

**Syllabus**

**Introduction: Wireless Sensor Network 8**

Introduction and Overview of Wireless Sensor Networks. AdhHoc Networks. Different Applications of Wireless Sensor Networks. Taxonomy of WSN Technology, Basic Sensor Network Architectural Elements, Home Control, Medical Applications, Basic Wireless Sensor Technology : Introduction, Sensor Node Technology, Sensor Taxonomy, WN Operating Environment, WN Trends, Wireless Network Standards: IEEE 802.15.4, ZigBee, IEE 1451

**MAC 8**

Medium Access Control Protocols for Wireless Sensor Networks Introduction, Background, Fundamentals of MAC Protocols, MAC Protocols for WSNs: Schedule Based Protocols, Random Access Based Protocols, Coordination, Schedule Synchronization, Adaptive Listening, Access Control and Data exchange

**Routing Algorithms of Wireless Sensor Network 8**

Data Dissemination and Gathering, Routing Challenges and Design Issues in Wireless Sensor Networks Network Scale and Time Varying Characteristics, Resource Constraints, Sensor Applications Data Models, Routing Strategies in Wireless Sensor Networks: WSN Routing Techniques, Flooding and Its Variants, Sensor Protocols for Information via Negotiation, Low Energy Adaptive Clustering Hierarchy, Power Efficient Gathering in Sensor Information Systems, Directed Diffusion, Geographical Routing,

**TCP 8**

Traditional Transport Control Protocols: TCP (RFC 793), UDP (RFC 768), MobileIP, Introduction, WSN Middleware Principles, Middleware Architecture: Existing Middleware: MiLAN (Middleware Linking Applications and Networks), IrisNet (Internet Scale Resource Intensive Sensor Networks Services),

**Operating System for Wireless Sensor Network 8**

Operating Systems for Wireless Sensor Networks Introduction, Examples of Operating Systems: TinyOS, Mate, MagnetOS

**Suggested Readings:**

1. [Kazem Sohraby](http://as.wiley.com/WileyCDA/Section/id-302477.html?query=Kazem+Sohraby), *Wireless Sensor Network: Technology, Protocols and Application*, Wiley.
2. Ibrahiem M. M. El Emary, S. Ramakrishnan,*Wireless Sensor Networks: From Theory to Applications,* CRC Press
3. By Edgar H. Callaway, Jr. *Wireless Sensor Networks: Architectures and Protocols,*CRC

**List of Experiments:**

Based on syllabus

**Design Engineering Problems/Open Ended Problems:**

1. Design and simulate energy efficient broadcast routing protocol in NS3.

2. Design and simulate Energy Efficient IEEE 802.15.4 MAC protocol in NS3

**Open Source Software for Wireless Sensor Network**

Network Simulator Software (NS2, NS3),

**Learning Web:**

1. nptel.ac.in
2. vlab.co.in

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| Course: Embedded System | | | Semester: |
| Course Code: CS-E05 | L T P | 3 1 0 | Credits: 4 |

**Objective:** To learn C language and assembly programming. To learn Object orientation for programming and C++. To learn software modeling fundamentals.

**Syllabus**

**Introduction: 8**

Introduction to assembly language and Data representation in C: Assembly language programming, macros, Data representation, Twos complement, fixed point and floating point number formats, Low level programming in C: Primitive data types, Pointers, Structures, Unions, Dynamic memory allocation, Functions, recursive functions, Linked lists.

**Programming in C: 8**

Register usage conventions, Typical use of addressing options, Instruction Sequencing, Procedure call and return, Functions, recursive functions, Parameter passing , Retrieving parameters, Everything in pass by value, Temporary variables, threads, preemptive kernels, system timer, scheduling.

**Object oriented programming: 8** Object oriented analysis and design, C++ classes and objects, functions, data structures, examples.

**Unified modeling language: 8** Connecting the object model with the use case model, Key strategies for object identification, UML basics. Object state behavior, UML state charts, Role of scenarios in the definition of behavior, Timing diagrams, Sequence diagrams, Event hierarchies, types and strategies of operations, Architectural design in UML concurrency design, threads in UML.

**Embedded software development tools and RTOS: 8** The compilation process, libraries, porting kernels, C extensions for embedded systems, emulation and debugging techniques, RTOS, system design using RTOS .

**Suggested Readings:**

**1.** Daniel W. Lewis, *Fundamentals of embedded software where C and assembly meet*,

Pearson Education, 2002.

**2.** Bruce Powel Douglas, Real time UML, Developing efficient objects for Embedded systems, 3rd

Edition 1999, Pearson Education.

**3.** Steve Heath*, Embedded system design*, Elsevier, 2003.

**4.** David E. Simon, *An Embedded Software Primer*, Pearson Education, 2003.

**5.** E. Balaguruswamy, *Object oriented programming with C++,* Tata McGraw Hill, 2011.

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| **Course: Natural Language Processing** | | | **Semester:** |
| **Course Code: CS-E06** | **L T P** | **3 1 0** | **Credits: 4** |

**Objective:** Objective of the course is to teach students the leading trends and systems in natural language processing. Make them understand the concepts of morphology, syntax, semantics and pragmatics of the language and that they are able to give the appropriate examples that will illustrate the above mentioned concepts.

**Syllabus**

**Introduction 6**

NLP tasks in syntax, semantics, and pragmatics. Applications such as information extraction, question answering, and machine translation. The problem of ambiguity. The role of machine learning.

**N-gram Language Models 6**

The role of language models, Simple N-gram models. Estimating parameters and smoothing. Evaluating language models.

**Part of Speech Tagging and Sequence Labeling 6** Lexical syntax. Hidden Markov Models. Maximum Entropy Models. Conditional Random Fields.

**Syntactic parsing 6** Grammar formalisms and tree banks. Efficient parsing for context-free grammars (CFGs). Statistical parsing and probabilistic CFGs (PCFGs). Lexicalized PCFGs.

**Semantic Analysis 8** Lexical semantics and word-sense disambiguation. Compositional semantics. Semantic Role Labeling and Semantic Parsing. Information Extraction (IE): Named entity recognition and relation extraction. IE using sequence labeling.

**Machine Translation (MT): 8** Basic issues in MT. Statistical translation, word alignment, phrase-based translation, and synchronous grammars.

**Suggested Readings:**

**1.** Jurafsky, Daniel, and James H. Martin, *Speech and Language**Processing: An Introduction to*

*Natural Language Processing,**Speech Recognition, and Computational Linguistics*, Prentice-

Hall, 2000.

**2.** Richard M Reese*, Natural Language Processing with Java*, Packt Publishing Ltd.

**3**. [Steven Bird](https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Steven+Bird%22), [Ewan Klein](https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Ewan+Klein%22), [Edward Loper](https://www.google.co.in/search?tbo=p&tbm=bks&q=inauthor:%22Edward+Loper%22), *Natural Language Processing with Python*, O'Reilly.

**4.** *Natural Language Processing of Semitic Languages* Springer 2014.

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| Course: Mobile Computing | | | Semester: |
| Course Code: CS-E07 | L T P | 3 1 0 | Credits: 4 |

**Objective:** Main objective of course is to understand the basic concepts of mobile computing, be familiar with the network protocol stack, and learn the basics of mobile telecommunication.

**Syllabus**

**Introduction: 8**

Wireless physical layer, wireless channel capacity, modulation techniques, OFDM.  Channel coding.  Common PHY designs, PHY bit rates, introduction to MIMO.

**Wireless link layer: 8**

MAC protocols, CSMA. Centralized MAC protocols, TDMA, CDMA etc. link adaptation, bit rate adaptation protocols. Error control, wrap up Link layer multicast. Energy and security considerations in the wireless PHY and link layers.

**Network layer: 8** Network layer: mobility management, Mobile IP, cellular hand offs. Multihop networks routing protocols: DSDV, DSR, AODV, routing security. Data transfer over multihop networks, opportunistic routing. 

**Transport layer: 8** TCP over wireless, performance issues. Transport layer mobility, application layer design for mobility and disconnected operations. 

**Mobile Platforms and Security: 8** Mobile computing platforms, Android architecture and security principles, Localization algorithms.  Energy efficiency, energy usage in apps, code offload. Future of mobile systems: some upcoming hot topics.

**Suggested Readings:**

**1.** Jochen Schiller, *Mobile Communications*, 2nd edition Pearson Pub Ltd.

**2.** Prasant Kumar Pattnaik and Rajib Mall, *Fundamentals of Mobile Computing*, PHI Learning.

3. Uwe Hansmann, Lothar Merk, Martin S. Nicklons and Thoma Stober, *Principles of Mobile*

*Computing*, Springer, 2003.

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| Course: Software Metrics | | | Semester: |
| Course Code: CS-E08 | L T P | 3 1 0 | Credits: 4 |

**Objective:** The objective of course is to develop different aspects of software development and it’s engineering.

**Basics of measurement:** 8

Measurement in everyday life, measurement in software engineering, scope of software metrics, representational theory of measurement, measurement and models, measurement scales, meaningfulness in measurement, goal-based framework for software measurement, classifying software measures, determining what to measure, software measurement validation, empirical investigation, types of investigation, planning and conducting investigations. Software-metrics data

**Collection and analysis:** 4

What is good data, how to define the data, how to collect the data, how to store and extract data, analyzing software-measurement data, frequency distributions, various statistical techniques.

**Measuring internal product attributes**: 4

Measuring size, aspects of software size, length, functionality and complexity, measuring structure, types of structural measures, control-flow structure, modularity and information flow attributes, data structures.

**Measuring external product attributes:** 10

Modeling software quality, measuring aspects of software quality, software reliability, basics of software reliability, software reliability problem, parametric reliability growth models, predictive accuracy, recalibration of software-reliability growth predictions, importance of operational environment, wider aspects of software reliability.

**Metrics for object-oriented systems:** 4

Intent and characteristics of object-oriented metrics, various object-oriented metric suites LK suite, CK suite and MOOD metrics.

**Dynamic Metrics:** 8

Runtime Software Metrics, Extent of Class Usage, Dynamic Coupling, Dynamic Cohesion, and Data Structure Metrics. Metrics for component-based systems: The intent of component-based metrics, distinguishing characteristics of component-based metrics, various component-based metrics.

**Resource measurement:** 2

Measuring productivity, teams, tools, and methods.

**Suggested Readings:**

1. Norman E-Fentor and Share Lawrence Pflieger.” Software Metrics”. International Thomson Computer Press, 1997.

2. Norman Fenton and James Bieman, “software metrics: a rigorous and practical approach, 3rded, CRC Press

3. Stephen H.Kan,”Metric and Models in software Quality Engineering”, Addison QWesley 1995.

4. C. Ravindranath Pandian, software metrics: A guide to planning, analysis and application, CRC Press, 2003