ANNA UNIVERSITY, CHENNAI
AFFILIATED INSTITUTIONS
M.E. BIGDATA ANALYTICS
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM

PROGRAM EDUCATIONAL OBJECTIVES:

- Apply quantitative modeling and data analysis techniques to the solution of real world business problems, communicate findings, and effectively present results using data visualization techniques.
- Apply principles of Data Science to the analysis of business problems.
- Employ cutting edge tools and technologies to analyze Big Data.

PROGRAM OUTCOMES POs:

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one‘s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes

- Understand the impact of big data for business decisions and strategy
- Gain hands-on experience on large-scale analytics tools to solve some open big data problems
- Understand the concept and challenge of big data and why existing technology is inadequate to analyze the big data

Mapping of POs/PSOs to PEOs

Contribution 1: Reasonable 2: Significant 3:Strong

	PEOs		
POs	Apply quantitative modeling and data analysis techniques to the solution of real world business problems, communicate findings, and effectively present results using data visualization techniques.	Apply principles of Data Science to the analysis of business problems.	Employ cutting edge tools and technologies to analyze Big Data.
1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	3	3
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	2	3
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	3	2	3
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	2	2
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	3	3
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	2	2	2
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	2	1	2

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	3	1	1
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	2	2
10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	3	2	1
11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one‘s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	2	2	2
12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	3	2

PSOs	**PEO 1**	**PEO 2**	**PEO 3**
1. Understand the impact of big data for business decisions and strategy	3	1	1
2. Gain hands-on experience on large-scale analytics tools to solve some open big data problems	3	1	3
3. Understand the concept and challenge of big data and why existing technology is inadequate to analyze the big data	1	3	1

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SEMESTER I

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MA5160	Applied Probability and Statistics	FC	4	4	0	0	4
2	CP5151	Advanced Data Structures and Algorithms	PC	4	4	0	0	4
3	BD5101	Foundations of Data Science	PC	5	3	2	0	4
4	BD5102	Big Data Mining And Analytics	PC	3	3	0	0	3
5	CP5152	Advanced Computer Architecture	PC	3	3	0	0	3
6	BD5103	Distributed Computing	PC	3	3	0	0	3
PRACTICALS								
7	CP5161	Data Structures Laboratory	PC	4	0	0	4	2
8	BD5111	Big Data Computing Laboratory	PC	4	0	0	4	2
			TOTAL	**30**	**20**	**2**	**8**	**25**

SEMESTER II

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	CP5191	Machine Learning Techniques	PC	3	3	0	0	3
2	CP5292	Internet of Things	PC	3	3	0	0	3
3	IF5191	Advanced Databases	PC	3	3	0	0	3
4	CP5092	Cloud Computing Technologies	PC	3	3	0	0	3
5	BD5201	Big Data Security	PC	3	3	0	0	3
6		Professional Elective I	PE	3	3	0	0	3
PRACTICALS								
7	IF5161	Databases Laboratory	PC	4	0	0	4	2
8	CP5281	Term Paper Writing and Seminar	EEC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER III

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Professional Elective II	PE	3	3	0	0	3
2.		Professional Elective III	PE	3	3	0	0	3
3.		Professional Elective IV	PE	3	3	0	0	3
PRACTICALS								
4.	BD5311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**25**	**12**	**1**	**12**	**19**

SEMESTER IV

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1	BD5411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 73

FOUNDATION COURSES (FC)

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MA5160	Applied Probability and Statistics	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	CP5151	Advanced Data Structures and Algorithms	PC	4	4	0	0	4
2	BD5101	Foundations of Data Science	PC	5	3	2	0	4
3	BD5102	Big Data Mining And Analytics	PC	3	3	0	0	3
4	CP5152	Advanced Computer Architecture	PC	3	3	0	0	3
5	BD5103	Distributed Computing	PC	3	3	0	0	3
6	CP5161	Data Structures Laboratory	PC	4	0	0	4	2
7	BD5111	Big Data Computing Lab	PC	4	0	0	4	2
8	CP5191	Machine Learning Techniques	PC	3	3	0	0	3
9	CP5292	Internet of Things	PC	3	3	0	0	3
10	IF5191	Advanced Databases	PC	3	3	0	0	3
11	CP5092	Cloud Computing Technologies	PC	3	3	0	0	3
12	BD5201	Big Data Security	PC	3	3	0	0	3
13	IF5161	Databases Laboratory	PC	4	0	0	4	2

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
1	CP5281	Term Paper Writing and Seminar	EEC	2	0	0	2	1
2	BD5311	Project Work Phase I	EEC	12	0	0	12	6
3	BD5411	Project Work Phase II	EEC	24	0	0	24	12

PROFESSIONAL ELECTIVES

S.NO	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
PROFESSIONAL ELECTIVE I								
1	BD5001	High Performance Computing for Big Data	PE	3	3	0	0	3
2	SE5091	Service Oriented Architecture and Design	PE	3	3	0	0	3
3	CP5094	Information Retrieval Techniques	PE	3	3	0	0	3
4	CP5009	Data Visualization Techniques	PE	3	3	0	0	3
5	SE5014	Principles of Supply Chain Management	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE II								
6	IF5002	Deep Learning	PE	3	3	0	0	3
7	MU5251	Multimedia Communication Networks	PE	3	3	0	0	3
8	BD5002	Agile Software Development	PE	3	3	0	0	3
9	BD5003	Predictive Modelling	PE	3	3	0	0	3
10	IF5091	Video Analytics	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE III								
11	BD5004	NOSQL Databases	PE	3	3	0	0	3
12	MP5007	Cognitive Computing	PE	3	3	0	0	3
13	CP5074	Social Network Analysis	PE	3	3	0	0	3
14	SE5006	Virtualization Techniques and Applications	PE	3	3	0	0	3
15	BD5005	Natural Language Processing	PE	3	3	0	0	3
PROFESSIONAL ELECTIVE IV								
16	SE5002	Business Intelligence	PE	3	3	0	0	3
17	BD5006	R Language	PE	3	3	0	0	3
18	BD5007	Web Analytics	PE	3	3	0	0	3
19	CP5075	Bio Informatics	PE	3	3	0	0	3
20	BD5008	Healthcare Data Analytics	PE	3	3	0	0	3

MA5160 APPLIED PROBABILITY AND STATISTICS L T P C
4 0 0 4

OBJECTIVES:

This course is designed to provide the solid foundation on topics in applied probability and various statistical methods which form the basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. It is framed to address the issues and the principles of estimation theory, testing of hypothesis and multivariate analysis.

UNIT I PROBABILITY AND RANDOM VARIABLES 12

Probability – Axioms of probability – Conditional probability – Baye's theorem - Random variables - Probability function – Moments – Moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a random variable.

UNIT II TWO DIMENSIONAL RANDOM VARIABLES 12

Joint distributions – Marginal and conditional distributions – Functions of two dimensional random variables – Regression curve – Correlation.

UNIT III ESTIMATION THEORY 12

Unbiased estimators – Method of moments – Maximum likelihood estimation - Curve fitting by principle of least squares – Regression lines.

UNIT IV TESTING OF HYPOTHESIS 12

Sampling distributions – Type I and Type II errors – Small and large samples – Tests based on Normal, t, Chi square and F distributions for testing of mean, variance and proportions – Tests for independence of attributes and goodness of fit.

UNIT V MULTIVARIATE ANALYSIS 12

Random vectors and matrices – Mean vectors and covariance matrices – Multivariate normal density and its properties – Principal components - Population principal components – Principal components from standardized variables

TOTAL: 60 PERIODS

OUTCOMES:

After completing this course, students should demonstrate competency in the following topics:

- Basic probability axioms and rules and the moments of discrete and continuous random variables.
- Consistency, efficiency and unbiasedness of estimators, method of maximum likelihood estimation and Central Limit Theorem.
- Use statistical tests in testing hypotheses on data.
- Perform exploratory analysis of multivariate data, such as multivariate normal density, calculating descriptive statistics, testing for multivariate normality.

The students should have the ability to use the appropriate and relevant, fundamental and applied mathematical and statistical knowledge, methodologies and modern computational tools.

REFERENCES:

1. Devore, J. L., "Probability and Statistics for Engineering and the Sciences", 8th Edition, Cengage Learning, 2014.

2. Dallas E. Johnson, “Applied Multivariate Methods for Data Analysis”, Thomson and Duxbury press, 1998.
3. Gupta S.C. and Kapoor V.K.,” Fundamentals of Mathematical Statistics”, Sultan and Sons, New Delhi, 2001.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund’s Probability and Statistics for Engineers ", Pearson Education, Asia, 8th Edition, 2015.
5. Richard A. Johnson and Dean W. Wichern, “Applied Multivariate Statistical Analysis”, 5th Edition, Pearson Education, Asia, 2002.

CO PO PSO MAPPING

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	-	-	-	-	-	-	-	-	-	-	3	2	2
CO2	3	3	-	-	2	-	-	-	-	-	-	-	3	2	2
CO3	3	3	-	3	2	-	-	-	2	3	2	-	3	2	1
CO4	3	3	3	3	-	-	-	-	2	3	2	-	3	2	1
CO5	3	3	3	3	-	-	-	-	2	3	2	-	3	2	3

CP5151 ADVANCED DATA STRUCTURES AND ALGORITHMS L T P C
4 0 0 4

OBJECTIVES:

- To understand the usage of algorithms in computing.
- To learn and use hierarchical data structures and its operations
- To learn the usage of graphs and its applications.
- To select and design data structures and algorithms that is appropriate for problems.
- To study about NP Completeness of problems.

UNIT I ROLE OF ALGORITHMS IN COMPUTING 12

Algorithms – Algorithms as a Technology- Insertion Sort – Analyzing Algorithms – Designing Algorithms- Growth of Functions: Asymptotic Notation – Standard Notations and Common Functions- Recurrences: The Substitution Method – The Recursion-Tree Method

UNIT II HIERARCHICAL DATA STRUCTURES 12

Binary Search Trees: Basics – Querying a Binary search tree – Insertion and Deletion- Red-Black trees: Properties of Red-Black Trees – Rotations – Insertion – Deletion -B-Trees: Definition of B-trees – Basic operations on B-Trees – Deleting a key from a B-Tree- Fibonacci Heaps: structure – Mergeable-heap operations- Decreasing a key and deleting a node-Bounding the maximum degree.

UNIT III GRAPHS 12

Elementary Graph Algorithms: Representations of Graphs – Breadth-First Search – Depth-First Search – Topological Sort – Strongly Connected Components- Minimum Spanning Trees: Growing a Minimum Spanning Tree – Kruskal and Prim- Single-Source Shortest Paths: The Bellman-Ford algorithm – Single-Source Shortest paths in Directed Acyclic Graphs – Dijkstra’s Algorithm; All-Pairs Shortest Paths: Shortest Paths and Matrix Multiplication – The Floyd-Warshall Algorithm;

UNIT IV ALGORITHM DESIGN TECHNIQUES 12

Dynamic Programming: Matrix-Chain Multiplication – Elements of Dynamic Programming – Longest Common Subsequence- Greedy Algorithms: An Activity-Selection Problem – Elements of the Greedy Strategy- Huffman Codes.

UNIT V NP COMPLETE AND NP HARD 12

NP-Completeness: Polynomial Time – Polynomial-Time Verification – NP- Completeness and Reducability – NP-Completeness Proofs – NP-Complete Problems

TOTAL: 60 PERIODS

OUTCOMES:

Upon the completion of the course the students should be able to:

- Design data structures and algorithms to solve computing problems
- Design algorithms using graph structure and various string matching algorithms to solve real-life problems
- Apply suitable design strategy for problem solving

REFERENCES:

1. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, “Data Structures and Algorithms”, Pearson Education, Reprint 2006.
2. Robert Sedgewick and Kevin Wayne, “ALGORITHMS”, Fourth Edition, Pearson Education.
3. S.Sridhar,”Design and Analysis of Algorithms”, First Edition, Oxford University Press. 2014
4. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, “Introduction to Algorithms”, Third Edition, Prentice-Hall, 2011.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	1									3	3	
CO2	3	3	3	3	2			1					2	3	
CO3	3	3	2	1									1	3	
CO4	3	3	2	3	3	2	3	1	1				3	3	
CO5	3	3	2	3	3	2	2						3	3	

BD5101 FOUNDATIONS OF DATA SCIENCE L T P C
3 2 0 4

OBJECTIVES:

- Able to apply fundamental algorithmic ideas to process data.
- Learn to apply hypotheses and data into actionable predictions.
- Document and transfer the results and effectively communicate the findings using visualization techniques**.**

UNIT I INTRODUCTION TO DATA SCIENCE 12

Data science process – roles, stages in data science project – working with data from files – working with relational databases – exploring data – managing data – cleaning and sampling for modeling and validation – introduction to NoSQL.

UNIT II MODELING METHODS 12

Choosing and evaluating models – mapping problems to machine learning, evaluating clustering
models, validating models – cluster analysis – K-means algorithm, Naïve Bayes – Memorization
Methods – Linear and logistic regression – unsupervised methods.

UNIT III INTRODUCTION TO R 12

Reading and getting data into R – ordered and unordered factors – arrays and matrices – lists and data frames – reading data from files – probability distributions – statistical models in R -manipulating objects – data distribution.

UNIT IV MAP REDUCE 12

Introduction – distributed file system – algorithms using map reduce, Matrix-Vector Multiplication by Map Reduce – Hadoop - Understanding the Map Reduce architecture - Writing Hadoop MapReduce Programs - Loading data into HDFS - Executing the Map phase - Shuffling and sorting - Reducing phase execution.

UNIT V DELIVERING RESULTS 12

Documentation and deployment – producing effective presentations – Introduction to graphical
analysis – plot() function – displaying multivariate data – matrix plots – multiple plots in one window - exporting graph - using graphics parameters. Case studies.

TOTAL : 60 PERIODS

OUTCOMES:

- Obtain, clean/process and transform data.
- Analyze and interpret data using an ethically responsible approach.
- Use appropriate models of analysis, assess the quality of input, derive insight from results, and investigate potential issues.
- Apply computing theory, languages and algorithms, as well as mathematical and statistical models, and the principles of optimization to appropriately formulate and use data analyses.
- Formulate and use appropriate models of data analysis to solve hidden solutions to business-related challenges.

REFERENCES:

1. Nina Zumel, John Mount, “Practical Data Science with R”, Manning Publications, 2014.
2. Mark Gardener, “Beginning R - The Statistical Pr ogramming Language”, John Wiley & Sons, Inc., 2012.
3. W. N. Venables, D. M. Smith and the R Core Team, “An Introduction to R”, 2013.
4. Tony Ojeda, Sean Patrick Murphy, Benjamin Bengfort, Abhijit Dasgupta, “Practical Data Science Cookbook”, Packt Publishing Ltd., 2014.
5. Nathan Yau, “Visualize This: The FlowingData Guide to Design, Visualization, and Statistics”, Wiley, 2011.

6. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, “Professional Hadoop Solutions”,
7. Wiley, ISBN: 9788126551071, 2015.
8. http://www.johndcook.com/R_language_for_programmers.html
9. http://bigdatauniversity.com/
10. http://home.ubalt.edu/ntsbarsh/stat-data/topics.htm#rintroduction

CO-PO MAPPING:															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1					3			1	3		
CO2	3	3	3	2					1		1	2		3	
CO3	3	3	3	2		1			1			3	3		3
CO4	3	3	3	3	2	2			2	1	1	3	1	2	1
CO5	3	3	3	3	2	1			2	1	1	3	2	1	

BD5102 BIG DATA MINING AND ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the computational approaches to Modeling, Feature Extraction
- To understand the need and application of Map Reduce
- To understand the various search algorithms applicable to Big Data
- To analyse and interpret streaming data
- To learn how to handle large data sets in main memory
- To learn the various clustering techniques applicable to Big Data

UNIT I DATA MINING AND LARGE SCALE FILES 9

Introduction to Statistical modeling – Machine Learning – Computational approaches to modeling – Summarization – Feature Extraction – Statistical Limits on Data Mining - Distributed File Systems – Map-reduce – Algorithms using Map Reduce – Efficiency of Cluster Computing Techniques.

UNIT II SIMILARITY DETECTION 9

Nearest Neighbor Search – Shingling of Documents – Similarity preserving summaries – Locality sensitive hashing for documents – Distance Measures – Theory of Locality Sensitive Functions – LSH Families – Methods for High Degree of Similarities.

UNIT III MINING DATA STREAMS 9

Stream Data Model – Sampling Data in the Stream – Filtering Streams – Counting Distance Elements in a Stream – Estimating Moments – Counting Ones in Window – Decaying Windows

UNIT IV LINK ANALYSIS AND FREQUENT ITEMSETS 9

Page Rank –Efficient Computation - Topic Sensitive Page Rank – Link Spam – Market Basket Model – A-priori algorithm – Handling Larger Datasets in Main Memory – Limited Pass Algorithm – Counting Frequent Item sets.

UNIT V CLUSTERING 9

Introduction to Clustering Techniques – Hierarchical Clustering –Algorithms – K-Means – CURE – Clustering in Non – Euclidean Spaces – Streams and Parallelism – Case Study: Advertising on the Web – Recommendation Systems

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students will be able to

- Design algorithms by employing Map Reduce technique for solving Big Data problems
- Design algorithms for Big Data by deciding on the apt Features set
- Design algorithms for handling petabytes of datasets
- Design algorithms and propose solutions for Big Data by optimizing main memory consumption
- Design solutions for problems in Big Data by suggesting appropriate clustering techniques.

REFERENCES:

1. Jure Leskovec, AnandRajaraman, Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, Second Edition, 2014.
2. Jiawei Han, MichelineKamber, Jian Pei, "Data Mining Concepts and Techniques", Morgan Kaufman Publications, Third Edition, 2011.
3. Ian H.Witten, Eibe Frank "Data Mining – Practical Machine Learning Tools and Techniques", Morgan Kaufman Publications, Third Edition, 2011.
4. David Hand, HeikkiMannila and Padhraic Smyth, "Principles of Data Mining", MIT PRESS, 2001

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	1	2	2		1	1	2	2	2	2	2
CO2	3	3	3	2	1	2	2		1	1	2	2	2	2	2
CO3	3	3	3	2	2	2	1		1	1	2	3	3	2	2
CO4	3	3	3	3	2	2	1		2	2	2	3	3	3	3
CO5	3	3	3	3	2	2	2		2	2	2	3	3	3	3

CP5152 ADVANCED COMPUTER ARCHITECTURE L T P C
3 0 0 3

OBJECTIVES:

- To introduce the students to the recent trends in the field of Computer Architecture and identify performance related parameters.
- To learn the different multiprocessor issues.
- To expose the different types of multicore architectures.
- To understand the design of the memory hierarchy.

UNIT I FUNDAMENTALS OF COMPUTER DESIGN AND ILP 9

Fundamentals of Computer Design – Measuring and Reporting Performance – Instruction Level Parallelism and its Exploitation – Concepts and Challenges –Exposing ILP - Advanced Branch Prediction - Dynamic Scheduling - Hardware-Based Speculation - Exploiting ILP - Instruction Delivery and Speculation - Limitations of ILP - Multithreading

UNIT II MEMORY HIERARCHY DESIGN 9

Introduction – Optimizations of Cache Performance – Memory Technology and Optimizations – Protection: Virtual Memory and Virtual Machines – Design of Memory Hierarchies – Case Studies.

UNIT III MULTIPROCESSOR ISSUES 9

Introduction- Centralized, Symmetric and Distributed Shared Memory Architectures –Cache Coherence Issues – Performance Issues – Synchronization – Models of Memory Consistency – Case Study-Interconnection Networks – Buses, Crossbar and Multi-stage Interconnection Networks

UNIT IV MULTICORE ARCHITECTURES 9

Homogeneous and Heterogeneous Multi-core Architectures – Intel Multicore Architectures – SUN CMP architecture – IBM Cell Architecture. Introduction to Warehouse-scale computers-Architectures- Physical Infrastructure and Costs- Cloud Computing –Case Study- Google Warehouse-Scale Computer.

UNIT V VECTOR, SIMD AND GPU ARCHITECTURES 9

Introduction-Vector Architecture – SIMD Extensions for Multimedia – Graphics Processing Units – Case Studies – GPGPU Computing – Detecting and Enhancing Loop Level Parallelism-Case Studies.

TOTAL :45 PERIODS

OUTCOMES:

Upon completion of this course, the students should be able to:

- Identify the limitations of ILP.
- Discuss the issues related to multiprocessing and suggest solutions
- Point out the salient features of different multicore architectures and how they exploit parallelism.
- Discuss the various techniques used for optimising the cache performance
- Design hierarchal memory system
- Point out how data level parallelism is exploited in architectures

REFERENCES:

1. Darryl Gove, “Multicore Application Programming: For Windows, Linux, and Oracle Solaris”, Pearson, 2011
2. David B. Kirk, Wen-mei W. Hwu, “Programming Massively Parallel Processors”, Morgan Kauffman, 2010
3. David E. Culler, Jaswinder Pal Singh, “Parallel computing architecture : A hardware/software approach” , Morgan Kaufmann /Elsevier Publishers, 1999
4. John L. Hennessey and David A. Patterson, “Computer Architecture – A Quantitative Approach”, Morgan Kaufmann / Elsevier, 5th edition, 2012.
5. Kai Hwang and Zhi.Wei Xu, “Scalable Parallel Computing”, Tata McGraw Hill, NewDelhi, 2003

CO-PO MAPPING:															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	2	-	-	-	-	-	-	1	-	2	1	2
CO2	2	2	2	1	-	-	-	-	-	-	-	-	1	2	1
CO3	1	3	3	2	-	-	-	-	-	-	1	2	3	2	1
CO4	2	1	3	2	-	-	-	-	-	2	-	2	1	1	2
CO5	3	3	3	3	-	-	-	-	-	1	-	3	2	3	2

BD5103 **DISTRIBUTED COMPUTING** **L T P C**
3 0 0 3

UNIT I **9**

Fundamentals: Introduction to distributed computing system, Evolution, Differentmodels, Gaining popularity, Definition, Issues in design, DCE, Message passing-Introduction, Desirable features of a good message passing system, Issues in IPC, Synchronization, Buffering, Multidatagram, Process addressing, Failure handling, Group communication.

UNIT II **9**

RPC: Introduction, RPC model, transparency of RPC, Implementing RPC mechanism, Stub generation, RPC messages, Marshalling arguments and results, Sever management, parameter-passing semantics, Call semantics, Communication protocols for RPCs, Complicated RPC, Client-server binding, exceptional handling, security, special types of RPC, RPC in heterogeneous environments, Lightweight RPC, Optimization for better performance ,Case studies-Sun RPC,DCE,RPC.

UNIT III **9**

Distributed Shared Memory and Synchronization: Introduction, General architecture of DSM systems, Design and implementation issues of DSM, Granularity, Structure of shared memory space, Consistency model, Replacement strategy, Thrashing, Different approaches to DSM, Advantages of DSM, Clock synchronization, Event ordering, Mutual exclusion, Deadlock, Election algorithm.

UNIT IV **9**

Resource and Process Management: Introduction, Desirable features of a good global scheduling algorithm, Task assignment approach, Load-balancing approach, Load sharing approach, Process migration, Threads.

UNIT V **9**

DFS and Security: Desirable features of good DFS, File models, File accessing, models, File sharing semantics, File caching schemes, File replication, Fault tolerance, Atomic Transaction, Design principles, Case Study: DCE DFS, Potential attacks to computer system, Cryptography, Authentication, Access control, Digital signatures, Design principles, DCE security service.

REFERENCE S:

1. PRADEEP K. SINHA Distributed Operating System - PHI.
2. ANDREW S. TENENBAUM, Modern Operating System - 2nd Edition, PHI, 1991

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	1	1	2	1			2	3		1	2		2
CO2	3	2	2	1	3	1		2	2	2		2	2		2
CO3	3	3	2	1	3	1	1	2	2	3	1	2	1	1	2
CO4	3	3	1	1	2	1	1		2	2	1	2	1	1	2
CO5	3	2	1	1	2	1	1	1	2	2	1	2	2	1	3

CP5161 **DATA STRUCTURES LABORATORY** **L T P C**
0 0 4 2

OBJECTIVES:

- To acquire the knowledge of using advanced tree structures.
- To learn the usage of heap structures.
- To understand the usage of graph structures and spanning trees.

LIST OF EXPERIMENTS:

Each student has to work individually on assigned lab exercises. Lab sessions could be scheduled as one contiguous four-hour session per week or two two-hour sessions per week. There will be about 15 exercises in a semester. It is recommended that all implementations are carried out in Java. If C or C++ has to be used, then the threads library will be required for concurrency. Exercises should be designed to cover the following topics:

EXPERIMENTS:

1. Implementation of Merge Sort and Quick Sort-Analysis
2. Implementation of a Binary Search Tree
3. Red-Black Tree Implementation
4. Heap Implementation
5. Fibonacci Heap Implementation
6. Graph Traversals
7. Spanning Tree Implementation
8. Shortest Path Algorithms (Dijkstra's algorithm, Bellmann Ford Algorithm)
9. Implementation of Matrix Chain Multiplication
10. Activity Selection and Huffman Coding Implementation.

TOTAL: 60 PERIODS

OUTCOMES:

Upon Completion of this course, the students will be able to:

- Design and implement basic and advanced data structures extensively.
- Design algorithms using graph structures
- Design and develop efficient algorithms with minimum complexity using design techniques.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	1	1	1			1	1	1	1	1		1
CO2	3	2	2	3	1				2	2	1	1	2	1	1
CO3	3	3	3	3	3	2	2	1	2	2	2	2	1	1	
CO4	3	2	3	3	2	1	1	1	2	2	1	1			1
CO5	2	2	3	3	2	1	1	1	1	1	2	1	1		1

BD5111 **BIG DATA COMPUTING LAB** **L T P C**
0 0 4 2

OBJECTIVES

- To understand setting up of Hadoop Cluster
- To solve problems using Map Reduce Technique

- To solve Big Data problems

LIST OF EXERCISES

1. Set up a pseudo-distributed, single-node Hadoop cluster backed by the Hadoop Distributed
   File System, running on Ubuntu Linux. After successful installation on one node, configuration of a multi-node Hadoop cluster(one master and multiple slaves).
2. MapReduce application for word counting on Hadoop cluster
3. Unstructured data into NoSQL data and do all operations such as NoSQL query with API.
4. K-means clustering using map reduce
5. Page Rank Computation
6. Mahout machine learning library to facilitate the knowledge build up in big data analysis.
7. Application of Recommendation Systems using Hadoop/mahout libraries

TOTAL:60 PERIODS

OUTCOMES

Set up multi-node Hadoop Clusters

- Apply Map Reduce algorithms for various algorithms
- Design new algorithms that uses Map Reduce to apply on Unstructured and structured data

CO-PO MAPPING:															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	2		2			2			
CO2	3	3	3	2	3	2	2		2			2			
CO3															
CO4															
CO5															

CP5191 MACHINE LEARNING TECHNIQUES L T P C

3 0 0 3

OBJECTIVES:

- To introduce students to the basic concepts and techniques of Machine Learning.
- To have a thorough understanding of the Supervised and Unsupervised learning techniques
- To study the various probability based learning techniques
- To understand graphical models of machine learning algorithms

UNIT I INTRODUCTION 9

Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Concept Learning as Search – Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm – Linear Discriminants – Perceptron – Linear Separability – Linear Regression.

UNIT II LINEAR MODELS 9

Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multi-layer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back-

Propagation – Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions – Support Vector Machines.

UNIT III TREE AND PROBABILISTIC MODELS 9

Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbor Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map

UNIT IV DIMENSIONALITY REDUCTION AND EVOLUTIONARY MODELS 9

Dimensionality Reduction – Linear Discriminant Analysis – Principal Component Analysis – Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic Offspring: - Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process

UNIT V GRAPHICAL MODELS 9

Markov Chain Monte Carlo Methods – Sampling – Proposal Distribution – Markov Chain Monte Carlo – Graphical Models – Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods

TOTAL: 45 PERIODS

OUT COMES:

Upon completion of this course, the students will be able to:

- Distinguish between, supervised, unsupervised and semi-supervised learning
- Apply the appropriate machine learning strategy for any given problem
- Suggest supervised, unsupervised or semi-supervised learning algorithms for any given problem
- Design systems that uses the appropriate graph models of machine learning
- Modify existing machine learning algorithms to improve classification efficiency

REFERENCES:

1 Ethem Alpaydin, “Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series)”, Third Edition, MIT Press, 2014

2 Jason Bell, “Machine learning – Hands on for Developers and Technical Professionals”, First Edition, Wiley, 2014

3 Peter Flach, “Machine Learning: The Art and Science of Algorithms that Make Sense of Data”, First Edition, Cambridge University Press, 2012.

4 Stephen Marsland, “Machine Learning – An Algorithmic Perspective”, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.

5 Tom M Mitchell, “Machine Learning”, First Edition, McGraw Hill Education, 2013.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	1								1	1		2
CO2	3	3	3	2					1		1	2	1		2

CO3	3	3	3	2		1			1			3	1	3	2
CO4	3	3	3	3	2	2			2	1	1	3	1	3	3
CO5	3	3	3	3	2	1			2	1	1	3	1	3	3

CP5292 INTERNET OF THINGS L T P C
3 0 0 3

OBJECTIVES:

- To understand the fundamentals of Internet of Things
- To learn about the basics of IOT protocols
- To build a small low cost embedded system using Raspberry Pi.
- To apply the concept of Internet of Things in the real world scenario.

UNIT I INTRODUCTION TO IoT 9

Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies - IoT Levels & Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management with NETCONF-YANG- IoT Platforms Design Methodology

UNIT II IoT ARCHITECTURE 9

M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture

UNIT III IoT PROTOCOLS 9

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus– Zigbee Architecture – Network layer – 6LowPAN - CoAP - Security

UNIT IV BUILDING IoT WITH RASPBERRY PI & ARDUINO 9

Building IOT with RASPERRY PI- IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints - IoT Device -Building blocks -Raspberry Pi -Board - Linux on Raspberry Pi - Raspberry Pi Interfaces -Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.

UNIT V CASE STUDIES AND REAL-WORLD APPLICATIONS 9

Real world design constraints - Applications - Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT – Software & Management Tools for IoT Cloud Storage Models & Communication APIs - Cloud for IoT - Amazon Web Services for IoT.

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of this course, the students should be able to:

- Analyze various protocols for IoT
- Develop web services to access/control IoT devices.
- Design a portable IoT using Rasperry Pi
- Deploy an IoT application and connect to the cloud.
- Analyze applications of IoT in real time scenario

REFERENCES:

1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015

2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), “Architecting the Internet of Things”, Springer, 2011.
3. Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRC Press, 2012.
4. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
5. Olivier Hersent, David Boswarthick, Omar Elloumi , “The Internet of Things – Key applications and Protocols”, Wiley, 2012

CO-PO MAPPING:															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	-	2	1	1	3	2	3	3	3	2
CO2	3	3	2	2	3	2	2	2	2	3	2	2	2	2	3
CO3	3	3	3	2	3	2	3	2	2	3	2	2	3	2	2
CO4	3	3	3	2	3	2	2	2	3	3	2	2	3	2	2
CO5	3	3	3	3	3	3	2	2	3	3	2	3	3	3	3

IF5191 ADVANCED DATABASES L T P C

3 0 0 3

OBJECTIVES:

- To understand the design of databases.
- To acquire knowledge on parallel and distributed databases and its applications.
- To study the usage and applications of Object Oriented and Intelligent databases.
- To understand the emerging databases like Mobile, XML, Cloud and Big Data

UNIT I PARALLEL AND DISTRIBUTED DATABASES 9

Database System Architectures: Centralized and Client-Server Architectures – Server System Architectures – Parallel Systems- Distributed Systems – Parallel Databases: I/O Parallelism – Inter and Intra Query Parallelism – Inter and Intra operation Parallelism – Design of Parallel Systems Distributed Database Concepts - Distributed Data Storage – Distributed Transactions – Commit Protocols – Concurrency Control – Distributed Query Processing – Case Studies

UNIT II INTELLIGENT DATABASES 9

Active Databases: Syntax and Semantics (Starburst, Oracle, DB2)- Taxonomy- Applications- Design Principles for Active Rules- Temporal Databases: Overview of Temporal Databases TSQL2- Deductive Databases-Recursive Queries in SQL- Spatial Databases- Spatial Data Types - Spatial Relationships- Spatial Data Structures-Spatial Access Methods- Spatial DB Implementation.

UNIT III XML DATABASES 9

XML Databases: XML Data Model – DTD – XML Schema – XML Querying – Web Databases – Open Database Connectivity.

UNIT IV MOBILE DATABASES 9

Mobile Databases: Location and Handoff Management - Effect of Mobility on Data

Management - Location Dependent Data Distribution - Mobile Transaction Models - Concurrency Control - Transaction Commit Protocols

UNIT V MULTIMEDIA DATABASES 9

Multidimensional Data Structures – Image Databases – Text / Document Databases – Video Databases – Audio Databases – Multimedia Database Design.

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of this course, a students should be able:

- To develop skills on databases to optimize their performance in practice.
- To analyze each type of databases and its necessity
- To design faster algorithms in solving practical database problems

REFERENCES:

1. C.J.Date, A.Kannan, S.Swamynathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2006.
2. Carlo Zaniolo, Stefano Ceri, Christos Faloutsos, Richard T.Snodgrass, V.S.Subrahmanian, Roberto Zicari, "Advanced Database Systems", Morgan Kaufmann publishers,2006.
3. Henry F Korth, Abraham Silberschatz, S. Sudharshan, "Database System Concepts", Sixth Edition, McGraw Hill, 2011.
4. R. Elmasri, S.B. Navathe, "Fundamentals of Database Systems", Sixth Edition, Pearson Education/Addison Wesley, 2010.
5. Vijay Kumar, "Mobile Database Systems", John Wiley & Sons, 2006.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1								1	1		1
CO2	2	3	3	2					1		1	2	1		
CO3	3	2	3	2		1	2		3			2	1		1
CO4	2	3	3	3	2	2	1		2	1	1	2		1	
CO5	1	2	3	3	2	1	3		2	2	1	3			

CP5092 CLOUD COMPUTING TECHNOLOGIES L T P C

3 0 0 3

OBJECTIVES:

- To understand the concepts of virtualization and virtual machines
- To gain expertise in server, network and storage virtualization.
- To understand and deploy practical virtualization solutions and enterprise solutions
- To gain knowledge on the concept of virtualization that is fundamental to cloud computing
- To understand the various issues in cloud computing
- To be able to set up a private cloud

- To understand the security issues in the grid and the cloud environment

UNIT I VIRTUALIZATION 9

Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines –Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization

UNIT II VIRTUALIZATION INFRASTRUCTURE 9

Comprehensive Analysis – Resource Pool – Testing Environment –Server Virtualization – Virtual Workloads – Provision Virtual Machines – Desktop Virtualization – Application Virtualization - Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation.

UNIT III CLOUD PLATFORM ARCHITECTURE 9

Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software- A Generic Cloud Architecture Design – Layered cloud Architectural Development – Virtualization Support and Disaster Recovery – Architectural Design Challenges - Public Cloud Platforms : GAE,AWS – Inter-cloud Resource Management

UNIT IV PROGRAMMING MODEL 9

Introduction to Hadoop Framework - Mapreduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster - Cloud Software Environments - Eucalyptus, Open Nebula, Open Stack, Nimbus

UNIT V CLOUD SECURITY 9

Cloud Infrastructure security: network, host and application level – aspects of data security, provider data and its security, Identity and access management architecture, IAM practices in the cloud, SaaS, PaaS, IaaS availability in the cloud - Key privacy issues in the cloud –Cloud Security and Trust Management

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of this course, the students should be able to:

- Employ the concepts of storage virtualization, network virtualization and its management
- Apply the concept of virtualization in the cloud computing
- Identify the architecture, infrastructure and delivery models of cloud computing
- Develop services using Cloud computing
- Apply the security models in the cloud environment

REFERENCES:

1. Danielle Ruest, Nelson Ruest, “Virtualization: A Beginner"s Guide”, McGraw-Hill Osborne Media, 2009.
2. Jim Smith, Ravi Nair , "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005
3. John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation,

Management, and Security", CRC Press, 2010.

4. Kai Hwang, Geoffrey C Fox, Jack G Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers, 2012.
5. Tim Mather, Subra Kumaraswamy, and Shahed Latif ,"Cloud Security and Privacy", O'Reilly Media, Inc.,2009.
6. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.
7. Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	1	1	1	3	2	-	-	-	2	2	2	2	1
CO2	2	2	1	1	1	3	2	-	-	-	2	2	2	2	-
CO3	2	2	-	-	-	3	-	-	-	-	1	1	2	1	2
CO4	2	2	-	-	-	1	-	-	-	-	-	-	1	2	2
CO5	2	2	1	1	1	1	1	-	-	-	1	1	1	1	1

BD5201 BIG DATA SECURITY L T P C
3 0 0 3

OBJECTIVES:

- To understand the significance of privacy, ethics in big data environment
- Analyzing the steps to secure big data
- To integrate the big data analytics in to the enterprise and its eco system
- To understand the security concerns of big-data.

UNIT I INTRODUCTION TO BIG DATA 9

Arrival of analytics - Big Data Reaches Deep - Obstacles Remain - Data Continue to Evolve - Realizing Value - The Case for Big Data - The Rise of Big Data Options - Beyond Hadoop - Big Data Sources Growing

UNIT II SECURITY, COMPLIANCE, AUDITING & PROTECTION 9

Pragmatic Steps to Securing Big Data - Classifying Data - Protecting Big Data Analytics - Big Data and Compliance - The Intellectual Property Challenge - Big Data: The Modern Era - Today, Tomorrow, and the Next Day - Changing Algorithms

UNIT III INTEGRATING BIG DATA ANALYTICS INTO THE ENTERPRISE 9

The Strategic Plan for Technology Adoption - Standardize Practices for Soliciting Business User Expectations - Acceptability for Adoption: Clarify Go/No-Go Criteria - Prepare the Data Environment for Massive Scalability - Promote Data Reuse - Institute Proper Levels of Oversight and Governance - Provide a Governed Process for Mainstreaming Technology-Considerations for Enterprise Integration

UNIT IV SECURITY ANALYTICS I 9

Introduction to Security Analytics – Techniques in Analytics – Analysis in everyday life – Challenges in Intrusion and Incident Identification – Analysis of Log file – Simulation and Security Process.

UNIT V SECURITY ANALYTICS II 9

Access Analytics – Security Analysis with Text Mining – Security Intelligence – Security Breaches

TOTAL: 45 PERIODS

OUTCOMES

- Design algorithms in a secure manner for Big data applications
- Use available security practices in big-data analytics.

REFERENCES :

1. Frank Ohlhorst John Wiley & Sons, “Big Data Analytics: Turning Big Data into Big Money”, John Wiley & Sons, 2013.
2. Mark Talabis, Robert McPherson, I Miyamoto and Jason Martin, “Information Security Analytics: Finding Security Insights, Patterns, and Anomalies in Big Data”, Syngress Media, U.S., 2014
3. David Loshin, "Big data analytics: From Strategic planning to enterprise integration with tools, techniques, NoSQL, and Graph, Elsevier,2013.
4. Behrouz A. Forouzan, “Cryptography and Network Security”, Tata McGraw Hill Education, 2nd Edition, 2010.
5. Douglas R. Stinson ,“Cryptography Theory and Practice ”, Chapman & Hall/CRC, 3rd Edition, 2006.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1		2	3	1	2	3		3	3	3		3	3		3
CO2	3	3	3	2	3	3	3	3	3	3			3	2	3
CO3	2	3	3	2	3	3	3	3	3	3			3	3	3
CO4	3	3		3	3	3	3	3	3				3	3	3
CO5		3	3	3	3		3	3	3				3	2	3

IF5161 **DATABASES LABORATORY** **L T P C**

0 0 4 2

OBJECTIVES:

The student should be able:

- To understand the concepts of DBMS.
- To familiarize with SQL queries.
- To write stored procedures in DBMS.
- To learn front end tools to integrate with databases.

EXPERIMENTS IN THE FOLLOWING TOPICS:

1. Data Definition, Manipulation of Tables and Views, Database Querying – Simple queries, Nested queries, Sub queries and Joins.
2. Triggers, Transaction Control.
3. Embedded SQL, Database Connectivity with Front End Tools High level language extensions - PL/SQL Basics, Procedures and Functions.
4. Active Databases, Deductive Databases.

5. Distributed and Parallel Transactions and Query Processing.
6. Mobile Database Query Processing.
7. Object Oriented Database Design.
8. Multimedia Database for Image and Video Processing.
9. Spatial and Temporal Databases.
10. XML Databases and No SQL Database Storage and Retrieval.

TOTAL: 60 PERIODS

OUTCOMES :

Upon completion of this course, the student should be able to:

- Design and Implement databases.
- Formulate complex queries using SQL.
- Design and Implement applications that have GUI and access databases for backend connectivity

CO-PO MAPPING:															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO2	3	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO3	3	2	2	-	-	-	-	-	-	-	-	-	2	2	-
CO4	3	2	2	-	-	-	-	-	-	-	-	-	3	2	-
CO5	3	2	2	-	-	-	-	-	-	-	-	-	2	2	-

CP5281 TERM PAPERWRITING AND SEMINAR L T P C

0 0 2 1

In this course, students will develop the scientific and technical reading and writing skills they need to understand and construct research articles. A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books) and then place it in logically developed ideas. The work involves the following steps:

1. Selecting a subject, narrowing the subject into a topic
2. Stating an objective.
3. Collecting the relevant bibliography (atleast 15 journal papers)
4. Preparing a working outline.
5. Studying the papers and understanding the authors contributions and critically analysing each paper.
6. Preparing a working outline
7. Linking the papers and preparing a draft of the paper.
8. Preparing conclusions based on the reading of all the papers.
9. Writing the Final Paper and giving final Presentation

Please keep a file where the work carried out by you is maintained.

Activities to be carried Out

Activity	Instructions	Submission week	Evaluation
Selection of area of interest and Topic Stating an Objective	You are requested to select an area of interest, topic and state an objective	2nd week	**3 %** Based on clarity of thought, current relevance and clarity in writing
Collecting Information about your area & topic	1. List 1 Special Interest Groups or professional society 2. List 2 journals 3. List 2 conferences, symposia or workshops 4. List 1 thesis title 5. List 3 web presences (mailing lists, forums, news sites) 6. List 3 authors who publish regularly in your area 7. Attach a call for papers (CFP) from your area.	3rd week	**3%** (the selected information must be area specific and of international and national standard)

Collection of Journal papers in the topic in the context of the objective – collect 20 & then filter	• You have to provide a complete list of references you will be using- Based on your objective -Search various digital libraries and Google Scholar
	• When picking papers to read - try to:
	  • Pick papers that are related to each other in some ways and/or that are in the same field so that you can write a meaningful survey out of them,
	  • Favour papers from well-known journals and conferences,
	  • Favour "first" or "foundational" papers in the field (as indicated in other people's survey paper),
	  • Favour more recent papers,
	  • Pick a recent survey of the field so you can quickly gain an overview,
	  • Find relationships with respect to each other and to your topic area (classification scheme/categorization)
	• Mark in the hard copy of papers whether complete work or section/sections of the paper are being considered
		4th week	**6%**
			
			(the list of standard papers and reason for selection)

Reading and notes for first 5 papers	Reading Paper Process
	• For each paper form a Table answering the following questions:
	  • What is the main topic of the article?
	  • What was/were the main issue(s) the author said they want to discuss?
	  • Why did the author claim it was important?
	  • How does the work build on other's work, in the author's opinion?
	  • What simplifying assumptions does the author claim to be making?
	  • What did the author do?
	  • How did the author claim they were going to evaluate their work and compare it to others?
	  • What did the author say were the limitations of their research?
	  • What did the author say were the important directions for future research?
	Conclude with limitations/issues not addressed by the paper (from the perspective of your survey)
		5th week	**8%**
			(the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)

Reading and notes for next5 papers	Repeat Reading Paper Process	6th week	**8%** (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)

Reading and notes for final 5 papers	Repeat Reading Paper Process	7th week	**8%** (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Draft outline 1 and Linking papers	Prepare a draft Outline, your survey goals, along with a classification / categorization diagram	8th week	**8%** (this component will be evaluated based on the linking and classification among the papers)
Abstract	Prepare a draft abstract and give a presentation	9th week	**6%** (Clarity, purpose and conclusion) **6%** Presentation & Viva Voce
Introduction Background	Write an introduction and background sections	10th week	**5%** (clarity)
Sections of the paper	Write the sections of your paper based on the classification / categorization diagram in keeping with the goals of your survey	11thweek	**10%** (this component will be evaluated based on the linking and classification among the papers)
Your conclusions	Write your conclusions and future work	12th week	**5%** (conclusions – clarity and your ideas)
Final Draft	Complete the final draft of your paper	13th week	**10%** (formatting, English, Clarity and linking) **4%** Plagiarism Check Report
Seminar	A brief 15 slides on your paper	14th & 15th week	**10%** (based on presentation and Viva-voce)

TOTAL : 30 PERIODS

ELECTIVES

BD5001 HIGH PERFORMANCE COMPUTING FOR BIG DATA L T P C
3 0 0 3

OBJECTIVES:

- To learn the fundamental concepts of High Performance Computing.
- To learn the network & software infrastructure for high performance computing.
- To understand the real time analytics using high performance computing.
- To learn the different ways of security perspectives and technologies used in HPC.
- To understand the emerging big data applications.

UNIT I INTRODUCTION 9

The Emerging IT Trends- IOT/IOE-Apache Hadoop for big data analytics-Big data into big insights and actions – Emergence of BDA discipline – strategic implications of big data – BDA Challenges – HPC paradigms – Cluster computing – Grid Computing – Cloud computing – Heterogeneous computing – Mainframes for HPC - Super computing for BDA – Appliances for BDA.

UNIT II NETWORK & SOFTWARE INFRASTRUCTURE FOR HIGH PERFORMANCE BDA 9

Design of Network Infrastructure for high performance BDA – Network Virtualization – Software Defined Networking – Network Functions Virtualization – WAN optimization for transfer of big data – started with SANs- storage infrastructure requirements for storing big data – FC SAN – IP SAN – NAS – GFS – Panasas – Luster file system – Introduction to cloud storage.

UNIT III REAL TIME ANALYTICS USING HIGH PERFORMANCE COMPUTING 9

Technologies that support Real time analytics – MOA: Massive online analysis – GPFS: General parallel file system – Client case studies – Key distinctions – Machine data analytics – operational analytics – HPC Architecture models – In Database analytics – In memory analytics.

UNIT IV SECURITY AND TECHNOLOGIES 9

Security, Privacy and trust for user – generated content: The challenges and solutions – Role of real time big data processing in the IOT's – End to end security framework for big sensing data streams – clustering in big data.

UNIT V EMERGING BIG DATA APPLICATIONS 9

Deep learning Accelerators – Accelerators for clustering applications in machine learning - Accelerators for classification algorithms in machine learning – Accelerators for Big data Genome Sequencing.

TOTAL: 45 PERIODS

OUTCOMES:

- Understand the basics concepts of high performance computing systems.

- Apply the concepts of network and software infrastructure for high performance computing.
- Use the real time analytics using high performance computing.
- Apply the security models and big data applications in high performance computing.

REFERENCES:

1. High-Performance Big-Data Analytics: Computing Systems and Approaches, 2015 Edition, Springer.
2. Big Data Management and Processing, Kuan-Ching Li , Hai Jiang, Albert Y. Zomaya, CRC Press.
3. High Performance Computing for Big Data: Methodologies and Applications, Chao wang ,CRC Press.
4. High-performance data mining and big data analytics, Khosrow Hassibi, CreateSpace Independent Publishing Platform.
5. High performance computing: Modern systems and practices , Thomas Sterling, Matthew Anderson, Morgan Kaufmann publishers.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	3	2		2					3	3	
CO2	3	3	3	2	2	2	2	1					3	3	
CO3	3	2	3	3	2	1	1	1					3	3	
CO4	3	3	3	3	2	1	1	1					3	3	
CO5	3	2	3	3	2	1	1	1					3	3	

SE5091 **SERVICE ORIENTED ARCHITECTURE AND DESIGN** **L T P C 3 0 0 3**

OBJECTIVES

- To understand the SOA architecture
- To understand the service oriented analysis and design
- To understand the development of deployment of web services
- To understand the security issues of SOA

UNIT I SOA FUNDAMENTALS **9**

Principles of Service Orientation - Client-Server Architecture - Distributed Internet Architecture - SOA Characteristics - Anatomy of SOA - Components - Interaction - Technical and Business Benefits - Multi-channel access - Business Process Management

UNIT II SOA AND WEB SERVICES **9**

Web Service Platform - Web Service Description - Service Contracts - Service Level Data Model - Service Discovery - Service Level Security - Service Level Interaction Patterns: SOAP basics - Messaging with SOAP - Message Exchange Patterns - Web WSDL basics, Writing a Java Web Service, writing a Java Web Service Client ,Describing Web Services: WSDL, Representing Data Types - XML Schema, Communicating Object Data, SOAP Related Technologies

UNIT III SERVICE ORIENTED ANALYSIS AND DESIGN **9**

Design principles - Business Centric SOA - Deriving Business services - Service Modeling - Coordination - Atomic Transaction - Business activities - Web Service Orchestration Business Process Execution Language (BPEL) - Choreography - Metadata Management- Entity centric business service design - Application Service design - Task centric business service design

UNIT IV WEB SERVICES DEVELOPMENT AND DEPLOYMENT **9**

XML and Web Services - WSDL basics - 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) - Web Services Interoperability Technologies - SOA support in .NET - Common Language Runtime - ASP.NET - Web forms - ASP.NET Web Services - Web Services Enhancements

UNIT V SOA APPLICATIONS AND SECURITY **9**

Security Overview: e-commerce based security (public key cryptography) – Public key encryption – Security issues in XML document – SOAP security issue – XML Security framework: XML Digital Signature (Enveloped, enveloping and detached) – Signature validation - XML Encryption – Types – Canonicalization - XML Key management.

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of this course, the student should be able to

- Develop and deploy simple and composite web services with SOA design principles considering the security issues
- Use the standards and technologies of modern web service implementations
- Efficiently use leading development tools to create and consume web services
- Implement a service oriented application

REFERENCES:

1. Eric Newcomer, Greg Lomow, “Understanding SOA with Web Services”, Pearson Education, 2004.
2. Frank Cohen, “Fast SOA”, Morgan Kaufmann, 2010.
3. Mark O’ Neill, “Web Services Security”, Tata McGraw-Hill Edition, 2003.
4. Sandeep Chatterjee, James Webber, “Developing Enterprise Web Services”, Pearson Education, 2003.
5. Shankar Kambhampaly, “Service Oriented Architecture for Enterprise Applications”, Wiley India Pvt Ltd, 2008.
6. Thomas Erl, “Service Oriented Architecture: Concepts, Technology, and Design”, Pearson Education, 2006.

CO-PO MAPPING:	

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	-	2	3	1	2	3	-	3	3	3	-	3	3	-	-
CO2	3	3	3	2	3	3	3	3	3	3	-	-	3	2	3
CO3	2	3	3	2	3	3	3	3	3	3	-	-	3	3	3
CO4	3	3	-	3	3	3	3	3	3	-	-	-	3	3	3
CO5	-	3	3	3	3	-	3	3	3	-	-	3	3	2	3

CP5094 INFORMATION RETRIEVAL TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To understand the basics of information retrieval with pertinence to modeling, query operations and indexing
- To get an understanding of machine learning techniques for text classification and clustering.
- To understand the various applications of information retrieval giving emphasis to multimedia IR, web search
- To understand the concepts of digital libraries

UNIT I INTRODUCTION: MOTIVATION 9

Basic Concepts – Practical Issues - Retrieval Process – Architecture - Boolean Retrieval – Retrieval Evaluation – Open Source IR Systems–History of Web Search – Web Characteristics–The impact of the web on IR —IR Versus Web Search–Components of a Search engine

UNIT II MODELING 9

Taxonomy and Characterization of IR Models – Boolean Model – Vector Model - Term Weighting – Scoring and Ranking –Language Models – Set Theoretic Models - Probabilistic Models – Algebraic Models – Structured Text Retrieval Models – Models for Browsing

UNIT III INDEXING 9

Static and Dynamic Inverted Indices – Index Construction and Index Compression. Searching - Sequential Searching and Pattern Matching. Query Operations -Query Languages – Query Processing - Relevance Feedback and Query Expansion - Automatic Local and Global Analysis – Measuring Effectiveness and Efficiency

UNIT IV CLASSIFICATION AND CLUSTERING 9

Text Classification and Naïve Bayes – Vector Space Classification – Support vector machines and Machine learning on documents. Flat Clustering – Hierarchical Clustering – Matrix decompositions and latent semantic indexing – Fusion and Meta learning

UNIT V SEARCHING THE WEB 9

Searching the Web –Structure of the Web –IR and web search – Static and Dynamic Ranking – Web Crawling and Indexing – Link Analysis - XML Retrieval Multimedia IR: Models and Languages – Indexing and Searching Parallel and Distributed IR – Digital

Libraries

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of this course, the students should be able to:

- Build an Information Retrieval system using the available tools.
- Identify and design the various components of an Information Retrieval system.
- Apply machine learning techniques to text classification and clustering which is used for efficient Information Retrieval.
- Design an efficient search engine and analyze the Web content structure.

REFERENCES:

1. Christopher D. Manning, Prabhakar Raghavan, Hinrich Schutze, "Introduction to Information Retrieval", Cambridge University Press, First South Asian Edition, 2008.
2. Ricardo Baeza – Yates, Berthier Ribeiro – Neto, "Modern Information Retrieval: The concepts and Technology behind Search" (ACM Press Books), Second Edition, 2011.
3. Stefan Buttcher, Charles L. A. Clarke, Gordon V. Cormack, "Information Retrieval Implementing and Evaluating Search Engines", The MIT Press, Cambridge, Massachusetts London, England, 2010

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PS**
CO1	3	3	3	1	3	3	2		3	2	2	3	3	3	
CO2	3	3	2	1	3	2	2		3	2	2	3	3	3	
CO3	3	3	3	3	3	2	2		3	1	1	2	2	3	
CO4	3	3	2	2	3	2	1		3	3	1	3	2	3	
CO5	3	3	3	3	3	2	2		3	1	1	3	2	3	

CP5009 DATA VISUALIZATION TECHNIQUES L T P C

3 0 0 3

OBJECTIVES:

- To develop skills to both design and critique visualizations.
- To introduce visual perception and core skills for visual analysis.
- To understand visualization for time-series analysis.
- To understand visualization for ranking analysis.
- To understand visualization for deviation analysis.
- To understand visualization for distribution analysis.
- To understand visualization for correlation analysis.
- To understand visualization for multivariate analysis.
- To understand issues and best practices in information dashboard design.

UNIT I CORE SKILLS FOR VISUAL ANALYSIS 9

Information visualization – effective data analysis – traits of meaningful data – visual perception –making abstract data visible – building blocks of information visualization –

analytical interaction – analytical navigation – optimal quantitative scales – reference lines and regions – trellises and crosstabs – multiple concurrent views – focus and context – details on demand – over-plotting reduction – analytical patterns – pattern examples.

UNIT II TIME-SERIES, RANKING, AND DEVIATION ANALYSIS 9

Time-series analysis – time-series patterns – time-series displays – time-series best practices – part-to-whole and ranking patterns – part-to-whole and ranking displays – best practices – deviation analysis – deviation analysis displays – deviation analysis best practices.

UNIT III DISTRIBUTION, CORRELATION, AND MULTIVARIATE ANALYSIS 9

Distribution analysis – describing distributions – distribution patterns – distribution displays – distribution analysis best practices – correlation analysis – describing correlations – correlation patterns – correlation displays – correlation analysis techniques and best practices – multivariate analysis – multivariate patterns – multivariate displays – multivariate analysis techniques and best practices.

UNIT IV INFORMATION DASHBOARD DESIGN 9

Information dashboard – Introduction– dashboard design issues and assessment of needs – Considerations for designing dashboard-visual perception – Achieving eloquence.

UNIT V INFORMATION DASHBOARD DESIGN 9

Advantages of Graphics _Library of Graphs – Designing Bullet Graphs – Designing Sparklines – Dashboard Display Media –Critical Design Practices – Putting it all together-Unveiling the dashboard.

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of the course, the students should be able to:

- Explain principles of visual perception
- Apply core skills for visual analysis
- Apply visualization techniques for various data analysis tasks
- Design information dashboard

REFERENCES:

1. Ben Fry, "Visualizing data: Exploring and explaining data with the processing environment", O'Reilly, 2008.
2. Edward R. Tufte, "The visual display of quantitative information", Second Edition, Graphics Press, 2001.
3. Evan Stubbs, "The value of business analytics: Identifying the path to profitability", Wiley, 2011.
4. Gert H. N. Laursen and Jesper Thorlund, "Business Analytics for Managers: Taking business intelligence beyond reporting", Wiley, 2010.
5. Nathan Yau, "Data Points: Visualization that means something", Wiley, 2013.
6. Stephen Few, "Information dashboard design: Displaying data for at-a-glance monitoring", second edition, Analytics Press, 2013.

7. Stephen Few, "Now you see it: Simple Visualization techniques for quantitative analysis", Analytics Press, 2009.
8. Tamara Munzner, Visualization Analysis and Design, AK Peters Visualization Series, CRC Press, Nov. 2014

CO-PO MAPPING:															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	1	2	1	3	3	1	2	1	1	2	2	1	1
CO2	2	3	1	2	1	2	3	2	3	3	2	3	1	2	2
CO3	1	2	1	2	3	2	2	2	2	2	3	3	1	2	2
CO4	1	1	3	3	3	1	1	2	3	2	2	3	1	1	2
CO5	2	2	3	3	3	1	2	2	1	2	1	1	2	2	2

SE5014 PRINCIPLES OF SUPPLY CHAIN MANAGEMENT **L T P C**
3 0 0 3

OBJECTIVES

The student should be able to

- Learn about the E-business environment driven by the Automation Software in quick movement of supply of products
- Study the fundamentals of supply chain management comprising of Inventory management and warehousing etc as co parts of entire business
- Learn the cost management for the supply of products
- Improve the overall organization performance and customer satisfaction by improving product or service delivery to consumer.

UNIT I FUNDAMENTALS OF SUPPLY CHAIN MANAGEMENT 9

Supply chain networks, Integrated supply chain planning, Decision phases in s supply chain, process view of a supply chain, supply chain flows, Overview of supply chain models and modeling systems, Supply chain planning: Strategic, operational and tactical, Understanding supply chain through process mapping and process flow chart.

UNIT II SCM STRATEGIES, PERFORMANCE 9

Supply chain strategies, achieving strategic fit, value chain, Supply chain drivers and obstacles, Strategic Alliances and Outsourcing, purchasing aspects of supply chain, Supply chain performance measurement: The balanced score card approach, Performance Metrics. Planning demand and supply: Demand forecasting in supply chain, Aggregate planning in supply chain, Predictable variability.

UNIT III PLANNING AND MANAGING INVENTORIES 9

Introduction to Supply Chain Inventory Management. Inventory theory models: Economic Order Quantity Models, Reorder Point Models and Multi echelon Inventory Systems, Relevant deterministic and stochastic inventory models and Vendor managed inventory models.

UNIT IV DISTRIBUTION MANAGEMENT 9

Role of transportation in a supply chain - direct shipment, warehousing, cross-docking; push vs. pull systems; transportation decisions (mode selection, fleet size), market channel structure, vehicle routing problem. Facilities decisions in a supply chain. Mathematical foundations of distribution management, Supply chain facility layout and capacity planning.

UNIT V STRATEGIC COST MANAGEMENT IN SUPPLY CHAIN 9

The financial impacts, Volume leveraging and cross docking, global logistics and material positioning, global supplier development, target pricing, cost management enablers, Measuring service levels in supply chains, Customer Satisfaction/Value/Profitability/Differential Advantage.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of this course, the students should be able to:

- Learn about the e- business for supply of products managed with the appropriate methodologies and management techniques
- Know Supply Chain Management consisting of all parties (Including Manufacturer, Marketer, Suppliers, transporters, Warehouses, Retailers and even customers) directly or indirectly involved in fulfilment of a customer
- Ensure that the supply chains deliver varying degrees of six outcomes — the traditional cost-related benefit plus responsiveness, security, sustainability, resilience and innovation — depending on key customers‘ needs
- Know automated back office software systems
- Know basic business process.

REFERENCES:

1. Agarwal D. K., “Supply Chain Management: Strategy, Cases and Best Practices”, Macmillan, 2010
2. Chandrasekaran, Nagarajan, “Supply Chain Management: Process, System, and Practice”, Oxford University Press, 2010.
3. David Simchi-Levi, Philip Kaminsky, and Edith Simchi-Levi, “Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies”, Second Edition, McGraw-Hill/Irwin, New York, 2003
4. Robert Handfield, Ernest Nichols, “Introduction to Supply Chain Management”, Prentice hall Publishers, 1999
5. Sunil Chopra, Peter Meindel. “Supply Chain Management: Strategy, Planning, and Operation”, Prentice Hall of India, 2002
6. Sunil Chopra, Peter Meindl, “Supply Chain Management”, Prentice Hall Publisher, 2001

CO-PO MAPPING:															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	1	1	3	3	1	1	1		1
CO2	3	2	3	2	3	3	1	1	3	3	2	1	1	1	1
CO3	2	3	3	3	2	2	1	1	3	3	3	1	1	1	1
CO4	3	1	2	3	3	1	1	1	2	2	2	2			1
CO5	1	2	2	3	3	1	1	2	3	2	1	2	1		1

IF5002 DEEP LEARNING L T P C
3 0 0 3

OBJECTIVES:

This course covers the basics of machine learning, neural networks and deep learning. Model for deep learning technique and the various optimization and generalization mechanisms are included. Major topics in deep learning and dimensionality reduction techniques are covered. The objective of this course is:

- To present the mathematical, statistical and computational challenges of building neural networks
- To study the concepts of deep learning
- To introduce dimensionality reduction techniques
- To enable the students to know deep learning techniques to support real-time applications
- To examine the case studies of deep learning techniques
-

UNIT I INTRODUCTION 9

Introduction to machine learning- Linear models (SVMs and Perceptrons, logistic regression)- Intro to Neural Nets: What a shallow network computes- Training a network: loss functions, back propagation and stochastic gradient descent- Neural networks as universal function approximates

UNIT II DEEP NETWORKS 9

History of Deep Learning- A Probabilistic Theory of Deep Learning- Backpropagation and regularization, batch normalization- VC Dimension and Neural Nets-Deep Vs Shallow Networks- Convolutional Networks- Generative Adversarial Networks (GAN), Semi-supervised Learning

UNIT III DIMENTIONALITY REDUCTION 9

Linear (PCA, LDA) and manifolds, metric learning - Auto encoders and dimensionality reduction in networks - Introduction to Convnet - Architectures – AlexNet, VGG, Inception, ResNet - Training a Convnet: weights initialization, batch normalization, hyperparameter optimization

UNIT IV OPTIMIZATION AND GENERALIZATION 9

Optimization in deep learning– Non-convex optimization for deep networks- Stochastic Optimization- Generalization in neural networks- Spatial Transformer Networks- Recurrent networks, LSTM - Recurrent Neural Network Language Models- Word-Level RNNs & Deep Reinforcement Learning - Computational & Artificial Neuroscience

UNIT V CASE STUDY AND APPLICATIONS 9

Imagenet- Detection-Audio WaveNet-Natural Language Processing Word2Vec - Joint Detection- BioInformatics- Face Recognition- Scene Understanding- Gathering Image Captions

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students will be able to

- Understand basics of deep learning
- Implement various deep learning models
- Realign high dimensional data using reduction techniques
- Analyze optimization and generalization in deep learning
- Explore the deep learning applications

REFERENCES:

1. Cosma Rohilla Shalizi, Advanced Data Analysis from an Elementary Point of View, 2015.

2. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 2013.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.
4. Michael Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.

MU5251 MULTIMEDIA COMMUNICATION NETWORKS L T P C
3 0 0 3

OBJECTIVES:

- To understand the multimedia communication models
- To analyze the guaranteed service model
- To study the multimedia transport in wireless networks
- To explore real-time multimedia network applications

UNIT I MULTIMEDIA COMMUNICATION MODELS 9

Common Multimedia applications - VoIP- Video Conferencing- Military Surveillance- Interactive TV- Video on Demand- Smart Phone - Requirements and Design challenges of multimedia communications-Architecture of Internet Multimedia Communication- Protocol Stack-H.323.

UNIT II BEST EFFORT AND GUARANTEED SERVICE MODEL 9

Best effort service model and its limitations-Resource allocation-Metrics-Max and Min fair sharing-Queuing-FIFO-Priority queue-Fair queue- Waited fair queue-Traffic policing-Token bucket-leaky bucket-Admission control-Packet classification and scheduling.

UNIT III MULTIMEDIA ON IP NETWORKS 9

QoS aware routing-RSVP-Integrated and Differentiated services-MPLS-Multicasting-IGMP-PIM-DVMRP

UNIT IV TRANSPORT LAYER SUPPORT FOR MULTIMEDIA 9

Multimedia over TCP-Significance of UDP- Multimedia Streaming- Audio and Video Streaming-Interactive and non Interactive Multimedia-RTP/RTCP-SIP-RTSP.

UNIT V MULTIMEDIA QOS ON WIRELESS NETWORKS 9

IEEE 802.11e, IEEE 802.16, 3G networks-UMTS, 3GPP, 4G networks-LTE-IMS.

TOTAL: 45 PERIODS

OUTCOMES:

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

- Deploy the right Multimedia Communication models
- Apply QoS to multimedia network applications with efficient routing techniques
- Develop the real-time multimedia network applications

REFERENCES:

1. James F. Kurose and Keith W. Ross, “Computer Networking-A Top-Down Approach Featuring the Internet”, Pearson, 2012.

2. Larry L. Peterson and Bruce S. Davie, “Computer Networks- A Systems Approach”, Morgan Kaufmann Publishers, 2007.
3. Mario Marques da Silva, “Multimedia Communications and Networking”, CRC Press, 2012.
4. Mark Wuthnow, Jerry Shih, Matthew Stafford, “IMS: A New Model for Blending Applications”, Auerbach Publications, 2009.

BD5002	AGILE SOFTWARE DEVELOPMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basic concepts of Agile Software Process.
- To gain knowledge in the area of various Agile Methodologies.
- To develop Agile Software Process
- To know the principles of Agile Testing
- Assess product quality risks within an Agile project

UNITI INTRODUCTION **9**

Software is new product development – Iterative development – Risk (Driven and Client (Driven iterative planning – Time boxed iterative development – During the Iteration, No changes from external stakeholders –Evolutionary and adaptive Development (Evolutionary requirements analysis – Early “Top Ten” high (level requirements and skilful analysis Evolutionary and adaptive planning – Incremental delivery – Evolutionary delivery – The most common mistake – Specific iterative and Evolutionary methods.

UNITII AGILE AND ITS SIGNIFICANCE **9**

Agile development – Classification of methods – The agile manifesto and Principles – Agile project management – Embrace communication and feedback – Simple practices and project tools – Empirical Vs defined and prescriptive Process – Principle(based versus Rule(Based – Sustainable discipline: The human touch – Team as a complex adaptive system – Agile hype – Specific agile methods. The facts of change on software projects – Key motivations for iterative Development – Meeting the requirements challenge iteratively – Problems with the Waterfall. Research evidence – Early historical project evidence – Standards (Body evidence – Expert and thought leader evidence – A Business case for iterative development – The historical accident of waterfall validity.

UNITIII AGILE METHODOLOGY **9**

Method overview – Lifecycle – Work products, Roles and Practices values – Common mistakes and misunderstandings – Sample projects – Process mixtures – Adoption strategies – Fact versus fantasy – Strengths versus “Other” history.

UNITIV SCRUM **9**

Concepts –deliverable and methods. XP: Concepts –deliverable and methods Unified process: Concepts- deliverable-methods.EVE: Concepts- Methods-deliverable. EVO: Method Overview, Lifecycle, Work Products, Roles and practices, Common mistakes and Misunderstandings, Sample Projects.

UNITV AGILE PRACTICING AND TESTING **9**

Project management – Environment – Requirements – Test – The agile alliances – The manifesto – Supporting the values – Agile testing – Nine principles and six concrete practices for testing on agile teams.

TOTAL :45 PERIODS

OUTCOMES:

- Demonstrate a systematic understanding of current agile techniques and practices used in industry.
- Apply industry standard agile techniques in develop software in a team.
- Use group and individual retrospectives to critically evaluate and propose improvements in developing software in a professional context.
- Apply concepts of XP and EVE in develop a software
- Managing the changes applying different testing techniques

TOTAL :30 PERIODS

REFERENCES:

1. Craig Larman "Agile and Iterative Development – A Manager's Guide" Pearson Education – 2004.
2. David J. Anderson and Eli Schragenheim, —Agile Management for Software Engineering: Applying the Theory of Constraints for Business Results, Prentice Hall, 2003.
3. Elisabeth Hendrickson, "Agile Testing" Quality Tree Software Inc 2008.
4. Kevin C. Desouza, —Agile Information Systems: Conceptualization, Construction, and Management, Butterworth-Heinemann, 2007
5. Shore,"Art of Agile Development" Shroff Publishers & Distributors, 2007

BD5003 PREDICTIVE MODELLING L T P C
3 0 0 3

OBJECTIVES :

- To understand the terms and terminologies of predictive modeling.
- To study the various predictive models, their merits, demerits and application.
- To get exposure to various analytical tools available for predictive modeling.

UNIT I INTRODUCTION TO PREDICTIVE MODELING 9

Core ideas in data mining - Supervised and unsupervised learning Classification vs Prediction -Steps in data mining- SEMMA Approach - Sampling -Pre-processing - Data cleaning - Data Partitioning - Building a model Statistical models - Statistical models for predictive analytics.

UNIT II PREDICTIVE MODELING BASICS 9

Data splitting – Balancing- Overfitting –Oversampling –Multiple Regression Artificial neural networks (MLP) - Variable importance- Profit/loss/prior probabilities - Model specification - Model selection - Multivariate Analysis.

UNIT III PREDICTIVE MODELS 9

Association Rules-Clustering Models –Decision Trees- Ruleset Models- KNearest Neighbors – Naive Bayes - Neural Network Model – Regression Models – Regression Trees – Classification & Regression Trees (CART) – Logistic Regression – Mulitple Linear Regression Scorecards –Support Vector Machines – Time Series Models - Comparison between models - Lift chart Assessment of a single model.

UNIT IV PREDICTIVE MODELING MARKUP LANGUAGE 9

Introduction to PMML – PMML Converter - PMML Structure – Data Manipulation in PMML – PMML Modeling Techniques - Multiple Model Support – Model Verification.

UNIT V TECHNOLOGIES AND CASE STUDIES 9

Weka – RapidMiner – IBM SPSS Statistics- IBM SPSS Modeler – SAS Enterprise Miner – Apache Mahout – R Programming Language.-Real time case study with modeling and analysis.

TOTAL : 45 PERIODS

OUTCOMES:

- Students who complete this course will be able to
- design and analyze appropriate predictive models.
- define the predictive models using PMML.
- apply statistical tools for analysis.

REFERENCES:

1. Kattamuri S. Sarma, “Predictive Modeling with SAS Enterprise Miner: Practical Solutions for Business Applications”, 2nd Edition, SAS Publishing, 2007.
2. 2. Alex Guazzelli, Wen-Ching Lin, Tridivesh Jena, James Taylor, “PMML in Action Unleashing the Power of Open Standards for Data Mining and Predictive Analytics”, 2nd Edition, Create Space Independent Publishing Platform,2012.
3. 3. Ian H. Witten, Eibe Frank , “Data Mining: Practical Machine Learning Tools and Techniques”, Morgan Kaufmann Series in Data Management Systems, Morgan Kaufmann, 3rd Edition, 2011.
4. 4. Eric Siegel , “Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die”, 1st Edition, Wiley, 2013
5. Conrad Carlberg, “Predictive Analytics: Microsoft Excel”, 1st Edition, Que Publishing, 2012.
6. Jeremy Howard, Margit Zwemer, Mike Loukides, “Designing Great Data Products-Inside the Drivetrain Approach, a Four-Step Process for Building Data Products – Ebook”, 1st Edition, O'Reilly Media, March 2012.

IF5091 VIDEO ANALYTICS L T P C

3 0 0 3

OBJECTIVES:

- To know the fundamental concepts of big data and analytics
- To learn various techniques for mining data streams
- To acquire the knowledge of extracting information from surveillance videos.
- To learn Event Modelling for different applications.

- To understand the models used for recognition of objects in videos.

UNIT I INTRODUCTION TO BIG DATA & DATA ANALYSIS 9

Introduction to Big Data Platform – Challenges of Conventional systems – Web data- Evolution of Analytic scalability- analytic processes and tools- Analysis Vs Reporting- Modern data analytic tools- Data Analysis: Regression Modeling- Bayesian Modeling- Rule induction.

UNIT II MINING DATA STREAMS 9

Introduction to Stream 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.

UNIT III VIDEO ANALYTICS 9

Introduction- Video Basics - Fundamentals for Video Surveillance- Scene Artifacts- **Object Detection and Tracking**: Adaptive Background Modelling and Subtraction- Pedestrian Detection and Tracking-Vehicle Detection and Tracking- Articulated Human Motion Tracking in Low-Dimensional Latent Spaces

UNIT IV BEHAVIOURAL ANALYSIS & ACTIVITY RECOGNITION 9

Event Modelling- Behavioural Analysis- Human Activity Recognition-Complex Activity Recognition- Activity modelling using 3D shape, Video summarization, shape based activity models- Suspicious Activity Detection

UNIT V HUMAN FACE RECOGNITION & GAIT ANALYSIS 9

Introduction: Overview of Recognition algorithms – Human Recognition using Face: Face Recognition from still images, Face Recognition from video, Evaluation of Face Recognition Technologies- Human Recognition using gait: HMM Framework for Gait Recognition, View Invariant Gait Recognition, Role of Shape and Dynamics in Gait Recognition

TOTAL: 45 PERIODS

OUTCOMES:

On successful completion of this course, students will be able to:

- Work with big data platform and its analysis techniques.
- Design efficient algorithms for mining the data from large volumes.
- Work with surveillance videos for analytics.
- Design of optimization algorithms for better analysis and recognition of objects in a scene.
- Model a framework for Human Activity Recognition

REFERENCES:

1. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2012.
2. Michael Berthold, David J.Hand, Intelligent Data Analysis, Springer, 2007.
3. Rama Chellappa, Amit K.Roy-Chowdhury, Kevin Zhou.S, “Recognition of Humans and their Activities using Video”, Morgan&Claypool Publishers, 2005.

4. Yunqian Ma, Gang Qian, “Intelligent Video Surveillance: Systems and Technology”, CRC Press (Taylor and Francis Group), 2009.

BD5004 NOSQL DATABASE L T P C
3 0 0 3

OUTCOMES:

Define, compare and use the four types of NoSQL Databases
Demonstrate an understanding of the detailed architecture, define objects, load data, query data and performance tune Column-oriented NoSQL databases.
Explain the detailed architecture, define objects, load data, query data and performance tune Document-oriented NoSQL databases.

UNIT I INTRODUCTION TO NOSQL DATABASES 9

Overview of NoSQL Databases -Comparison of relational databases to new NoSQL stores, MongoDB, Cassandra, HBASE, Neo4j use and deployment, Application, RDBMS approach, Challenges NoSQL approach, Key-Value and Document Data Models, Aggregate-Oriented Databases.

UNIT II DATABASE FOR MODERN WEB 9

Replication and sharding, Map Reduce on databases. Distribution Models, Single Server, Sharding, Master-Slave Replication, Peer-to-Peer Replication, Combining Sharding and Replication Document Databases ,Scaling, Suitable Use Cases,Web Analytics or Real-Time Analytics, E-Commerce Applications, Complex Transactions Spanning Different Operations, Queries against Varying Aggregate Structure

UNIT III COLUMN- ORIENTED NOSQL DATABASES 9

Column- oriented NoSQL databases using Apache HBASE, Column-oriented NoSQL databases using Apache Cassandra, Architecture of HBASE, Column-Family Data Store, Features, Consistency, Transactions, Availability, Query Features, Scaling, Suitable Use Cases, Event Logging, Content Management Systems, Blogging Platforms, Counters, Expiring Usage.

UNIT IV KEYVALUE DATABASE DESIGNS 9

NoSQL Key/Value databases using Riak, Key-Value Databases, Key-Value Store, Key-Value Store Features, Consistency, Transactions, Query Features, Structure of Data, Scaling, Suitable Use Cases, Storing Session Information, User Profiles, Preferences, Shopping Cart Data, Relationships among Data, Multi operation Transactions, Query by Data, Operations by Sets.

UNIT V GRAPH DATABASE DESIGN 9

Graph NoSQL databases using Neo4,NoSQL database development tools and programming languages, Graph Databases, Features, Consistency, Transactions, Availability, Query Features, Scaling, Suitable Use Cases, Connected Data, Routing, Dispatch, and Location-Based Services, Recommendation Engines.

TOTAL:45 PERIODS

OUTCOMES:

- Demonstrate an understanding of installing MongoDB.
- Explain the techniques used to create, insert, update and delete data/documents.
- Demonstrate the various techniques used to query the database.

- Explain techniques to optimize querying using indexing.
- Explain the technique of splitting data across machines via sharding

REFERENCES:

1. NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Sadalage, P. & Fowler , Pearson Education
2. A Guide to Modern Databases and the NoSQL Movement Edition,Redmond, E. &Wilson,1st Edition. Chodorow, K. (2013). MongoDB: The Definitive Guide (2nd ed.). Upper Saddle River, NJ: Pearson Education, Inc. ISBN-13: 978-1449344689 ISBN-10: 1449344682.

MP5007	COGNITIVE COMPUTING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn about design of cognitive systems
- To be familiar with techniques to support cognitive systems
- Able to analyze the effectiveness of a cognitive system
- Understand the deployment of cognitive applications
- Understand the development process of cognitive systems

UNIT I INTRODUCTION TO COGNITIVE COMPUTING 9

The Foundation of Cognitive Computing-Cognitive Computing as a New Generation-The Uses of Cognitive Systems-What Makes a System Cognitive?-Artificial Intelligence as the Foundation of Cognitive Computing-Understanding Cognition-Understanding Complex Relationships Between Systems-The Elements of a Cognitive System-Design Principles for Cognitive Systems-Components of a Cognitive System-Building the Corpus-Bringing Data into the Cognitive System-Machine Learning-Hypotheses Generation and Scoring-Presentation and Visualization Services.

UNIT II NATURAL LANGUAGE PROCESSING IN COGNITIVE SYSTEMS 9

Natural Language Processing in Support of a Cognitive System-The Role of NLP in a Cognitive System-Semantic Web-Applying Natural Language Technologies to Business Problems. Representing Knowledge in Taxonomies and Ontologies-Representing Knowledge-Defining Taxonomies and Ontologies-Explaining How to Represent Knowledge-Models for Knowledge Representation-Implementation Considerations.

UNIT III ADVANCED ANALYTICS IN COGNITIVE COMPUTING 9

Applying Advanced Analytics to Cognitive Computing-Advanced Analytics Is on a Path to Cognitive Computing-Key Capabilities in Advanced Analytics-Using Advanced Analytics to Create Value-Impact of Open Source Tools on Advanced Analytics- Case studies.

UNIT IV COGNITIVE SYSTEMS APPROACHES 9

The Role of Cloud and Distributed Computing in Cognitive Computing-Leveraging Distributed Computing for Shared Resources-Why Cloud Services Are Fundamental to Cognitive Computing Systems-The Business Implications of Cognitive Computing: Preparing for Change-Advantages of New Disruptive Models-The Difference with a Cognitive Systems

Approach-Meshing Data Together Differently-Using Business Knowledge to Plan for the Future-Building Business Specific Solutions-Making Cognitive Computing a Reality.

UNIT V BUILDING A COGNITIVE APPLICATION 9

The Process of Building a Cognitive Application-The Emerging Cognitive Platform-Defining the Objective-Defining the Domain-Understanding the Intended Users and Defining their Attributes-Defining Questions and Exploring Insights-Creating and Refining the Corpora-Training and Testing- CASE STUDY: Building a Cognitive Healthcare Application-Foundations of Cognitive Computing for Healthcare-Constituents in the Healthcare Ecosystem-Cognitive Applications across the Healthcare Ecosystem- Emerging Cognitive Computing Areas- Future Applications for Cognitive Computing.

TOTAL : 45 PERIODS

OUTCOMES:

- Clear understanding of the elements and principles in designing a cognitive system
- Appreciate the role of Natural language processing and knowledge representation in Cognitive systems
- Analyze a cognitive computing system through case studies
- Able to select an appropriate approach to build a cognitive system
- Provide a system flow to deploy a cognitive application

REFERENCES:

1. Developing Cognitive Applications https://www.ibm.com/developerworks/learn/cognitive/
2. Machine Learning and Cognitive Systems: The Next Evolution of Enterprise intelligence,https://www.wired.com/.../machine-learning-cognitive-system.
3. Marcia Kaufman Adrian Bowles, Judith Hurwitz, “Cognitive Computing and Big Data Analytics”, First Edition, Wiley.
4. Steven Bird, Ewan Klein, Edward Loper, “ Natural Language Processing with Python – Analyzing text with natural language toolkit”, O’Reilly Media , 2009.
5. Tom M. Mitchell, “Machine Learning” , McGraw Hill.

CP5074 SOCIAL NETWORK ANALYSIS L T P C
3 0 0 3

OBJECTIVES:

- To understand the components of the social network.
- To model and visualize the social network.
- To mine the users in the social network.
- To understand the evolution of the social network.
- To know the applications in real time systems.

UNIT I INTRODUCTION 9

Introduction to Web - Limitations of current Web – Development of Semantic Web – Emergence of the Social Web – Statistical Properties of Social Networks -Network analysis - Development of Social Network Analysis - Key concepts and measures in network analysis - Discussion networks - Blogs and online communities - Web-based networks.

UNIT II MODELING AND VISUALIZATION 9

Visualizing Online Social Networks - A Taxonomy of Visualizations - Graph Representation - Centrality- Clustering - Node-Edge Diagrams - Visualizing Social Networks with Matrix-Based Representations- Node-Link Diagrams - Hybrid Representations - Modelling and aggregating social network data **–** Random Walks and their Applications –Use of Hadoop and Map Reduce - Ontological representation of social individuals and relationships.

UNIT III MINING COMMUNITIES 9

Aggregating and reasoning with social network data, Advanced Representations – Extracting evolution of Web Community from a Series of Web Archive - Detecting Communities in Social Networks - Evaluating Communities – Core Methods for Community Detection & Mining - Applications of Community Mining Algorithms - Node Classification in Social Networks.

UNIT IV EVOLUTION 9

Evolution in Social Networks – Framework - Tracing Smoothly Evolving Communities - Models and Algorithms for Social Influence Analysis - Influence Related Statistics - Social Similarity and Influence - Influence Maximization in Viral Marketing - Algorithms and Systems for Expert Location in Social Networks - Expert Location without Graph Constraints - with Score Propagation – Expert Team Formation - Link Prediction in Social Networks - Feature based Link Prediction – Bayesian Probabilistic Models - Probabilistic Relational Models.

UNIT V APPLICATIONS 9

A Learning Based Approach for Real Time Emotion Classification of Tweets, A New Linguistic Approach to Assess the Opinion of Users in Social Network Environments, Explaining Scientific and Technical Emergence Forecasting, Social Network Analysis for Biometric Template Protection

TOTAL : 45 PERIODS

OUTCOMES:

Upon Completion of the course, the students should be able to

- Work on the internals components of the social network
- Model and visualize the social network
- Mine the behaviour of the users in the social network
- Predict the possible next outcome of the social network
- Apply social network in real time applications

REFERENCES:

1. Ajith Abraham, Aboul Ella Hassanien, Václav Snášel, “Computational Social Network Analysis: Trends, Tools and Research Advances”, Springer, 2012
2. Borko Furht, “Handbook of Social Network Technologies and Applications”, Springer, 1st edition, 2011
3. Charu C. Aggarwal, “Social Network Data Analytics”, Springer; 2014
4. Giles, Mark Smith, John Yen, “Advances in Social Network Mining and Analysis”, Springer, 2010.
5. Guandong Xu , Yanchun Zhang and Lin Li, “Web Mining and Social Networking – Techniques and applications”, Springer, 1st edition, 2012
6. Peter Mika, “Social Networks and the Semantic Web”, Springer, 1st edition, 2007.
7. Przemyslaw Kazienko, Nitesh Chawla,”Applications of Social Media and Social

Network Analysis", Springer,2015

SE5006	VIRTUALIZATION TECHNIQUES AND APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To understand the concepts of virtualization and virtual machines
- To understand the implementation of process and system virtual machines
- To explore the aspects of high level language virtual machines
- To gain expertise in server, network and storage virtualization.
- To understand and deploy practical virtualization solutions and enterprise solutions

UNIT I OVERVIEW OF VIRTUALIZATION 9

System architectures - Virtual Machine basics - Process vs System Virtual Machines - Taxonomy. Emulation: Basic Interpretation - Threaded Interpretation - Precoded and Direct Threaded Interpretation - Binary Translation. System Virtual Machines - Key concepts - Resource utilization basics

UNIT II PROCESS VIRTUAL MACHINES 9

Implementation – Compatibility – Levels – Framework – State Mapping – Register – Memory Address Space – Memory Architecture Emulation – Memory Protection – Instruction Emulation – Performance Tradeoff - Staged Emulation – Exception Emulation – Exception Detection – Interrupt Handling – Operating Systems Emulation – Same OS Emulation – Different OS Emulation – System Environment

UNIT III HIGH LEVEL LANGUAGE VIRTUAL MACHINES AND SERVER VIRTUALIZATION 9

HLL virtual machines: Pascal P-Code – Object Oriented HLLVMs - Java VM architecture - Java Native Interface - Common Language Infrastructure. Server virtualization: Partitioning techniques - virtual hardware - uses of virtual servers - server virtualization platforms

UNIT IV NETWORK AND STORAGE VIRTUALIZATION 9

Design of Scalable Enterprise Networks – Layer2 Virtualization – VLAN - VFI - Layer 3 Virtualization – VRF - Virtual Firewall Contexts - Network Device Virtualization - Data- Path Virtualization - Routing Protocols. Hardware Devices – SAN backup and recovery techniques – RAID – Classical Storage Model – SNIA Shared Storage Model – Virtual Storage: File System Level and Block Level

UNIT V APPLYING VIRTUALIZATION 9

Practical Virtualization Solutions: Comparison of Virtualization Technologies: Guest OS/ Host OS – Hypervisor – Emulation – Kernel Level – Shared Kernel, Enterprise Solutions: VMWare Server – VMWare ESXi – Citrix Xen Server – Microsoft Virtual PC – Microsoft Hyper-V – Virtual Box, Server Virtualization: Configuring Servers with Virtualization – Adjusting and Tuning Virtual servers – VM Backup – VM Migration, Desktop Virtualization: Terminal services – Hosted Desktop – Web-based Solutions – Localized Virtual Desktops, Network and Storage Virtualization: Virtual Private Networks – Virtual LAN – SAN and VSAN

– NAS

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of this course, the student should be able to

- Deploy legacy OS on virtual machines.
- Analyze the intricacies of server, storage and network virtualizations
- Design and develop applications on virtual machine platforms

REFERENCES:

1. Chris Wolf, Erick M. Halter, “Virtualization: From the Desktop to the Enterprise”, APress 2005.
2. David Marshall, Wade A. Reynolds, “Advanced Server Virtualization: VMware and Microsoft Platform in the Virtual Data Center”, Auerbach Publications, 2006.
3. James E. Smith, Ravi Nair, “Virtual Machines: Versatile Platforms for Systems and Processes”, Elsevier/Morgan Kaufmann, 2005.
4. Kenneth Hess , Amy Newman, “Practical Virtualization Solutions: Virtualization from the Trenches”, Prentice Hall, 2010
5. Kumar Reddy, Victor Moreno, “Network virtualization”, Cisco Press, July, 2006.

BD5005 NATURAL LANGUAGE PROCESSING L T P C

3 0 0 3

OBJECTIVES:

- Learn the techniques in natural language processing.
- Be familiar with the natural language generation.
- To understand the use of CFG and PCFG in NLP
- Be familiar with the natural language generation
- To understand the role of semantics of sentences and pragmatics
- To apply the NLP techniques to IR applications

UNIT I INTRODUCTION 9

Introduction: Origins and challenges of NLP – Computing with Language: Texts and Words , Texts as Lists of Words, Computing with Language: Simple Statistics, Language Modeling: Grammar-based LM, Statistical LM – Regular Expressions, Finite-State Automata – English Morphology, Transducers for lexicon and rules, Tokenization, Detecting and Correcting Spelling Errors, Minimum Edit Distance

UNIT II WORD LEVEL ANALYSIS 9

Accessing Text from the Web and from Disk , Strings: Text Processing at the Lowest Level, Text Processing with Unicode , Regular Expressions for Detecting Word Patterns,Unsmoothed N-grams, Evaluating N-grams, Smoothing, Interpolation and Backoff – Word Classes, Part-of-Speech Tagging, Rule-based, Stochastic and Transformation-based tagging, Issues in PoS tagging – Hidden Markov and Maximum Entropy models.

UNIT III SYNTACTIC ANALYSIS 9

Analyzing Sentence Structure,Context-Free Grammars, Grammar rules for English, Treebanks, Grammar Development, Normal Forms for grammar – Dependency Grammar – Syntactic Parsing, Ambiguity, Dynamic Programming parsing – Shallow parsing – Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGs – Feature structures, Unification of feature structures.

UNIT IV SEMANTICS AND PRAGMATICS 10

Analyzing the Meaning of Sentences : Natural Language Understanding, Propositional Logic, First-Order Logic , Requirements for representation – Syntax-Driven Semantic analysis, Semantic attachments – Word Senses, Relations between Senses, Thematic Roles, selectional restrictions – Word Sense Disambiguation, WSD using Supervised, Dictionary & Thesaurus, Bootstrapping methods – Word Similarity using Thesaurus and Distributional methods.

UNIT V DISCOURSE ANALYSIS AND LEXICAL RESOURCES 8

Discourse segmentation, Coherence – Reference Phenomena, Anaphora Resolution using Hobbs and Centering Algorithm – Coreference Resolution – Resources: Porter Stemmer, Lemmatizer, Penn Treebank, Brill's Tagger, WordNet, PropBank, FrameNet, Brown Corpus, British National Corpus (BNC).

TOTAL :45 PERIODS

OUTCOMES:

- Analyze and generate the natural language text
- To tag a given text with basic Language features
- To design an innovative application using NLP components
- To implement a rule based system to tackle morphology/syntax of a language
- To design a tag set to be used for statistical processing for real-time applications
- To compare and contrast the use of different statistical approaches for different types of NLP applications.

REFERENCES:

1. Daniel Jurafsky, James H. Martin—Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech, Pearson Publication, 2014.
2. Steven Bird, Ewan Klein and Edward Loper, —Natural Language Processing with Python, First Edition, OReilly Media, 2009.
3. Breck Baldwin, —Language Processing with Java and LingPipe Cookbook, Atlantic Publisher, 2015.
4. Richard M Reese, —Natural Language Processing with Java, OReilly Media, 2015.
5. Nitin Indurkhya and Fred J. Damerau, —Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.
6. Tanveer Siddiqui, U.S. Tiwary, —Natural Language Processing and Information Retrieval, Oxford University Press, 2008.

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OBJECTIVES:

The student should be able to

- Identify the enormous opportunities that currently exists in providing business intelligence services
- Gain a practical understanding of the key data mining methods of classification, prediction, data reduction and exploration
- Understand and help develop the strategies of modern enterprise decision makers
- Acquire knowledge in many scientific and technological fields including data warehouses, data mining, content analytics, business process management, visual analytics
- Gain competences in information systems, web science, decision science, software engineering, and innovation and entrepreneurship.

UNIT I INTRODUCTION **9**

BI Basics – Meeting the BI challenge – BI user models – Basic reporting and querying – BI Markets - BI and Information Exploitation – Value of BI – BI cycle – Bridging the analysis gap – BI Technologies – BI Decision Support Initiatives – BI Project Team.

UNIT II BI BIG PICTURE **9**

Advanced Emerging BI Technologies – Human factors in BI implementations – BI design and development – OO Approach to BI - BI Environment – BI business process and information flow – Identifying BI opportunities – Evaluating Alternatives - BI solutions – BI Project Planning.

UNIT III BI ARCHITECTURE **9**

Components of BI Architecture – BI Design and prototyping – Importance of Data in Decision Making - Data requirements Analysis - Using OLAP for BI – Data warehouse and Technical BI Architecture – Business Rules – Data Quality – Data Integration – High performance BI - BI 2.0 – GoOLAP Fact Retrieval Framework.

UNIT IV BI TECHNOLOGIES **9**

Successful BI – LOFT Effect – Importance of BI Tools – BI standardization - Creating business value through location based intelligence – Technologies enabling BI – technologies for information integration - Building effective BI Systems – Strategic, Tactical, Operational and Financial Intelligence.

UNIT V FUTURE OF BI **9**

Knowledge Discovery for BI – Markov Logic Networks – BI Search and Text Analytics – Advanced Visualisation – Semantic Web Technologies for building BI - Service oriented BI – Collaborative BI - Evaluating BI – Stakeholder model of BI.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of this course, the students should be able to:

- Assess the business intelligence potential of today‘s data rich environment
- Plan how to decide when to use which technique
- Outline how to implement major techniques using Excel add-ins
- Gain the intellectual capital required to provide business analytics services.

REFERENCES:

1. CindiHowson,"Successful Business Intelligence”, Tata McGraw-Hill Education, 2007
2. David Loshin,” Business Intelligence: The Savvy Manager's Guide”, Morgan Kaufmann, 2nd Edition, Newnes Publishers, 2012
3. Elizabeth Vitt, Michael Luckevich, Stacia Misner, “Business Intelligence”, O'Reilly Media, Inc., 2010.
4. Larissa Terpeluk Moss, S. Atre, ”Business Intelligence Roadmap: The Complete Project Lifecycle for Decision-Support Applications, Addison-Wesley Information Technology Series”, illustrated edition, Addison-Wesley Professional, 2003
5. Marie - Aude Aufaure, Esteban Zimány, “Business Intelligence”, First European Summer School eBISS, 2011.
6. Murugan Anandarajan, Asokan Anandarajan, Cadambi A. Srinivasan, ”Business Intelligence Techniques: A Perspective from Accounting and Finance”, illustrated Springer, 2003
7. Rajiv Sabherwal, Irma Becerra-Fernandez, “Business Intelligence”, illustrated Edition, John Wiley & Sons, 2010

BD5006 R LANGUAGE L T P C

3 0 0 3

UNIT I INTRODUCTION TO DATA ANALYSIS 9

Overview of Data Analytics, Need of Data Analytics, Nature of Data, Classification of Data: Structured, Semi-Structured, Unstructured, Characteristics of Data, Applications of Data Analytics

UNIT II HADOOP -HIVE and HIVEQL, HBASE 9

Hive Architecture and Installation, Comparison with Traditional Database, HiveQL - Querying Data - Sorting And Aggregating, Map Reduce Scripts, Joins & Subqueries, 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

UNIT III R PROGRAMMING BASICS 9

Overview of R programming, Environment setup with R Studio, R Commands, Variables and Data Types, Control Structures, Array, Matrix, Vectors, Factors, Functions, R packages

UNIT IV DATA VISUALIZATION USING R 9

Reading and getting data into R (External Data): Using CSV files, XML files, Web Data, JSON files, Databases, Excel files. Working with R Charts and Graphs: Histograms,Boxplots,Bar Charts, Line Graphs, Scatter plots, Pie Charts

UNIT V STATISTICS WITH R 9

Random Forest, Decision Tree, Normal and Binomial distributions, Time Series Analysis,Linear and Multiple Regression, Logistic Regression ,Survival Analysis,-Prescriptive Analytics:Creating data for analytics through designed experiments, Creating data for analytics through active learning, Creating data for analytics through reinforcement learning

REFERENCES:

1. Jared P. Lander, "R for Everyone: Advanced Analytics and Graphics", Addison-Wesley Data & Analytics Series, 2013.
2. An Introduction to R, Notes on R: A Programming Environment for Data Analysis and Graphics. W. N. Venables, D.M. Smith and the R Development Core Team. Version 3.0.1 2013-05-16). URL: https://cran.r-project.org/doc/manuals/r-release/R-intro.pdf
3. Vignesh Prajapati, "Big Data Analytics with R and Haoop", Packet Publishing 2013
4. Norman Matloff , "The Art of R Programming: A Tour of Statistical Software Design", No Starch Press, 2011.
5. Mark Gardener, " Beginning R – The Statistical Programming Language", Wiley, 2013
6. Robert Knell, " Introductory R: A Beginner's Guide to Data Visualisation, Statistical Analysis and Programming in R", Amazon Digital South Asia Services Inc, 2013.
7. W. N. Venables, D. M. Smith and the R Core Team, "An Introduction to R", 2013.

BD5007 WEB ANALYTICS L P T C
3 0 0 3

OBJECTIVES:

- To know the importance of qualitative data, get insights and techniques.
- To develop customer-centric approach in dealing with data.
- To know the principles, tools and methods of web intelligence.
- To apply analytics for business situations.

UNIT I INTRODUCTION [9]

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

UNIT-II STRATEGIES FOR ANALYTICS [9]

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

UNIT III CONCEPTS OF WEB ANALYTICS [9]

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.

UNIT IV GOOGLE ANALYTICS [9]

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

UNIT V ADVERTISING AND PROMOTION [9]

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

TOTAL:45 PERIODS

OUTCOMES:

- Know the concepts and terminologies related to web analytics.
- Explore various parameters used for web analytics and their impact.
- Explore the use of tools and techniques of web analytics.
- Get experience on websites, web data insights and conversions

REFERENCES:

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.
3. Magy Seif El-Nasr, Anders Drachen, Alessandro Canossa, eds., "Game Analytics: Maximizing the Value of Player Data", Springer, 2013.
4. Bing Liu, "Web Data Mining: Exploring Hyperlinks, Content, and Usage Data", 2nd Edition, Springer, 2011.
5. Justin Cutroni, "Google Analytics", O'Reilly, 2010.
6. Eric Fettman, Shiraz Asif, Feras Alhlou , "Google Analytics Breakthrough", John Wiley & sons, 2016.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	2	2	3	2	3	3	1	2	2	3	2
CO2	3	3	3	3	2	2	2	2	3	3	2	2	2	3	2
CO3	3	3	3	2	3	2	3	3	2	3	2	2	2	3	2
CO4	3	3	3	3	3	2	3	2	3	2	2	2	2	3	2
CO5	3	3	3	3	3	2	3	2	3	3	2	2	2	3	3

CP5075 BIO INFORMATICS L T P C

3 0 0 3

OBJECTIVES:

- To get exposed to the fundamentals of bioinformatics.
- To learn bio-informatics algorithm and phylogenetic concept.
- To understand open problems and issues in replication and molecular clocks.
- To learn assemble genomes and corresponding theorem.
- To study and exposed to the domain of human genomics.

UNIT I INTRODUCTION AND FUNDAMENTALS 9

Fundamentals of genes , genomics , molecular evolution – genomic technologies – beginning of bioinformatics - genetic data –sequence data formats – secondary database – examples – data retrival systems – genome browsers.

UNIT II BIOINFORMATICS ALGORITHM AND ANALYSIS 9

Sequence alignment and similarity searching in genomic databases: BLAST and FASTA – additional bioinformatics analysis involving nucleic acid sequences-additional bioinformatics analysis involving protein sequences – Phylogenetic Analysis.

UNIT III DNA REPLICATION AND MOLECULAR CLOCKS 9

Beginning of DNA replication – open problems – multiple replication and finding replication – computing probabilities of patterns in a string-the frequency array-converting patterns-solving problems- finding frequents words-Big-O notation –case study-The Tower of Hanoi problem.

UNIT IV ASSEMBLE GENOMES AND SEQUENCES 9

Methods of assemble genomes – string reconstruction – De Bruijn graph – Euler's theorem – assembling genomes –DNA sequencing technologies – sequence antibiotics – Brute Force Algorithm – Branch and Bound algorithm – open problems – comparing biological sequences- Case Study –Manhattan tourist Problem.

UNIT V HUMAN GENOME 9

Human and mouse genomes-random breakage model of chromosome evolution – sorting by reversals – greedy heuristic approach – break points- rearrangements in tumor and break point genomes-break point graps- synteny block construction -open problems and technologies.

TOTAL : 45 PERIODS

OUTCOMES:

Upon Completion of the course, the students should be able to:

- Deploy the genomics technologies in Bioinformatics.
- Able to distinct efficient algorithm and issues.
- Deploy the replication and molecular clocks in bioinformatics.
- Work on assemble genomes and sequences.
- Use the Microarray technologies for genome expression.

REFERENCES:

1. Ion Mandoiu and Alexander Zelikovsky **,** "Computational Methods for Next Generation Sequencing Data Analysis " Wiley series 2016.
2. Istvan Miklos,Renyi Institutue, "Introduction to algorithms in bioinformatics",Springer 2016
3. Philip Compeau and Pavel pevzner, "Bioinformatics Algorithms: An Active Learning Approach" Second edition volume I , Cousera, 2015.
4. Supratim Choudhuri, "Bioinformatics For Beginners", Elsevier, 2014.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	2	1	1	2	1	-	1	-	-	2	2	2	

CO2	2	3	3	2	2	2	2	1	1	-	1	2	1	2	
CO3	3	3	3	3	3	2	2	1	3	1	2	3	1	2	
CO4	3	3	3	3	3	2	2	1	3	1	2	3	2	3	
CO5	2	1	1	3	-	1	2	2	-	-	-	3	3	1	

BD5008 HEALTHCARE DATA ANALYTICS L T P C
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Objectives:

- To explore the various forms of electronic health care information.
- To learn the techniques adopted to analyze health care data.
- To understand the predictive models for clinical data
- To understand the applications of data analytics in healthcare

UNIT 1 INTRODUCTION 8

Introduction to Healthcare Data Analytics- Electronic Health Records– Components of EHR- Coding Systems- Benefits of EHR- Barrier to Adopting EHR- Challenges- Phenotyping Algorithms.

UNIT II ANALYSIS 9

Biomedical Image Analysis- Mining of Sensor Data in Healthcare- Biomedical Signal Analysis- Genomic Data Analysis for Personalized Medicine.

UNIT III BASIC ANALYTICS 9

Natural Language Processing and Data Mining for Clinical Text- Mining the Biomedical- Social Media Analytics for Healthcare.

UNIT IV ADVANCED DATA ANALYTICS 10

Review of Clinical Prediction Models- Temporal Data Mining for Healthcare Data- Visual Analytics for Healthcare- Predictive Models for Integrating Clinical and Genomic Data- Information Retrieval for Healthcare- Privacy-Preserving Data Publishing Methods in Healthcare.

UNIT V APPLICATIONS 9

Applications and Practical Systems for Healthcare– Data Analytics for Pervasive Health- Fraud Detection in Healthcare- Data Analytics for Pharmaceutical Discoveries- Clinical Decision Support Systems- Computer-Assisted Medical Image Analysis Systems- Mobile Imaging and Analytics for Biomedical Data.

TOTAL PERIODS:45

REFERENCES

- Chandan K. Reddy and Charu C Aggarwal, “Healthcare data analytics”, Taylor & Francis, 2015
- Hui Yang and Eva K. Lee, “Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, Wiley, 2016.

OUTCOMES:

Students will be able to:

- Analyze health care data using appropriate analytical techniques.
- Apply analytics for decision making in healthcare services.
- Apply data mining to integrate health data from multiple sources and develop efficient clinical decision support systems.

CO-PO MAPPING:															
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	3	3	3	2		2			2	2	2	3
CO2	3	3	3	3	3	3	2		1	2		2	3	2	2
CO3	3	3	3	3	3	2	1		1			3	3	3	3
CO4	3	3	3	2	3	2	2		2	1		3	3	3	2
CO5	3	3	3	3	2	2	1		2	1		3	2	2	2