# ACADEMIC CURRICULA

(Course Structure and Detailed Syllabi)

## MASTER'S DEGREE PROGRAM

## M.TECH

in Computer Science and Engineering

(Specialization: Data Analytics)

**Revised on 2019**

## School of Computer Engineering

KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY

Deemed to be University U/S 3 of the UGC Act, 1956

BHUBANESWAR, ODISHA, INDIA

# SCHOOL OF COMPUTER ENGINEERING

# SPECIALIZATION: DATA ANALYTICS

## SEMESTER-I

| Sr. No. | Subject Code | Subject | Teaching Hours | | | Credit |
|---|---|---|---|---|---|---|
| | | **Theory** | L | T | P | |
| 1 | MA-6101 | Mathematical Foundation of Computer Science | 3 | 0 | 0 | 3 |
| 2 | CS-6105 | Algorithms and Complexity | 3 | 0 | 0 | 3 |
| 3 | CS-6108 | High Performance Computing | 3 | 0 | 0 | 3 |
| 4 | CS-6304 | Data Science & Analytics | 3 | 0 | 0 | 3 |
| 5 | | Elective-I | 3 | 0 | 0 | 3 |
| | | **Total Theory** | 15 | 0 | 0 | **15** |
| | | **Practical** | | | | |
| 7 | CS-6191 | Computing Laboratory | 0 | 0 | 3 | 2 |
| 8 | CS-6394 | Data Science & Analytics Laboratory | 0 | 0 | 3 | 2 |
| | | **Total Practical** | 6 | | | **4** |
| | | **Sessional** | | | | |
| | CS-6381 | Seminar | **0** | **0** | **2** | **1** |
| | | **Total Semester Credit** | | | | **20** |

## SEMESTER-II

| Sr. No. | Subject Code | Subject | Teaching Hours | | | Credit |
|---|---|---|---|---|---|---|
| | | **Theory** | L | T | P | |
| | RS-6001 | Fundamentals of Research Methodology | 3 | 0 | 0 | 3 |
| 2 | CS-6109 | Computational Intelligence | 3 | 0 | 0 | 3 |
| 3 | CS-6305 | Business Analytics & Intelligence | 3 | 0 | 0 | 3 |
| 4 | | Elective-II | 3 | 0 | 0 | 3 |
| 5 | | Elective-III | 3 | 0 | 0 | 3 |
| | | **Total Theory** | 15 | 0 | 0 | **15** |
| | | **Practical** | | | | |
| 7 | CS-6192 | Computational Intelligence Laboratory | 0 | 0 | 3 | 2 |
| 8 | CS-6395 | Business Intelligence Laboratory | 0 | 0 | 3 | 2 |
| | | **Total Practical** | 6 | | | **4** |
| | | **Sessional** | | | | |
| 9 | CS-6382 | Seminar | 0 | 0 | 2 | **1** |
| | | **Semester Total** | **23** | | | **20** |

## SEMESTER-III

| Sr. No. | Subject Code | Subject | Teaching Hours | Credit |
|---|---|---|---|---|
| 1 | CS-6387 | Thesis Part-I | - | 14 |
| | | **Semester Total** | | **14** |

## SEMESTER-IV

| Sr. No. | Subject Code | Subject | Teaching Hours | Credit |
|---|---|---|---|---|
| 1 | CS-6388 | Thesis Part-II | - | 16 |
| | | **Semester Total** | | **16** |
| | | **Total M. Tech. credit** | | **70** |

## LIST OF DEPARTMENT ELECTIVES

### ELECTIVES - I

| Sr. No. | Subject Code | Subject | Credit |
|---|---|---|---|
| 1 | CS-6321 | Information Storage & Management | 3 |
| 2 | CS-6324 | Distributed & Parallel Databases | 3 |
| 3 | CS-6337 | Knowledge Discovery Technologies | 3 |
| 4 | CS-6221 | Data & Knowledge Security | 3 |

### ELECTIVES - II

| Sr. No. | Subject Code | Subject | Credit |
|---|---|---|---|
| 1 | CS-6137 | Internet of Things | 3 |
| 2 | CS-6339 | Natural Language Processing | 3 |
| 3 | CS-6340 | Image & Video Analytics | 3 |
| 4 | CS-6138 | Cloud Computing | 3 |

### ELECTIVES - III

| Sr. No. | Subject Code | Subject | Credit |
|---|---|---|---|
| 1 | CS-6325 | Information Retrieval | 3 |
| 2 | CS-6338 | Data Visualization | 3 |
| 3 | CS-6134 | Machine Learning | 3 |
| 4 | CS-6341 | Web Intelligence | 3 |

## MA-6101 MATHEMATICAL FOUNDATION OF COMPUTER SCIENCE Cr-3

**Course Outcome:** At the end of the course, students will be able to:

CO1:*Understand the numerical methods to solve and find the roots of the equations.*
CO2:*Utilize the statistical tools in multi variable distributions.*
CO3:*Use probability formulations for new predictions with discrete and continuous random variable.*
CO4:*To understand various graphs in different geometries related to edges.*
CO5:*Understand vector spaces and related topics arising in magnification and rotation of images.*

**Prerequisites:** *Basic Mathematical knowledge.*

**UNIT-I**

*Numerical Methods:* Significant figures, Error definitions, Approximations and round off errors accuracy and precision. Roots of Equations: Bairstow-Lin's Method , Graeffe's Root Squaring Method. Computation of eigen values of real, symmetric matrices: Jacobi and Givens method.

**UNIT-II**

*Probability & Statistics:* Random Variable, Some Special Distributions : Binomial, Hyper-geometric, Exponential, Weibul distribution, Point and Interval Estimation, Testing of Hypothesis, Bivariate Distribution, Co-relation and Regression Analysis.

**UNIT-III**

*Graph Theory:* Isomorphism, Planar Graphs, Graph Coloring, Hamilton Circuits and Euler Cycle.

**UNIT-IV**

*Linear Algebra:* Vector spaces, subspaces, Linearly Independent and Dependent Vectors, Bases and Dimension, Coordinate Vectors-Illustrative Examples. Linear Transformations, Representation of Transformations by Matrices; Linear Functional; Non Singular Linear Transformations, Inverse of a Linear Transformation.

**Text Book:**


1. M.K.Jain, S.R.K.Iyengar and R.K.Jain: Numerical Methods for Scientific and Engineering Computation. 6th Ed.,New Age Int.Publishers.2012
2. T.Veerarajan: "Probability, Statistics and Random Process",3 rd Edition,Tata Mc-Graw Hill Co.,2016.
3. V Krishnamurthy V.P. Mainra, J.l. Arora, "An Introduction To Linear Algebra"; Published by Affiliated East-West Press Pvt Ltd. New Delhi, 2016.

## RS 6001 FUNDAMENTALS OF RESEARCH METHODOLOGY Cr-3

**Course Outcome:** At the end of the course, students will be able to:

CO1: *Conduct review of literature effectively*
CO2: *Formulate a viable research problem*
CO3: *Effectively write a technical paper based on research findings*
CO4: *Analyze and interpret research data*
CO5: *Develop awareness on IPR and allied issues*
CO6: *Follow ethical practices in research*

**UNIT I**

Introduction: Types of research, Literature review, Research gap, Motivation, Research objectives and specifications, Formulation of research questions, Research approach, Research hypothesis.

**UNIT II**

Research Writing: Methodology to write a technical paper/short communication/research proposal/monograph, Abstract writing, Report or presentation of results, Bibliography.

**UNIT III**

Data Analysis: Classification of data, Methods of data collection, Statistical techniques, Design of experiments and choosing an appropriate statistical technique, Introduction to mathematical modeling (regression, model fitting), Hypothesis testing, Statistical inference.

**UNIT IV**

Intellectual Property: Intellectual property, Patent, Trademark, GI, Copyright and related rights, Research Incentives, PCT and WIPO.

Plagiarism: Definition, Plagiarism and consequences, IPR Violation and Detection.

**UNIT V**

Research Ethics: Professional ethics in research, Ethical issues, Definition and importance, Ethical guidelines, Peer review, Research misconduct, Conflicts of interest.

**Reference Books:**


1. C. R. Kothari, Research Methodology, New Age International, 2004.
2. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.
3. J. W. Bames, Statistical Analysis for Engineers and Scientists, Tata McGraw-Hill, New York.
4. Donald Cooper, Business Research Methods, Tata McGraw-Hill, New Delhi.
5. Leedy P. D., Practical Research: Planning and Design, McMillan Publishing Co.
6. Day R. A., How to Write and Publish a Scientific Paper, Cambridge University Press, 1989.
7. Manna, Chakraborti, Values and Ethics in Business Profession, Prentice Hall of India, New Delhi, 2012.
8. R. Subramanian, Professional Ethics, Oxford University Press, 2013.

## CS-6105 ALGORITHMS AND COMPLEXITY Cr-3

**Course Outcome:** Upon completion of the course, students are expected to do the following:
CO:1 *Understand different algorithm design techniques*
CO2: *Analyze the asymptotic performance of algorithms*
CO3: *Apply important algorithm design paradigms and methods of analysis.*
CO4: *Modify existing algorithms to apply in common engineering design problems*
CO5: *Understand the different classes of problems: P, NP , NP Complete and NP Hard.*

**Prerequisites:** *Design of Algorithm and Analysis, Programming*

**UNIT-I** **12 hrs**

*Introduction:* Algorithms, Analyzing Algorithms, Designing Algorithms
*Mathematical foundations:* Growth of functions, Asymptotic notations, Recurrences, Substitution, iteration, master and recursion tree methods, Amortized analysis.
*Sorting and Order statistics:* Quick-sort, Analysis of quick-sort, Randomized version of quick-sort, Medians and order statistics, merge-sort, Heap Sort, Heap property, priority queues.

**UNIT-II** **7 hrs**

*Dynamic programming:* Elements of dynamic programming, Matrix chain multiplication, longest common subsequence.
*Greedy Algorithms:* Elements of the Greedy strategy, Activity selection, Huffman codes.

**UNIT-III** **8 hrs**

*Graph Algorithms:* Representations of Graphs, Breadth-first search, Depth-first search, Topological sort, Minimum spanning trees: algorithms of Kruskal and Prim, Single source shortest paths : Dijkstra's algorithm, All-pairs shortest paths: Floyd-Warshall algorithm.

**UNIT-IV** **9 hrs**

*Computational Geometry:* Finding the convex hull, Finding the closest pair of points.
*Complexity Classes:* P, NP, NP-completeness and reducibility.
*Approximation Algorithms:* Vertex cover problem, Travelling-salesperson problem.

**Text Book:**

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, Introduction to Algorithms, PHI, Third Edition, 2009.

**Reference Books:**

1. Donald E. Knuth, Art of Computer Programming, The, Volumes 1-3.
2. K. Rosen, Discrete Mathematics and its Applications, 4th edition, 2003
3. Jon Kleinberg and Eva Tardos, Algorithm Design, Addison-Wesley, 2006.
4. Michael T Goodrich and Roberto Tamassia, “Algorithm Design: Foundations, Analysis, and Internet Examples”, Wiley, Students Edition

## CS-6108 HIGH PERFORMANCE COMPUTING Cr-3

Upon completion of the course, students are expected to do the following:

CO1: *Understand about different quantitative techniques used to measure performance of system with various criteria like CPI, CPU time, speed up, throughput, efficiency etc.*
CO2: *Understand the concept of different types of hazards along with their structural implementation and applications*
CO3: *Able to identify the criteria to enhance the performance of a pipelined processors.*
CO4: *Understand ILP and the techniques to exploit ILP in scalar, super scalar, super pipelined processor and VLIW processor.*
CO5: *Able to classify various parallel architecture like centralized and distributed memory architecture*

**Prerequisites:** *Computer Organization and Architecture*

**UNIT-I** **5 hrs**

*Introduction:* Review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance. CISC and RISC processors.

**UNIT-II** **9 hrs**

*Pipelining:* Basic concepts, instruction and arithmetic pipeline, data hazards, control hazards, and structural hazards, techniques for handling hazards. Exception handling. Pipeline optimization techniques. Compiler techniques for improving performance.

**UNIT-III** **8 hrs**

*Hierarchical memory technology:* Introduction, Coherence and locality of reference properties; Cache memory organizations, Techniques for reducing cache misses; Virtual memory organization, mapping and management techniques, memory replacement policies.

**UNIT-IV** **8 hrs**

*Instruction-level parallelism:* Basic concepts, techniques for increasing ILP, superscalar, super-pipelined and VLIW processor architectures. Array and vector processors.

**UNIT-V** **6 hrs**

*Multiprocessor architecture:* Taxonomy of parallel architectures. Centralized shared-memory architecture: synchronization, memory consistency, interconnection networks. Distributed shared-memory architecture.

**Text Book:**

1. John L. Hennessy and David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann.

**Reference Books**:

1. John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw-Hill
2. M. J. Flynn, Computer Architecture: Pipelined and Parallel Processor Design, Narosa Publishing House.
3. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw-Hill.

## CS-6304 DATA SCIENCE & ANALYTICS Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Work with data science platform and explore the big data analytics techniques business applications.*
CO2: *Design efficient algorithms for mining the data from large volumes.*
CO3: *Demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making & Recommendation System.*
CO4: *Analyze the HADOOP and Map Reduce technologies associated with big data analytics.*
CO5: *Think critically in making decisions based on data and deep analytics.*

**Prerequisites:** *Database Management System, Mathematical knowledge on statistics & probabilities.*

**UNIT-I** **6 hrs**

*Introduction to Data Science:* Introduction to Data Science Platform – Challenges of Conventional Systems - Intelligent data analysis – Nature of Data - Analytic Processes and Tools - Analysis vs Reporting. Descriptive Statistics, Probability Distributions.

**UNIT-II** **7 hrs**

*Mining data streams:* Introduction to Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform(RTAP) Applications - Case Studies - Real Time Sentiment Analysis- Stock Market Predictions.

**UNIT-III** **8 hrs**

*Decision Analysis:* Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.
*Recommendation Systems:* Building a User-Facing Data Product - Algorithmic ingredients of a Recommendation Engine - Dimensionality Reduction - Singular Value Decomposition - Principal Component Analysis

**UNIT-IV** **8 hrs**

*Predictive Analytics*- Simple linear regression- Multiple linear regression- Interpretation of regression coefficients. Visualizations - Visual data analysis techniques- interaction techniques - Systems and applications
*Presecriptive Analytics:* Creating data for analytics through designed experiments, creating data for analytics through Active learning, creating data for analytics through Reinforcement learning

**UNIT-V** **7 hrs**

*Understanding Hadoop Fundamentals and Frameworks :* The MapReduce Framework; Techniques to Optimize MapReduce Jobs; Uses of MapReduce; Role of HBase in Big Data Processing; Storing Data in Hadoop : Introduction of HDFS, Architecture, HDFC Files, Introducing HBase, Architecture, Storing Big Data with HBase , Interacting with the Hadoop Ecosystem; HBase in Operations Programming with HBase; Installation, Combining HBase and HDFS. Frameworks: Applications on Big Data Using Pig and Hive – Data processing operators in Pig – Hive services – HiveQL – Querying Data in Hive - fundamentals of HBase and ZooKeeper - IBM InfoSphere BigInsights and Streams.

**Text Books:**


1. Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, 2007.
2. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly. 2014
3. BIG DATA and ANALYTICS, Seema Acharya, Subhasinin Chellappan, Wiley publications.


**Reference Books**:


1. "Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data", McGrawHill Publishing, 2012.
2. Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", CUP, 2012.
3. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.

## CS-6109 COMPUTATIONAL INTELLIGENCE Cr-3

CO1: *Able to understand the basic concepts and characteristics of soft computing and also its associated methodologies.*
CO2: *Able to apply various set theoretic operations in fuzzy sets.*
CO3: *Able to understand and analyze fuzzy rules, fuzzy reasoning and various fuzzy inference systems.*
CO4: *Able to understand derivative free optimization and apply genetic algorithms to optimization problems.*
CO5: *Able to understand concepts of artificial neural networks and apply neural networks to various classification problems.*

**Prerequisites:** *Basic Mathematical knowledge on set theory, matrices, vectors and statistics*

**UNIT-I** **5 hrs**

*Introduction to Neuro-Fuzzy and Soft Computing* : Introduction, Soft Computing constituents and Conventional AI, Neuro-Fuzzy and Soft Computing characteristics.

**UNIT-II** **6 hrs**

*Fuzzy Set Theory* : Fuzzy sets, Basic definitions and terminologies, Set-theoretic operations, Member function formulation and parameterization, More on union, intersection and complement.

**UNIT-III** **10 hrs**

*Fuzzy Rules, Fuzzy Reasoning and Fuzzy Inference Systems* : Extension principle and fuzzy relations, Fuzzy if-then rules (including linguistic variables), Fuzzy reasoning, Fuzzy inference systems, Mamdani fuzzy model, Sugeno fuzzy model, Tsukamoto fuzzy model.

**UNIT-IV** **6 hrs**

*Genetic Algorithms* : Derivative free Optimization, Genetic Algorithms.

**UNIT-V** **9 hrs**

*Artificial Neural Networks* : Introduction to ANN, Perceptrons and MLP, Perceptron learning algorithm, Adaline and Madaline, Backpropagation Multilayer Perceptrons, Some supervised and unsupervised learning networks.

**Text Book:**

1. Neuro-Fuzzy and Soft Computing, Jang, Sun, Mizutani, PHI/Pearson Education

**Reference Books**:

1. Genetic Algorithms: Search, Optimization and Machine Learning, Davis E. Goldberg, Addison Wesley, N.Y.
2. Neural Network Design, M. T. Hagan, H. B. Demuth, Mark Beale, Cengage Learning.
3. Neural Networks: A Comprehensive Foundation, Simon Haykin, Prentice Hall.
4. Neural Networks, Fuzzy Logic and Genetic Algorithms, S. Rajasekaran and G.A.V. Pai, PHI
5. Neural Networks, Satish Kumar, TMH.
6. Fuzzy Logic with Engineering Applications, Timothy J. Ross, McGraw-Hill

## CS-6305 BUSINESS ANALYTICS & INTELLIGENCE Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Understand the essentials and fundamentals of business analytics, business intelligence and the corresponding terminologies.*
CO2: *Familiar with the steps involved in the business analytics process.*
CO3: *Interact competently on the topic of business analytics & Intelligence*
CO4: *Develop specific skills, competencies, and points of view needed by professionals in the field most closely related to this course*
CO5: *Analyze and critically evaluate ideas, arguments and points of view*

**Prerequisites:** *Database Management System, Mathematical knowledge on statistics & probabilities.*

**UNIT-I** **5 hrs**

**Introduction and overview of Data Mining Process:** What Is Business Analytics?, What Is Data Mining?, Data Mining and Related Terms, Big Data, Data Science, Other Terminology and Notation, Core Ideas in Data Mining, The Steps in Data Mining, Predictive Power and Over fitting, Building a Predictive Model.

**UNIT-II** **5 hrs**

**Data Exploration and Dimension Reduction: Data Visualization:** Uses of Data Visualization, Basic Charts, Multidimensional Visualization, Specialized Visualizations.

**UNIT-III** **7 hrs**

**Dimension Reduction:** Introduction, Curse of Dimensionality, Correlation Analysis, Reducing the Number of Categories in Categorical Variables, Converting a Categorical Variable to a Numerical Variable, Principal Components Analysis.

**UNIT-IV** **10 hrs**

**Prediction and Classification Methods:** Logistic Regression, Multiple Linear Regression, k-Nearest Neighbours (k-NN), The Naive Bayes Classifier, Classification and Regression Trees, Dimension Reduction Using Regression Models, Dimension Reduction Using Classification and Regression Trees, Neural Network.

**UNIT-V** **9 hrs**

**Mining Relationships among Records:** Association Rules: Discovering Association Rules in Transaction Databases, The Apriori Algorithm, The Process of Rule Selection, Cluster Analysis: Introduction, Measuring Distance Between Two Records, Measuring Distance Between Two Clusters, Hierarchical (Agglomerative) Clustering, Non-Hierarchical Clustering: The k-Means Algorithm.

**Text Books:**


1. Data Mining For Business Analytics: Concepts, Techniques, and Applications in R, Galit Shmueli, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, and Kenneth C. Lichtendahl Jr., Wiley publication, ISBN: 978-1-118-87936-8
2. Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner, Galit Shmueli, Wiley publication, ISBN: 9788126517589


**Reference Books**:


1. How to Measure Anything: Finding the Value of Intangibles in Business, by Douglas W. Hubbard, Wiley 3rd Edition, and ISBN: 9781118539279
2. Analytics at Work: Smarter Decisions, Better Results, by Thomas H. Davenport, Jeanne G. Harris, Robert Morison, Harvard Business Press, ISBN: 9781422177693
3. Data Science for Business by F. Provost and T. Fawcett, ISBN: 978-1-4493-6132-7

# ELECTIVES - I

## CS-6321 INFORMATION STORAGE & MANAGEMENT Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Understand and describe data center infrastructure and its elements*
CO2: *Understand and describe third platform technologies - cloud, big data, social, and mobile*
CO3: *Evaluate various types of intelligent storage systems and their deployment*
CO4: *Evaluate various storage networking technologies and their deployment*
CO5: *Articulate business continuity and archiving solutions*

**Prerequisites:** *Basic understanding of computer architecture, operating systems, networking, and databases*

**UNIT-I** **5 hrs**

*Storage System: Introduction to Information Storage and Management:* Information Storage, Evolution of Storage Technology and Architecture, Data Center Infrastructure, Key Challenges in Managing Information, Information Life cycle.

**UNIT-II** **6 hrs**

*Storage System Environment:* Components of a Storage System Environment, Disk Drive Components, Disk Drive Performance, Fundamental Laws Governing Disk Performance, Logical Components of the Host.

**UNIT-III** **8 hrs**

*Data Protection: RAID:* Implementation of RAID, RAID Array Components, RAID Levels, RAID Comparison, RAID Impact on Disk Performance, Hot Spares. Intelligent Storage System: Components of an Intelligent Storage System, Intelligent Storage Array.

**UNIT-IV** **8 hrs**

*Storage Networking Technologies and Storage Virtualization:* Direct-Attached Storage: Types of DAS, DAS Benefits and Limitations, Storage Area Networks: Fibre Channel: Overview, The SAN and Its Evolution, Components of SAN, Network-Attached Storage.

*Introduction to Business Continuity:* Information Availability, BC Terminology, BC Planning Lifecycle, Failure Analysis, Business Impact Analysis, BC Technology Solutions.

**UNIT-V** **9 hrs**

*Backup and Recovery:* Backup Purpose, Backup Considerations, Backup Granularity, Recovery Considerations, Backup Methods, Backup Process, Backup and Restore Operations, Backup Topologies - Serverless Backup, Backup to Tape, Backup to Disk. Storage Security and Management: Storage Security Framework, Risk Triad, Storage Security Domains, Security Implementations in Storage Networking, Monitoring the Storage Infrastructure, Storage Management Activities, Storage Infrastructure Management Challenges.

**Text Books:**

1. Information Storage and Management: Storing, Managing, and Protecting Digital Information Edited by G. Somasundaram and Alok Shrivastava, EMC Education Services, Wiley Publishing Inc.

**Reference Books**:

1. Information Storage and Management: Storing, Managing, and Protecting Digital Information in Classic, Virtualized, and Cloud Environments, Second Edition by EMC Education Services

## CS-6324 DISTRIBUTED AND PARALLEL DATABASE Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Identify the introductory distributed and parallel database concepts and its structures.*
CO2: *Understand various architectures of DDBMS and apply various fragmentation*
CO3: *Understand the steps of query processing and the optimization techniques.*
CO4: *Learn and understand various Query Optimization Algorithms*
CO5: *Understand Transaction Management & Compare various approaches to concurrency*

**Prerequisites:** *Basic concept of DBMS, RDBMS & Networking*

**UNIT-I** **6 hrs**

*Concepts of Distributed and Parallel DBMS:* Information systems, overview of traditional DBMS structure, distributed and parallel data processing, concepts of distributed DBMS, Promises of DDBSs, Complicating factors, Problem areas, types of parallelism in database systems.

**UNIT-II** **6 hrs**

*Distributed and Parallel DBMS Architecture:* Client-Server Architecture: structure of client-server systems, client-server standards, database middleware. Heterogeneous Database Servers. Architecture of Distributed DBMS: transparencies in DDBMS, architecture of DDBMS, types and role of fragmentation, types and role of replication, allocation problem.

**UNIT-III** **8 hrs**

*Query processing:* Optimization of Distributed Query: problem of query processing, distributed query, query decomposition, objectives of query optimization, distributed query optimization algorithms, optimization of join operation, load balancing. Parallel Query Processing: multiprocessor architectures, parallel relational operators, parallel query processing, parallelism in main-memory DBMS, parallel handling of integrity constraints.

**UNIT-IV** **9 hrs**

*Transaction Model of the DDBMS:* Introduction To Transaction Management: Definition of Transaction, Properties of Transaction, types of transaction, Distributed Concurrency Control: Serializability theory, Taxonomy of concurrency control mechanisms; locking bases concurrency control algorithms, Concurrency Control Algorithms.

**UNIT-V** **7 hrs**

*Reliability and Security aspects of DDBMS:* Reliability concepts and measures, failures and failure tolerance, reliability protocols, architectural consideration, security problems, security policies, security models for DDBMS.

**Text Books:**

1. Principles of Distributed Database Systems by M. Tamer Özsu , Patrick Valduriez, Springer
2. Distributed Databases - Principles and Systems; Stefano Ceri; Guiseppe Pelagatti; Tata McGraw Hill; 1985.

**Reference Books**:

1. Principles of Distributed Database Systems, Ozsu, Pearson Publication
2. Distributed Database Mangement Systems, Rahimi & Haug, Wiley
3. Distributed Database Systems, Chanda Ray, Pearson Publication

## CS-6337 KNOWLEDGE DISCOVERY TECHNOLOGIES Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Preprocess the data and apply appropriate algorithms.*
CO2: *Integrate knowledge discovery tools.*
CO3: *Use Map risk prediction and anamoly detection as knowledge discovery tools.*
CO4: *Analyze similarity clustering for health record based applications as knowledge discovery tool*
CO5: *Predict relationships using relationship discovery*

**Prerequisites:** *Data Mining & Warehousing*

**UNIT-I** **6 hrs**

*introduction:* Data Mining-Knowldege Discovery Process–Data Understanding–Data – Concepts of Learning-Classification-Summary –Knowledge representation— Cate-set and interval-Fuzzy sets.

**UNIT-II** **5 hrs**

*Data Preprocessing :* Subverting Knowledge discovery-Effects of technology properties-Sense making and situational awareness.

**UNIT-III** **9 hrs**

*Risk Prediction and Anamoly Detection:* Goals-Problems-Human variability-Computational difficulty- Rarity-Justifiable preemption-Hindsight Bias-Outline of prediction-attributes - Missing values - Reason – Errors - Ranking-Technologies.

**UNIT-IV** **10 hrs**

*Similarity Clustering:* Goals-Clustering technology- Distance based-density based- Distribution based-Decomposition based-Hierarchical-biclustering-clusters and prediction- Symbiotic clustering E-Health perspectives-Ehealth records-EHealth-Epublic health Information system.

**UNIT-V** **6 hrs**

*Relationship Discovery:* Goals-Outline of Textual analysis-Technologies-Discovery - Public textual data.

**Text Books:**

1. David Skillicorn, “Knowledge Discovery for Counterterrorism and Law Enforcement”, 1st Edition, Chapman & Hall/CRC Data Mining and Knowledge Discovery Series, 2008.

**Reference Books**:

1. Krzysztof J. Cios, Witold Pedrycz, Roman W. Swiniarski, Lukasz Andrzej Kurgan, “Data Mining: A Knowledge Discovery Approach”,1st Edition, Springer Science & Business Media LLC, 2007

## CS-6221 DATA AND KNOWLEDGE SECURITY Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Understand fundamentals of Database system architecture & its security requirements*
CO2: *Understand the concept of Distributed Database Management System Architecture & its design issues*
CO3: *Understand the working principles of Data Centralized and Distributed Authorization control*
CO4: *Understand various security issues in database interoperability*
CO5: *Understand the concept of Knowledge base systems, its design & underlying security issues*

**Prerequisites:** *Data Base Management System*

**UNIT-I** **5 hrs**

**Data Security:** Database systems- architectures- storage structures- storage issues in Database Management Systems- Security of data at various levels of Database Management Systems

**UNIT-II** **8 hrs**

**Distributed Databases:** Distributed Data Processing- Distributed Database system- Distributed Database Management System Architecture: Architectural models for Distributed Database Management System – Global directory issues – Distributed database design – distributed design issues – fragmentation – Allocation.

**UNIT-III** **9 hrs**

**Semantic Data Control:** View Management – Data centralized Authorization control – Distributed Authorization control – Centralized Semantic Integrity Control- Database interoperability - issues related to security in database interoperability.

**UNIT-IV** **8 hrs**

**Knowledge base systems** - Knowledge base system design – storage of knowledge – various formats – Levels of security issues in Knowledge base system design – conceptual level – implementation level .

**UNIT-V** **6 hrs**

E**xpert Systems** – Design of Expert systems – Knowledge representation techniques in Expert system – structured, semi structured and unstructured data – Knowledge Management and security issues.

**Text Books:**

1. Security in Computing, Charles P. Pfleeger and Shari Lawrence Pfleeger & Jonathan Margulies, Fifth Edition, Pearson Education, 2018

**Reference Books**:

1. Principles of Distributed Database Systems, M.Tamer OZSU and Patrick Valdureiz, Second Edition , Pearson Education, 2001
2. Artificial Intelligence: A Modern approach, Stuart Russel and Peter Norwig, Third Edition, Pearson Education, 2003
3. Knowledge Management, Ganesh Natarajan and Sandhya Shekhar, Tata McGrawHill, 2000

# ELECTIVES - II

## CS-6137 INTERNET OF THINGS Cr-3

Course Outcomes: At the end of the course, the students will be able to:

CO1: Understand basics of Internet of Things.
CO2: Understand the characteristics and building blocks of Internet of Things.
CO3: Understand the State of Art-IoT Architecture.
CO4: Understand how sensors and embedded systems work.
CO5: Understand how to communicate with mobile devices using various communication platforms such as Bluetooth and Wi-Fi.

Prerequisites: Computer Networks and some programming experience.

**Fundamentals:** Definition & Characteristics of IoT, Physical Design of IoT - Things in IoT , IoT Protocols , Logical Design of IoT, IoT Enabling Technologies - Wireless Sensor Networks, Cloud Computing, Big Data Analytics ,Communication Protocols, Embedded Systems .IoT Levels & Deployment Templates. Application of Domain Specific IoTs.

**IoT and M2M :** Introduction, M2M , Difference between IoT and M2M. SDN and NFV for IoT.
IoT System Management with NETCONF-YANG: Need for IoT Systems Management, Simple Network Management Protocol(SNMP) , NETCONF,YANG

**IoT Platform Design Methodlogy:** Introduction, IoT Design Methodology. Case Study on IoT System for Weather Monitoring,Case Study on IoT System for Home Automation, Case Study on IoT System for Industry Automation.

**IoT Physical Devices & Endpoints:** IoT Device, Exemplary Device: Arduino, About the Arduino Uno input and output Control an LED with Arduino , Interfacing an LED with Switch with Arduino, Interfacing Relay with Arduino. Analog to Digital Converter, Reading value from potential meter, DHT-11 temperature sensor, LDR, Interfacing of various sensors with Arduino, Raspberry Pi, Intel, BeagleBone Black, Cubieboard.

**IoT Physical Server and Cloud Offering:** Introduction to Cloud Storage Models & Communication APIs , (8.1)Client-Server model for IoT, Different server side web technologies for IoT-PHP ,JSP ,Servlet ,Node JS, Different Client side web technologies for IoT -HTML, Java script and JSON, AJAX. MVC architecture for IoT, Web socket and HTTP, Arduino as a web-client, Dweet , Thingspeak, freebord.io.

**Case Studies Illustrating IoT Design:** Introduction, Home Automation- Smart Lighting, Home Intrusion Detection , Cities -Smart Parking, Environment -Weather Monitoring System ,Weather Reporting Bot ,Air Pollution Monitoring , Forest Fire Detection ,Agriculture - Smart Irrigation , Productivity Applications - IoT Printer .

**Advanced Topics:** Data Analytics for IoT- Apache Hadoop, Using Hadoop MapReduce for Batch Data Analysis, Apache Oozie, Apache Spark. Tools for IoT- Chef, Chef Case Studies ,Puppet , Puppet Case Study, NETCONF-YANG Case Studies

**Text Books:**

1. Arshadeep Bahga,Vijay Madisetti, "Internet of Things -A Hands-on Approach", Universities Press, 1st Edition, ISBN:9788173719547.

**Reference Books:**

1. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", Wiley Publication, 1st Edition, November 2013,ISBN:9781118430620.
2. Harry Fairhead ,"Raspberry Pi IOT in C", IO Press Publication, 1st Edition, ISBN:9781871962468

## CS-6339 NATURAL LANGUAGE PROCESSING Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Understand the fundamentals of NLP*
CO2: *Process the text data at syntactic and semantic level.*
CO3: *Extract the key information from Text data.*
CO4: *Analyze the text content to provide predictions related to a specific domain using language models*
CO5: *Generate the use cases for usage of NLP tools for real life applications.*

**Prerequisites:** *Computational Intelligence*

**UNIT-I** **6 hrs**

*Fundamentals of NLP:* Natural Language Processing – Linguistic Background -Mathematical Foundations-Morphological Analysis-Tokenization- Stemming-Lemmatization - Boundary Determination.

**UNIT-II** **7 hrs**

*Understanding Data:* Reading unstructured data - Representing text data - Part of speech tagging - Syntactic representation - Text similarity - WordNet based similarity- Shallow parsing -Semantic representation.

**UNIT-III** **7 hrs**

*Information Retrival:* Information retrieval and Information extraction - Named Entity Recognition - Relation Identification-Template filling.

**UNIT-IV** **9 hrs**

*Language Models:* Language model - Probabilistic Models - n-gram language models- Hidden Markov Model- Topic Modelling - Graph Models -Feature Selection and classifiers -Rule-based Classifiers - Maximum entropy classifier – Clustering-Word and Phrase-based Clustering.

**UNIT-V** **7 hrs**

*Tools:* Natural Language Tool kit, Apache OpenNLP. Applications of Text Analytics , Applications in Social media - Life science - Legal Text–Visualization -Case studies.

**Text Books:**

1. Christopher D. Manning and Hinrich Schutze, “Foundations of Statistical Natural Language Processing”, MIT Press, 1999.

**Reference Books**:

1. Steven Struhl, “Practical Text Analytics: Interpreting Text and Unstructured Data for Business Intelligence”, Kogan Page, 2015.
2. Matthew A. Russell, “Mining the Social Web”, O'Reilly Media, 2013.
3. Steven Bird, Ewan Klein and Edward Loper, “Natural Language Processing with Python”, 1 st Edition, O'Reilly Media, 2009.

## CS-6340 IMAGE AND VIDEO ANALYTICS Cr-3

**Course Outcomes:** At the end of the course, the students will be able to:

CO1: *Understand fundamentals of digital image processing, image and video analysis.*
CO2: *Understand the real time use of image and video analytics.*
CO3: *Demonstrate real time image and video analytics applications and others.*
CO4: *Understand the fundamental principles of image and video analysis and have an idea of their application.*
CO5: *Apply image and video analysis in real world problems*

**Prerequisites:** *Image Processing*

**UNIT-I** **7 hrs**

*Digital image representation*- Visual Perception- Sampling and Quantization- Basic Relations between Pixels- Mathematical Tools Used in Digital Image Processing: Fundamental Operations –Vector and Matric Operations- Image Transforms (DFT, DCT, DWT, Hadamard).

**UNIT-II** **8 hrs**

*Fundamentals of spatial filtering:* spatial correlation and convolution-smoothingblurring- sharpening- edge detection - Basics of filtering in the frequency domain: smoothing-blurring- sharpening--Histograms and basic statistical models of image.

**UNIT-III** **7 hrs**

*Colour models and Transformations* – Image and Video segmentation-Image and video demonising- Image and Video enhancement- Image and Video compression.

*Object detection and recognition in image and video*-Texture models Image and Video classification models- Object tracking in Video

**UNIT-IV** **9 hrs**

*Image and Video Analysis* – Image representation and image models, Image and Video classification and segmentation, multiband stechniques for texture classification and segmentation, adaptive and neural methods for image segmentation, edge and boundary detection, Algorithms for image processing.

**UNIT-V** **5 hrs**

*Applications and Case studies*- Industrial- Retail- Transportation & Travel- Remote sensing-Video Analytics in WSN: IoT Video Analytics Architectures.

**Text Books:**

1. C. Gonzalez and R.E. Woods.” Digital Image Processing”. 3rd Edition. Addison Wesley, 2007.
2. Alan C Bovik, Handbook of Image and Video Processing, 2nd Edition, Academic Press, 2005

**Reference Books**:

1. W. Härdle, M. Müller, S. Sperlich, A. Werwatz, “Nonparametric and Semi parametric Models”, Springer, 2004.
2. Rick Szelisk, “Computer Vision: Algorithms and Applications”, Springer 2011.
3. Jean-Yves Dufour, “Intelligent Video Surveillance Systems”, Wiley, 2013.
4. Caifeng Shan, Fatih Porikli, Tao Xiang, Shaogang Gong, “Video Analytics for Business Intelligence”, Springer, 2012.

## CS-6138 CLOUD COMPUTING Cr-3

Course Outcomes: At the end of the course, the students will be able to:

CO1: Understand the basic concept and essentials of Distributed System and Cloud Computing
CO2: Understand the architecture and concepts of different cloud services :IaaS, Paas and SaaS
CO3: Understand the different cloud models: public, private, hybrid and community cloud
CO4: Understand the concept the concept of virtualization and scheduling techniques
CO5: Examine various cloud applications and issues.

Prerequisites: Basic knowledge of operating system and networking

**Introduction to Cloud Computing:** Definitions, Roots of Cloud Computing: Fundamental concepts of Distributed Systems, Cluster Computing, Grid Computing, and Mobile Computing.

**Basics of Cloud Computing:** Concepts, Characteristics of Cloud Computing, Need for Cloud, Cloud Deployment models: private, public, hybrid and community cloud, Cloud Services: Resource-as-a-Service (RaaS), Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS), Examples of each services.

**Cloud Services: RaaS:** Usage of Physical resources like servers, networks, data center etc, IaaS: Virtualization, Virtual Machine provisioning and Migration Services, Scheduling techniques of Virtual machines for resource reservation. PaaS: Integrated lifecycle platform: Google App Engine, Microsoft Azure, Anchored life cycle platform: Salesforce platform, SaaS: Characterizing SaaS, Salesforce's software environment.

**Data base as a service (DaaS):** Cloud Data Storage System, CAP theorem Cloud Data Storage services, Suitability of SQL and NoSQL, Applications of Big Databases, Cloud Security and privacy issues, Mobile Cloud, Integration of Cloud with Wireless Sensor Network and its application.

**Text Books:**

1. "Cloud Computing" by Shailendra Singh, Oxford University Press, 2018

**Reference Books:**

1. "Cloud Computing Principles and Paradigms", edited by Rajkumar Buyya, James Broberg and Andrzej Goscinski, Wiley Publication, 2013
2. "Cloud Computing for Dummies", Judith Hurwitz, Robin Bloor, Marcia Kaufman and Fern Halper, Wiley Publication, 2009

# ELECTIVES - III

## CS-6325 INFORMATION RETRIEVAL Cr-3

Course Outcomes: At the end of the course, the students will be able to:

CO1: Identify Data Base Management systems and data ware houses
CO2: Use knowledge of data structures and indexing methods in information retrieval Systems
CO3: Choose clustering and searching techniques for different data base systems
CO4: Explain different types of search algorithms like Hardware text search systems and software text search systems
CO5: Explain how does Web search work.

Prerequisites: Database Management System

**Introduction:** Definition, Objectives, Functional Overview, Principles of Information Retrieval , Relationship to DBMS, Digital libraries and Data Warehouses. Information Retrieval System Capabilities: Search, Browse, Miscellaneous. Cataloging and Indexing: Objectives, Indexing Process, Automatic Indexing, Information Extraction.

**Data Structures:** Introduction, Zipfs Law, Vector space model, cosine similarity. Scoring techniques, Stemming Algorithms, Inverted file structures, N-gram data structure, PAT data structure, Signature file structure, Hypertext data structure.

**Automatic Indexing:** Classes of automatic indexing, Statistical indexing, Natural language, Concept indexing, Hypertext linkages, Document and Term Clustering: Introduction, Thesaurus generation, Item clustering, Hierarchy of clusters.

**User Search Techniques:** Search statements and binding, Relevance feedback, Selective dissemination of information search, Weighted searches of Boolean systems, Searching the internet and hypertext, Information Visualization: Introduction, Cognition and perception, Information visualization technologies.

Text Search Algorithms: Introduction, Software text search algorithms, Hardware text Search Systems.

**Text Books:**


1. Information Retrieval Data Structures and Algorithms, Frakes, W.B., Ricardo Baeza-Yates, Prentice Hall,2006
2. Information Retrieval Systems: Theory and Implementation, Kowalski, Gerald, Mark T Maybury, Kluwer Academic Press.,2010


**Reference Books:**


1. Introduction to Information Retrieval, P Raghavan, M Manning and P Schutze, Cambridge University Press, 2008
2. Modern Information Retrieval, Yates, Pearson Education.2008
3. Information Storage & Retieval, Robert Korfhage John Wiley & Sons,2012.

## CS-6338 DATA VISUALIZATION Cr-3

Course Outcomes: At the end of the course, the students will be able to:

CO1: Understand the key techniques and theory behind data visualization
CO2: Understand how fundamental principles of design and human cognition inform effective visualizations.
CO3: Utilize popular visualization applications such as Tableau and Excel.
CO4: Develop web pages that allow others to interact with data.
CO5: Evaluate information visualization systems and other forms of visual presentation for their effectiveness

Prerequisites: Big Data Analytics/DMDW

**Introduction:** Overview of Visualization, 2-D Graphics, SVG-example, 2-D Drawing, 3-D Graphics, Photorealism, Non-Photorealism, The Human, Memory, Reasoning, The Human Retina, Perceiving Two Dimensions, Perceiving Perspective.

**Visualization of Numerical Data:** Data, Mapping, Charts, Glyphs, Parallel Coordinates, Stacked Graphs, Tufte's Design Rules, Using Color.

**Visualization of Non-Numerical Data:** Graphs and Networks, Embedding Planar Graphs, Graph Visualization, Tree Maps, Principal Component Analysis, Multidimensional Scaling, Packing

**Visualization Dashboard:** Visualization Systems, The Information Visualization Mantra, Database Visualization, Visualization System Design.

**Web Programming:** Overview and intro to web programming, Marks and Channels, intro to D3 and selections, D3 chart help, Interactive computing, MVC, browsers, event callbacks, interaction design, D3 events, Tooltips, D3 Graphs, D3 transitions, interactive dynamics, Narrative structure, narrative layouts, narrative spectrum, Ellipsis, Declarative programming, reactive programming

**Text Books:**

1. Visualization Analysis & Design by Tamara Munzner (ISBN 9781466508910)

**Reference Books:**

1. Interactive Data Visualization for the Web by Scott Murray 2nd Edition (2017)
2. D3.js in Action by Elijah Meeks 2nd Edition (2017)
3. Semiology of Graphics by Jacques Bertin (2010)
4. The Grammar of Graphics by Leland Wilkinson
5. ggplot2 Elegant Graphics for Data Analysis by Hadley Wickham

## CS-6134 MACHINE LEARNING Cr-3

Upon completion of the course, students are expected to do the following:

CO1: Formulate machine learning problems corresponding to different applications: data, model selection, model complexity.
CO2: Demonstrate understanding of a range of machine learning algorithms along with their strengths and weaknesses.
CO3: Implement machine learning solutions to classification, regression, and clustering problems.
CO4: Design and implement various machine learning algorithms in a range of real-world applications.
CO5: Evaluate and analyse the performance of a machine-learning algorithm or a system based on machine learning algorithm.

Prerequisites: Basic probability, linear algebra, calculus and some programming experience.

Introduction, Linear Classification, perceptron Update rule, Perceptron convergence, generalization, Maximum Margin classification, Classification errors, regularization, Logistic regression, linear regression,

Estimator bias and variance , active learning, Non-linear prediction, kernals, kernal regression, Support vector machine (SVM) and kernels, kernel optimization, model selection, Model selection criteria.

Description length, Feature Selection, Combining Classifiers, boosting, margin, and complexity, margin and generalization, mixture models, Mixture and expectation maximization (EM) algorithm, Regularization.

Clustering, Spectral Clustering, Markov Models, Hidden Markov Models(HMM), Bayesian Networks, Learning Bayesian Networks, Probabilistic inference, Collaborative filtering.

**Text Books:**

1. Machine Learning., Mitchell, Tom, McGraw-Hill, ISBN: 97800704280, 3rd Edition.

**Reference Books:**

1. Neural Networks for Pattern Recognition., Christopher, Bishop, Oxford University Press,1995,ISBN: 9780198538646,
2. Pattern Classification., Richard, Duda, Peter Hart and David Stork, Wiley Interscience, 2000,ISBN: 9780471056690
3. The Elements of Statistical Learning: Data Mining, Inference and prediction., Hastie, T., R. Tibshirani and J.H Friedman . , NY. Springer, ISBN: 9780387952840, 2005.
4. Information Theory, Interference and learning algorithms., MacKay, David, Cambridge ,UK, Cambridge University Press,. ISBN: 9780521642989, 2003.

## CS-6341 WEB INTELLIGENCE Cr-3

Course Outcomes: At the end of the course, the students will be able to:

CO1: Know the concepts and terminologies related to web analytics.
CO2: Know the principles, tools and methods of web intelligence.
CO3: Apply analytics for business situations.
CO4: Explore various parameters used for web analytics and their impact.
CO5: Explore the use of tools and techniques of web analytics.

Prerequisites: Analysis experience

Web Analytics – Basics – Traditional Ways – Expectations – Data Collection – Clickstream Data – Weblogs – Beacons – JavaScript Tags – Packet Sniffing – Outcomes data – Competitive data – Search Engine Data.

Qualitative Analysis – Customer Centricity – Site Visits – Surveys – Questionnaires – Website Surveys – Post visits – Creating and Running- Benefits of surveys – Critical components of successful strategy.

Web Analytic concepts – URLS – Cookies – Time on site – Page views – Understand standard reports – Website content quality – Navigation reports (top pages, top destinations, site overlay). – Search Analytics – Internal search, SEO and PPC – Measuring Email and Multichannel Marketing - Competitive intelligence and Web 2.0 Analytics – Segmentation – Connectable reports.

Google Analytics: Analytics - Cookies - Accounts vs Property - Tracking Code - Tracking Unique Visitors - Demographics - Page Views & Bounce Rate Acquisitions - Custom Reporting.

Goals & Funnels – Filters - Ecommerce Tracking - Real Time Reports - Customer Data Alert - Adwords Linking - Adsense Linking -Attribution Modeling - Segmentation - Campaign Tracking - Multi-Channel Attribution.

**Text Books:**


1. Avinash Kaushik, “Web Analytics 2.0: The Art of Online Accountability and Science Of Customer Centricity “, 1st edition, Sybex, 2009.
2. Michael Beasley, “Practical Web Analytics for User Experience: How Analytics can help you Understand your Users”, Morgan Kaufmann, 2013.


**Reference Books:**


1. Magy Seif El-Nasr, Anders Drachen, Alessandro Canossa, eds., “Game Analytics: Maximizing the Value of Player Data”, Springer, 2013.
2. Bing Liu, “Web Data Mining: Exploring Hyperlinks, Content, and Usage Data”, 2nd Edition, Springer, 2011.
3. Justin Cutroni, “Google Analytics”, O’Reilly, 2010.

## Course Details for Practicals, Sessionals & Thesis Works

| Subject Code | Subject Name | Subject Details |
|---|---|---|
| CS-6191 | Computing Laboratory | Course details on different experiments in individual laboratories are decided by the concerned faculty member and programmer on day-to-day applications on demands during the academic session. |
| CS-6192 | Computational Intelligence Laboratory | |
| CS-6394 | Data Science & Analytics Laboratory | |
| CS-6395 | Business Intelligence Laboratory | |
| CS-6381 | Seminar (Semester-I) | Seminar topics will be decided by the concerned faculty member assigned to the individual student. The progress of the student's performance will be evaluated by a panel of faculty member as a reviewer during the final presentation at the end of each semester. |
| CS-6382 | Seminar (Semester-II) | |
| CS-6387 | Thesis Part-I | The topic for the thesis work will be decided and approved by the concerned faculty member as a supervisor for individual students. The progress of research work and thesis will be taken care of by the supervisors. The thesis will be evaluated periodically as per the guideline of the University by the panel of the reviewer of internal and external examiners. |
| CS-6388 | Thesis Part-II | |