SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur, Chengalpattu Dt.-603203, Tamil Nadu.

DEPARTMENT OF INFORMATION TECHNOLOGY

M.Tech – DATA SCIENCE

POST GRADUATE

CURRICULA AND SYLLABI

(REGULATIONS 2019)

TABLE OF CONTENT

VISION AND MISSION

VISION OF THE INSTITUTE

"Educate to excel in Social Transformation"

- To accomplish and maintain international eminence and become a model institution for higher learning through dedicated development of minds, advancement of knowledge and professional application of skills to meet the global demands.

MISSION OF THE INSTITUTE

- To contribute to the development of human resources in the form of professional engineers and managers of international excellence and competence with high motivation and dynamism, who besides serving as ideal citizen of our country will contribute substantially to the economic development and advancement in their chosen areas of specialization

- To build the institution with international repute in education in several areas at several levels with specific emphasis to promote higher education and research through strong institute-industry interaction and consultancy.

VISION OF THE DEPARTMENT

- To create a data analytical expert for the future generation in order to empower, inspire others with most trusted analytics while remaining receptive to ethical, societal and environmental issues in data world.

MISSION OF THE DEPARTMENT

- **M1:** To mould the students into innovative and high quality Data Science professionals to meet the global challenges and entrepreneurs of International excellence as global leaders capable of contributing towards technological innovations learning process, participation citizenship in their neighbourhood and economic growth.

- **M2:** To transmute value-based decision for all sectors through the application of Data Science and attain the state-of-the-art in data science.

PROGRAMME OUTCOMES(POs)

After going through the two years of study, Master of Technology in Data science Graduates will exhibit ability to:

POs	Graduate Attribute	Programme Outcome
PO1	**Engineering knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using the first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**	Design solutions for the 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.
PO4	**Conduct investigations of complex problems**	Use research-based knowledge and research methods including the design of experiments, analysis and interpretation of data, and the synthesis of the information to provide valid conclusions.
PO5	**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.
PO6	**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.
PO7	**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.
PO8	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**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.
PO11	**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.
PO12	**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.

PROGRAMME SPECIFIC OUTCOMEs (PSOs)

PSOs	PROGRAMME SPECIFIC OUTCOMEs
PSO1	Design and analyse a next generation data security based on machine learning algorithms using Deep Learning techniques.
PSO2	Design and develop advanced storage structures, data preprocessing, optimization and visualization techniques for in depth understanding of the technologies in data science and business analytics.
PSO3	Design, plan and install research and computational technologies using latest hardware and software components that would be helpful in contemporary business environments.
PSO4	Design a data analytics model with indispensable data science engineering to unravel solutions for emerging Artificial Intelligence, IoT and Big Data problems using statistical analyse with professional statistical software.

MAPPING PG-DATA SCIENCE

S.No	Semester	Course code	Title	PO												PSO			
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
			FIRST YEAR SEMESTER - I																
1	I	1918109	Mathematical Foundation for Data Science	3	3		2									2			2
2		1924101	Introduction to Big Data Analytics	3	3	3	2	2	1							3	3	2	
3		1924102	Data Science and R Essentials	3	2	3		3										3	
4		1924103	Machine Learning	3	3	3	3	2								2	2		2
5		1924104	Next Generation Databases	3	3	3	3	2										2	
6		1924105	Data Science and R Essentials Laboratory	1	2	3		3										3	
7		1924106	Machine Learning Laboratory	3	3	3	1		1			1			2	1	1		1
			FIRST YEAR SEMESTER - II																
8	II	1918201	Statistical Learning for Data Science	3	2											2	2		2
9		1924201	Image and Video Processing	1	3	3		2		1				3	2	2		3	
10		1924202	Data Preprocessing and Optimization Techniques	2	2	2	2	3								1	3		3
11		1924203	Advanced Data Visualization Techniques	2	3	3	1	2		2	1			2					2

S.No	Semester	Course code	Title	PO 1	2	3	4	5	6	7	8	9	10	11	12	PSO 1	2	3	4
12		1924210	Data Visualization Laboratory	2	3	3		2		2			3	3	2			3	2
13		1924211	Mini project with research paper writing	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
SECOND YEAR SEMESTER – III																			
14		1924301	Deep learning	2	2	2	2									3	2	2	
15	III	1924314	Project Work - Phase I	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
16		1924315	Online Course (NPTEL,MOOC etc)/Internship from	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
SECOND YEAR SEMESTER – IV																			
17	IV	1924401	Project Work – Phase II	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
FIRST YEAR SEMESTER II – PROFESSIONAL ELECTIVE – I																			
18		1924204	IoT Technologies	3	3	2	2	2									2	3	2
19		1924205	Web Scraping	2	2	1	2	2	2	2	2		1			1	2	2	
20	II	1924206	Information Storage Techniques	3	3	3	3	3	2	3	2	2	2	3	3	3	2	3	
21		1924207	Computational Intelligence	3	3	2	1								1	2	2		2
22		1924208	Open Source Tools for Data Science	3	2	3	3	3	2	3	2	2	2	2	2	2	2	3	2

S.No	Semester	Course code	Title	PO 1	2	3	4	5	6	7	8	9	10	11	12	PSO 1	2	3	4
23		1924209	Business Intelligence	3	3	2	2		2	2							3		
SECOND YEAR **SEMESTER III – PROFESSIONAL ELECTIVE -II**																			
24	III	1924302	Big Data Analytics for IoT	3	3	2	3	3	2								2	3	2
25		1924303	Social Network Analytics	2	2	2	2		2	2	2		2			1		2	
26		1924304	Techniques in Image and Video Analytics	3	2	2	2	3	1	2								2	3
27		1924305	Soft Computing	2	2	3		1											3
28		1924306	Principles of Ethical Hacking	2	2	2	3	3								2			
29		1924307	Business Analytics Case Studies	3	2	3	2	2	2		3	1	1	2	1			2	3
SECOND YEAR **SEMESTER –III PROFESSIONAL ELECTIVE-III**																			
30	III	1924308	Health Care Analytics	2	2	3	3	2	2	3					3		2		3
31		1924309	Security for Data Science	3	2	2	1	3								2			
32		1924310	Blockchain Technology	3	2	2	2	2								3	3	3	3
33		1924311	Fog Computing	3	2	2	2									3	1	2	3
34		1924312	Data Analytics and Natural Language Processing	1	2	3		3	1			1	1	1	2	1	2	1	
35		1924313	Principles of Green Computing	2	2	3	2	3	2	2	2				3		2	2	

SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution, Affiliated to Anna University, Chennai)

DEPARTMENT OF INFORMATION TECHNOLOGY

M. Tech. DATA SCIENCE
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM

I TO IV SEMESTERS CURRICULA & SYLLABI

SEMESTER - I

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1918109	Mathematical Foundation for Data Science	FC	4	4	0	0	4
2.	1924101	Introduction to Big Data Analytics	PC	3	3	0	0	3
3.	1924102	Data Science and R Essentials	PC	3	3	0	0	3
4.	1924103	Machine Learning	PC	3	3	0	0	3
5.	1924104	Next Generation Databases	PC	3	3	0	0	3
PRACTICAL								
6.	1924105	Data Science and R Essentials Laboratory	PC	4	0	0	4	2
7.	1924106	Machine Learning Laboratory	PC	4	0	0	4	2
TOTAL				24	16	0	8	20

SEMESTER - II

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1918201	Statistical Learning for Data Science	FC	4	4	0	0	4
2.	1924201	Image and Video Processing	PC	3	3	0	0	3
3.	1924202	Data Preprocessing and Optimization Techniques	PC	3	3	0	0	3
4.	1924203	Advanced Data Visualization Techniques	PC	3	3	0	0	3
5.	19XXXXX	Professional Elective - I	PE	3	3	0	0	3
PRACTICAL								
6.	1924210	Data Visualization Laboratory	PC	4	0	0	4	2
7.	1924211	Mini Project with Research Paper Writing	EEC	4	0	0	4	2
TOTAL				24	16	0	8	20

SEMESTER - III

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1924301	Deep Learning	PC	3	3	0	0	3
2.	19XXXXX	Professional Elective - II	PE	3	3	0	0	3
3.	19XXXXX	Professional Elective - III	PE	3	3	0	0	3
PRACTICAL								
4.	1924314	Project Work – Phase I	EEC	12	0	0	12	6
5.	1924315	Online Course (NPTEL,MOOC etc.)/Internship from Industry	EEC	0	0	0	0	1
		TOTAL		**21**	**9**	**0**	**12**	**16**

SEMESTER - IV

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1.	1924401	Project Work - Phase II	EEC	24	0	0	24	12
		TOTAL		**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 68

PROFESSIONAL ELECTIVES (PE)

SEMESTER - II

PROFESSIONAL ELECTIVE- I

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1924204	IoT Technologies	PE	3	3	0	0	3
2.	1924205	Web Scraping	PE	3	3	0	0	3
3.	1924206	Information Storage Techniques	PE	3	3	0	0	3
4.	1924207	Computational Intelligence	PE	3	3	0	0	3
5.	1924208	Open Source Tools for Data Science	PE	3	3	0	0	3
6.	1924209	Business Intelligence	PE	3	3	0	0	3

SEMESTER - III

PROFESSIONAL ELECTIVE - II

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1924302	Big Data Analytics for IoT	PE	3	3	0	0	3
2.	1924303	Social Network Analytics	PE	3	3	0	0	3
3.	1924304	Techniques in Image and Video Analytics	PE	3	3	0	0	3
4.	1924305	Soft Computing	PE	3	3	0	0	3
5.	1924306	Principles of Ethical Hacking	PE	3	3	0	0	3
6.	1924307	Business Analytics Case Studies	PE	3	3	0	0	3

SEMESTER - III

PROFESSIONAL ELECTIVE - III

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	1924308	Health Care Analytics	PE	3	3	0	0	3
2.	1924309	Security for Data Science	PE	3	3	0	0	3
3.	1924310	Blockchain Technology	PE	3	3	0	0	3
4.	1924311	Fog Computing	PE	3	3	0	0	3
5.	1924312	Data Analytics and Natural Language Processing	PE	3	3	0	0	3
6.	1924313	Principles of Green Computing	PE	3	3	0	0	3

CATEGORY
FUNDAMENTAL COURSE (FC)

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1918109	Mathematical Foundation for Data Science	FC	4	4	0	0	4
2.	1918201	Statistical Learning for Data Science	FC	4	4	0	0	4
		TOTAL		8	8	0	0	8

PROFESSIONAL CORE(PC)

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1924101	Introduction to Big Data Analytics	PC	3	3	0	0	3
2.	1924102	Data Science and R Essentials	PC	3	3	0	0	3
3.	1924103	Machine Learning	PC	3	3	0	0	3
4.	1924104	Next Generation Databases	PC	3	3	0	0	3
5.	1924105	Data Science and R Essentials Laboratory	PC	4	0	0	4	2
6.	1924106	Machine Learning Laboratory	PC	4	0	0	4	2
7.	1924201	Image and Video Processing	PC	3	3	0	0	3
8.	1924202	Data Preprocessing and Optimization Techniques	PC	3	3	0	0	3
9.	1924203	Advanced Data Visualization Techniques	PC	3	3	0	0	3
10.	1924204	Data Visualization Laboratory	PC	4	0	0	4	2
11.	1924301	Deep Learning	PC	3	3	0	0	3
		TOTAL		36	24	0	12	30

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	1924205	Mini Project with Research Paper Writing	EEC	4	0	0	4	2
2.	1924302	Project Work Phase - I	EEC	12	0	0	12	6
3.	1924303	Self-Study Paper/Internship from Industry	EEC	0	0	0	0	1
4.	1924401	Project Work Phase- II	EEC	24	0	0	24	12
		TOTAL		40	0	0	40	21

PROFESSIONL ELLECTIVE (PE)

SL NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	19XXXXX	Professional Elective - I	PE	3	3	0	0	3
2.	19XXXXX	Professional Elective - II	PE	3	3	0	0	3
3.	19XXXXX	Professional Elective - III	PE	3	3	0	0	3
		TOTAL		9	9	0	0	9

SUMMARY

S.NO.	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL	PERCENTAGE
		I	II	III	IV		
1.	FC	4	4			8	11.76 %
2.	PC	16	11	3		30	44.12 %
3.	PE		3	6		9	13.24 %
4.	EEC		2	7	12	21	30.88 %
	TOTAL	20	20	16	12	68	100 %

FC-FUNDAMENTAL COURSE

PC-PROFESSIONAL CORE

PE-PROFESSIONL ELLECTIVE

EEC-EMPLOYABILITY ENHANCEMENT COURSES

1918109   **MATHEMATICAL FOUNDATION FOR DATA SCIENCE**   **L T P C**
                                                                    4 0 0 4

OBJECTIVES:

- To understand and apply matrix techniques for engineering applications.
- To understand and apply, vector spaces, basis and dimensions, linear transformations
- To familiarize the student with basic concepts of Graph Theory: Isomorphism.
- To solve the problems in Formulation of optimization problems, convex set, convex functions, convex optimization.
- To acquaint the student with mathematical tools needed in evaluating search methods for Multivariable unconstrained problems.

UNIT – I: **MATRICES**   **12**

Eigen values, Eigen vectors, and Diagonalization, singular value decomposition. Positive definite Matrices-Minima, Maxima and saddle points, Test of Positive definiteness, semi-definite and indefinite Matrices.

UNIT - II: **LINEAR ALGEBRA**   **12**

Geometry of linear equations, real vector spaces (Rn, matrices etc.) and subspaces, linear independence, basis and dimensions, linear transformations, orthogonality, Orthogonal basis, Gram Schmidt Process projections and least square applications

UNIT - III: **GRAPH THEORY**   **12**

Graph Theory: Isomorphism, Planar graphs, graph colouring, Hamilton circuits and Euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems

UNIT - IV: **OPTIMIZATION TECHNIQUES**   **12**

Introduction- Formulation of optimization problems, classification of optimization problems, overview of analytical solution for unconstrained optimization problems, constrained optimization, convex set, convex functions, convex optimization problem, Kuhn- Tucker conditions, Search methods – Overview of single variable search methods,

UNIT - V: MULTI – VARIABLE OPTIMIZATION   12

Search methods for Multivariable unconstrained problems - Optimality criteria, unidirectional search – direct search methods- evolutionary search method, Hook-Jeeves pattern search method, gradient based methods –Cauchy's steepest descent method, Newton's method.

TOTAL: 60 PERIODS

OUTCOMES :

At the end of the course, the student should be able to:

- Apply the idea of reducing complex problems into simple form using matrix technique.
- Basic application of vector spaces, basis and dimensions, linear transformations
- Equips the students to have basic knowledge and understanding of Graph Theory, Isomorphism of Graphs.
- Apply the concept of Formulation of optimization problems, convex set, convex functions, convex optimization.
- Basic application of mathematical tools needed in evaluating search methods for Multivariable unconstrained problems.

REFERENCE BOOKS:

1. Gilbert Strang, Linear Algebra and its Applications, Fourth Edition, Cambridge University Press. 2009.
2. Howard Anton and Chris Rorrers," Elementary Linear Algebra", Tenth Edition, 2010 John Wiley & Sons, Inc.
3. Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, New Delhi, 2004.
4. S.S. Rao, "Optimization Theory and Applications", Second Edition, New Age International (P) Limited Publishers, 1995 5. M. AsgharBhatti, "Practical Optimization Methods: with Mathematics Applications", Springer Verlag Publishers, 2000.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	3		2									2			2
CO 2	3	3		2									2			2
CO 3	3	3		2									2			2
CO 4	3	3		2									2			2
CO 5	3	3		2									2			2
Average	3	3		2									2			2

1924101   **INTRODUCTION TO BIG DATA ANALYTICS**   **L T P C**

                                                                                          3 0 0 3

OBJECTIVES:

- To know the fundamental concepts of big data and analytics.
- To explore tools and practices for working with big data
- To learn about stream computing.
- To know about the research that requires the integration of large amounts of data.
- To learn about various NoSQL Data Stores such as key Value Stores, Document Stores, Tabular Stores etc.

UNIT – I: INTRODUCTION TO BIG DATA   9

Evolution of Big data – Best Practices for Big data Analytics – Big data characteristics – Validating – The Promotion of the Value of Big Data – Big Data Use Cases-Characteristics of Big Data Applications – Perception and Quantification of Value - Understanding Big Data Storage – Types of Digital Data-Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data - 3Vs of Big Data - Non Definitional traits of Big Data - Business Intelligence vs. Big Data - Data warehouse and Hadoop environment - Coexistence.

UNIT - II: CLASSIFICATION OF ANALYTICS   9

Big Data Analytics: Classification of analytics - Data Science - Terminologies in Big Data - CAP Theorem - BASE Concept. NoSQL: Types of Databases – Advantages – NewSQL - SQL vs. NOSQL vsNewSQL. Introduction to Hadoop: Features – Advantages – Versions - Overview of Hadoop Eco systems - Hadoop distributions - Hadoop vs. SQL – RDBMS vs. Hadoop - Hadoop Components – Architecture – HDFS - Map Reduce: Mapper – Reducer – Combiner – Partitioner – Searching – Sorting - Compression. Hadoop 2 (YARN): Architecture - Interacting with Hadoop Eco systems.

UNIT - III: MONGO DB   9

Mongo DB: Introduction – Features - Data types - Mongo DB Query language - CRUD operations – Arrays - Functions: Count – Sort – Limit – Skip – Aggregate - Map Reduce. Cursors – Indexes - Mongo Import – Mongo Export. Cassandra: Introduction – Features - Data types – CQLSH - Key spaces - CRUD operations – Collections – Counter – TTL -

Alter commands - Import and Export - Querying System tables.

UNIT - IV: HADOOP ECO SYSTEMS   9

Hive – Architecture - data type - File format – HQL – SerDe - User defined functions - Pig: Features – Anatomy - Pig on Hadoop - Pig Philosophy - Pig Latin overview - Data types - Running pig - Execution modes of Pig - HDFS commands - Relational operators - Eval Functions - Complex data type - Piggy Bank - User defined Functions - Parameter substitution - Diagnostic operator. Types of Digital Data-Characteristics of Data – Evolution of Big Data - Definition of Big Data - Challenges with Big Data - 3Vs of Big Data - Non Definitional traits of Big Data - Business Intelligence vs. Big Data - Data warehouse and Hadoop environment - Coexistence.

UNIT - V: CASE STUDIES   9

Big Data Case Studies – Retail sector, public sector, banking sector, small business, scientific research, health care sector.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Work with big data tools and its analysis techniques
- Analyze data by utilizing clustering and classification algorithms
- Learn and apply different mining algorithms and recommendation systems for large volumes of data
- Perform analytics on data streams
- Learn NoSQL databases and management

TEXT BOOKS:

1. AnandRajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
2. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann/El sevier Publishers, 2013.

REFERENCE BOOKS:

1. EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", Wiley publishers, 2015.

2. Bart Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley Publishers, 2015.

3. DietmarJannach and Markus Zanker, "Recommender Systems: An Introduction", Cambridge University Press, 2010.

4. Kim H. Pries and Robert Dunnigan, "Big Data Analytics: A Practical Guide for Managers " CRC Press, 2015.

5. Jimmy Lin and Chris Dyer, "Data-Intensive Text Processing with MapReduce", Synthesis Lectures on Human Language Technologies, Vol. 3, No. 1, Pages 1-177, Morgan Claypool publishers, 2010

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	3	3	1									3			
CO 2			3	3	3									3		
CO 3		3	3												2	
CO 4		3	3		2	1								3		
CO 5		3	3		2									3		
Average	3	3	3	2	2	1							3	3	2	

1924102   **DATA SCIENCE AND R ESSENTIALS**   **L T P C**
                                                          3 0 0 3

OBJECTIVES:

- To provide you with the knowledge and expertise to become a proficient data scientist.
- To demonstrate an understanding of statistics and machine learning concepts that are vital for data science
- To produce Python code to statistically analyse a dataset; critically evaluate data visualisations based on their design and use for communicating stories from data.
- To understanding the basic concept of R language
- To apply the concept of descriptive statistics in R

UNIT – I: **INTRODUCTION**   **9**

Introduction to core concepts and technologies: Introduction Terminology, data science process, data science toolkit, Types of data, Example applications. Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources.

UNIT - II: **DATA ANALYSIS**   **9**

Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance, Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naïve Bayes. Data visualization Introduction, Types of data visualization.

UNIT - III: **PYTHON**   **9**

Introduction to python- Data Types-Operators-input and output statements-flow control-string data type-list, tuble, set data structure-Dictionary data structure-functions-modules-exception handling-file handling-python data base programme.

UNIT - IV: **INTRODUCTION TO R PROGRAMMING**   **9**

What is R? –RStudio Overview - Arithmetic Operators - Logical Operations -Using Functions - Creating Variables - Numeric, Character and Logical Data - Vectors - Data Frames - Factors - Sorting Numeric, Character, and Factor Vectors - Special Values

UNIT - V: **DESCRIPTIVE STATISTICS IN R**   **9**

Statistical graphs-Statistical graphs-Iteration-Conditional statements-Data exploration and visualization-Data querying: SQL and R-Writing functions Reporting-Interactive reporting with Rmarkdown.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the basic concept of data science
- Able to apply the programming concept of Python.
- Write the programme in python
- Understand the fundamental syntax of R through readings, practice exercises, demonstrations, and writing R code.
- Apply critical programming language concepts such as data types, iteration, control structures, functions, and Boolean operators by writing R programs and through examples

TEXT BOOKS:

1. Cathy O'Neil and Rachel Schutt. "Doing Data Science, Straight Talk From The Frontline". O'Reilly.
2. Jure Leskovek, AnandRajaraman and Jeffrey Ullman. "Mining of Massive Datasets. v2.1", Cambridge University Press.
3. Andreas C. Mueller , Sarah Guido "Introduction to Machine Learning with Python" O'Reilly.
4. Dave Kuhlman "A Python Book: Beginning Python, Advanced   Python, and Python Exercises"

REFERENCE BOOKS:

1. Norman Matloff , "The Art of R Programming: A Tour of Statistical Software Design", No Starch Press, 2011
2. Jared P. Lander, "R for Everyone: Advanced Analytics and Graphics", Addison-Wesley Data & Analytics Series, 2013.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
CO 1	3	1												3		
CO 2	1	2	3											3		
CO 3	1	2	3		3									3		
CO 4	1	2	2		3									3		
CO 5	1	2	3		3									3		
Average	3	2	3		3									3		

1924103   **MACHINE LEARNING**   **L T P C**
                                                                        3 0 0 3

OBJECTIVES:

- To introduce the basic concepts and techniques of Machine Learning. To develop the skills in using recent machine learning software for solving practical problems.
- To be familiar with a set of well-known supervised, semi-supervised algorithms
- Able to know the concept of unsupervised learning algorithms
- To understand the neural networks algorithms.
- To Apply the concept of pattern recognition methods

UNIT – I: **INTRODUCTION**   **9**

Introduction- overview of machine learning- Different forms of learning- Generative 6 learning- Gaussian parameter estimation- maximum likelihood estimation- MAP estimation- Bayesian estimation- bias and variance of estimators- missing and noisy features- nonparametric density estimation- applications- software tools.

UNIT - II: **NEURAL NETWORKS**   **9**

Neural networks- the perceptron algorithm- multilayer perceptron's- back propagationnonlinear regression- multiclass discrimination- training procedures- localized network structure- dimensionality reduction interpretation.

UNIT - III: **SUPERVISED LEARNING**   **9**

Decision Trees: ID3, Classification and Regression Trees, Regression: Linear Regression, Multiple Linear Regression, Logistic Regression, Neural Networks: Introduction, Perceptron, Multilayer Perceptron, Support vector machines: Linear and Non-Linear, Kernel Functions, KNearest Neighbours.

UNIT - IV: **UNSUPERVISED LEARNING**   **9**

Introduction to clustering, Hierarchical: AGNES, DIANA, Partitional: K-means clustering, K-Mode Clustering, Expectation Maximization, Gaussian Mixture Models. Bayesian Learning, Bayes Optimal Classifier, Naıve Bayes Classifier, Bayesian Belief Networks

UNIT - V: **PATTERN RECOGNITION**   **9**

Introduction: Basics of pattern recognition – Design principles of pattern recognition system – Learning and adaptation – Pattern recognition approaches. Parameter

Estimation Techniques, Non-parametric Estimation Techniques,Linear Discriminant Functions,Dimension Réduction Techniques, Nonmetric Data.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Ability to implement and apply machine learning algorithms to real-world applications.
- Identify the machine learning algorithms which are more appropriate for various types of learning tasks in various domains
- Incorporate transfer of knowledge in machine learning algorithms
- Analyse the neural networks algorithm.
- Implement pattern recognition techniques and solve real-world problems

TEXT BOOKS:

1. EthemIpaydin,"IntroductiontoMachineLearning",MITPress,PrenticeHallofIndia, Third Edition2014.
2. MehryarMohri, AfshinRostamizadeh, AmeetTalwalkar"Foundations of Machine Learning", MIT Press,2012.
3. Tom Mitchell, "Machine Learning", McGraw Hill, 3rdEdition,1997.
4. CharuC.Aggarwal,"DataClassificationAlgorithmsandApplications",CRCPress,2014.
5. Charu C. Aggarwal, "DATA CLUSTERING Algorithms and Applications", CRC Press, 2014.
6. Richard O. Duda, Peter E. Hart, and David G.Stork, "Pattern Classification", second edition, Wiley-Interscience, 2001
7. Chritopher Bishop, "Pattern Recognition and Machine Learning", Springer,2006.
8. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012
9. JiaweiHanandMichelineKambersandJianPei,"DataMiningConcepts andTechniques",3rd edition, Morgan Kaufman Publications, 2012.

REFERENCE BOOKS:

1.Tom Mitchell, "Machine Learning", McGraw-Hill, 1997

2. Francois Chollet, "Deep Learning with Python", Manning Publications, 2017

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	3	3	3	2								3	3		2
CO 2	3	3	3	3	2								2	2		2
CO 3	3	3	3	3	2								2	2		2
CO 4	3	3	3	3	2								2	2		2
CO 5	3	3	3	3	2								2	2		2
Average	3	3	3	3	2								2	2		2

1924104   **NEXT GENERATION DATABASES**   **L T P C**

                                                                                     3 0 0 3

OBJECTIVES:

- To explore the concepts of NoSQL Databases.
- To understand and use columnar and distributed database patterns.
- To learn to use various Data models for a variety of databases.
- To understand the distributed database techniques
- To know the data models and storage ideas.

UNIT – I: INTRODUCTION   9

Database Revolutions- System Architecture- Relational Database- Database Design-
Data Storage- Transaction Management- Data warehouse and Data Mining- Information
Retrieval.

UNIT - II: DOCUMENT DATABASES   9

Big Data Revolution- CAP Theorem- Birth of NoSQL- Document Database—XMLDatabases-
JSON Document Databases- Graph Databases.

UNIT - III: COLUMN DATABASES   9

Column Databases— Data Warehousing Schemes- Columnar Alternative- Sybase IQ-
CStoreandVertica- Column Database Architectures- SSD and In-Memory Databases— In-
Memory Databases- Berkeley Analytics Data Stack and Spark.

UNIT - IV: DISTRIBUTED DATABASES   9

Distributed Database Patterns— Distributed Relational Databases- Non-relationalDistributed
Databases- MongoDB - Sharing and Replication- HBase- Cassandra-Consistency Models—
Types of Consistency- Consistency MongoDB- HBaseConsistency- Cassandra Consistency.

UNIT - V: DATA MODELS AND STORAGE   9

Data Models and Storage- SQL- NoSQL APIs- Return SQL- Advance Databases—
PostgreSQL- Riak- CouchDB- NEO4J- Redis- Future Databases— Revolution Revisited-
Counter revolutionaries- Oracle HQ- Other Convergent Databases- Disruptive
DatabaseTechnologies.

                                                              TOTAL :45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Explore the relationship between Big Data and NoSQL databases
- Work with NoSQL databases to analyze the big data for useful business applications.
- Work with different data models to suit various data representation and storageneeds.
- Apply the distributed database techniques
- Analyse the Future Databases

TEXT BOOKS:

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", Sixth Edition, McGrawHill.2019.
2. Guy Harrison, "Next Generation Databases", Apress, 2015.
3. Eric Redmond, Jim R Wilson, "Seven Databases in Seven Weeks", LLC. 2012.
4. Dan Sullivan, "NoSQL for Mere Mortals", Addison-Wesley, 2015.

REFERENCE BOOKS:

1. Adam Fowler, "NoSQL for Dummies ", John Wiley & Sons, 2015.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	3	2											2		
CO 2		3	3	3	1									3		
CO 3		3	3	3	3									2		
CO 4	2	3		3	3									3		
CO 5	3	3	3	2	2									2		
Average	3	3	3	3	2									2		

1924105   **DATA SCIENCE AND R ESSENTIALS LABORATORY**   **L T P C**

                                                                     0 0 4 2

OBJECTIVES:

- Make use of Data sets in implementing the machine learning algorithms
- Implement the machine learning concepts and algorithms in any suitable language of choice.
- Understand the reinforcement concept
- Understand the classification and clustering algorithms
- Learn the usage of python and R in implementing machine Learning algorithms

LIST OF EXPERIMENTS:

1. Basic concepts of R programming
2. Viewing and manipulating data,plotting data reading your won data
3. Describing and comparing two or more data sets –experimental data,boxplots,a factorial design, observational data
4. Comparing means in factorial studies-Factorial design-The effect of a factor on the response-the principles of ANOVA
5. Estimating a linear relationship-A statistical model for a linear relationship least squares estimates the R function lm scrutinising the residuals.
6. Curve fitting in factorial studies-modelling FTP times on the internet-an experiment with capacitors.
7. Densities of Random Variables Off the Shelf Distributions in *R,* Matching a Density to Data ,More About Making Histograms.
8. Building Confidence in Confidence Intervals-Populations Versus Samples, Large Sample Confidence Intervals ,Simulating Data Sets,Evaluating the Coverage of Confidence Intervals
9. Implement and demonstrate the Candidate-Elimination algorithm
10. Implement the non-parametric Locally Weighted Regression algorithm
11. Implement and demonstrate the FIND-S algorithm
12. Examining stock returns (http://lipas.uwasa.fi/~sjp/Teaching/rp/r/ex11.R)

                                                                TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Apply various classification and clustering techniques for problems using tools like R and Python.
- Implement solutions for various prediction problems using tools.
- Design and development of game and traffic control system using reinforcement learning.
- Implement the machine learning algorithms using python and R.
- Design and develop solutions for the machine learning algorithms using various datasets.

LIST OF SOFTWARE FOR A BATCH OF 20 STUDENTS:

SOFTWARE:

R Studio or Equivalent Open Source tools for windows /Linux

HARDWARE:

Standalone desktops 20 Nos.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	1	2			3									3		
CO 2	1	2	3		3									3		
CO 3	1	2	3		3									3		
CO 4	1	2	2		3									3		
CO 5	1	2	3		3									3		
Average	1	2	3		3									3		

MACHINE LEARNING LABORATORY

OBJECTIVES:

- To Make use of Data sets in implementing the machine learning algorithms
- To implement the machine learning concepts and algorithms in any suitable language of choice.
- To Understand the reinforcement concept
- To evaluate the classification and clustering algorithms
- Learn the usage of python in implementing machine Learning algorithms

LIST OF EXPERIMENTS:

1. Study and usage of python tool.
2. Implement a classifier.
3. Develop a predictive model.
4. Implement a decision tree algorithm.
5. Implement back propagation algorithm.
6. Implement similarity based clustering algorithm.
7. Implement clustering algorithm for any data set.
8. Apply reinforcement learning.
9. implement and demonstrate the Candidate-Elimination algorithm
10. implement k-Nearest Neighbour algorithm
11. Implement the non-parametric Locally Weighted Regression algorithm

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Apply various classification and clustering techniques for problems using tools like Python.
- Implement solutions for various prediction problems using tools.
- Design and development of game and traffic control system using reinforcement learning.
- Implement the machine learning algorithms using python.
- Design and develop solutions for the machine learning algorithms using various datasets.

LIST OF SOFTWARE FOR A BATCH OF 20 STUDENTS:

SOFTWARE:

Python 3 interpreter for Windows/Linux, Open Source tools

HARDWARE:

Standalone desktops 20 Nos.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	3	3	1					1			2	1	2		
CO 2	3	3	3	2		1			1			1	1	2		
CO 3	3	3	3	1					1			1	1	1		1
CO 4	3	3	3	2					1			2	2	1		
CO 5	3	3	3	1									1	1		
Average	3	3	3	1		1			1			2	1	1		1

1918201   **STATISTICAL LEARNING FOR DATA SCIENCE**   **L T P C**

                                                                        4 0 0 4

OBJECTIVES:

- To provide the required skill to apply the statistical tools in engineering problems.
- To introduce the basic concepts of probability and random variables and concepts of two dimensional random variables.
- To acquaint the knowledge of testing of hypothesis for small and large samples this plays an important role in real life problems.
- To introduce the basic concepts of Time Series as a discrete stochastic process.
- To introduce the basic concepts of classifications of design of experiments this plays very important roles in randomized block design, Lattin square design.

UNIT – I: **PROBABILITY AND RANDOM VARIABLES**   **12**

Introduction to probability –Bayes theorem-Random variables-discrete random variable (Binomial, Poisson, Geometric), Continues random variable (Uniform, Exponential and Normal distribution).Moment generating function.

UNIT - II: **TWO DIMENSIONAL RANDOM VARIABLES**   **12**

Joint distribution –Marginal and conditional distribution covariance –correlation and regression (linear and Multiple). Central limit theorem, Chebyshev's inequality.

UNIT - III: **THEORY OF SAMPLING AND TEST OF HYPOTHESIS**   **12**

Introduction to hypothesis, Large and small samples test -mean and variance (single and double), test, Independent of attributes and contingency table

UNIT - IV: **TIME SERIES ANALYSIS**   **12**

Introduction to Stochastic process, Time series as a discrete stochastic process.Stationarity, Main characteristics of stochastic process (mean, auto co variation and auto correlation function). Autoregressive models AR (p), Yull-Worker equation Auto regressive moving average models ARMA. Seasonality in Box –Jenkins model

UNIT - V: **DESIGNOF EXPERIMENTS**   **12**

Analysis of variance (one way & two ways) classification – completely randomized design – randomized block design – Lattin square design.

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the fundamental knowledge of the concepts of probability and have knowledge of standard distributions which can describe real life phenomenon.

- Understand the basic concepts of one and two dimensional random variables and apply in engineering applications.

- Apply the concept of testing of hypothesis for small and large samples in real life problems.

- Apply the basic concepts of Time Series as a discrete stochastic process

- Have the notion of sampling distributions classifications of design of experiments in the field of statistical quality control.

REFERENCE BOOKS:

1. T.Veerarajan , "Probability, Statistics and Random Processes" Tata McGraw-Hill, Education 2008

2. K.S.Trivedi.John , "Probability and statistics with reliability, Queuing and computer Science Application", Second edition, Wiley&Son, 2016

3. Maurice George Kendall, J. K. Ord,"Time series" Oxford University Press, 1990

4. Levin Richard and Rubin Davids, "Statistics for Management ", Pearson Publications,2016

5. Robert Stine, Dean Foster ,"Statistical for Business: Decision Making and Analysis". Pearson Education, 2nd edition,2013

E BOOKS:

1. http://www.math.harvard.edu/~knill/teaching/math144_1994/probability.pdf

2. http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/book.pdf MOOC 3.

3. https://nptel.ac.in/courses/IIT-MADRAS/Principles_of_Communication1/Pdfs/1_5.pdf 2 https://nptel.ac.in/courses/110104024

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	3											2	2		2
CO 2	3	2														
CO 3	3	2														
CO 4	3	2														2
CO 5	3	2														
Average	3	2											2	2		2

1924201   **IMAGE AND VIDEO PROCESSING**   **L T P C**

                                                                                           3 0 0 3

OBJECTIVES:

- To provide concept of signals and systems frequency domain image filtering and enhancement.
- To analyze the spatial domain image enhancement
- To explore the concept of image compression techniques.
- To understand the video processing methods
- To learn the video compression standards.

UNIT – I: DIGITAL SIGNAL PROCESSING, FREQUENCY DOMAIN   9

IMAGE FILTERING AND ENHANCEMENT

2-D signals and systems, 2D symmetry and periodicity,2D DFT, symmetry and other properties, 2-D FIR filters, frequency response, circular symmetry, Visual Perception and Color Spaces (1 week) Physiological characteristics of the eye and image formation, Human color vision.

UNIT - II: SPATIAL DOMAIN IMAGE ENHANCEMENT AND   9

FILTERING& RESTORATION

Image decimation and interpolation, multi-resolution pyramids Image sampling, Spatio-temporal (M-D) sampling theory Edge detection, Image enhancement, Noise filtering, Image restoration:Image degradation model , Inverse Filtering , Wiener filtering

UNIT - III: FUNDAMENTALS OF IMAGE COMPRESSION ENTROPY   9

CODING

Lossless image compression, JPEG image compression, JPEG-2000 image compression, Multi-resolution and Wavelet Transform

UNIT - IV: VIDEO PROCESSING   9

Video sampling, flicker, spatial frequency response, Motion modeling and estimation, Optical flow modeling and estimation, Block matching, feature matching, Parametric motion estimation, Video filtering , Deinterlacing, Denoising

UNIT - V: VIDEO COMPRESSION STANDARDS   9

MC-DCT video compression: MPEG-1, MPEG-2 video compression, H.263/MPEG-4 video compression: Compression efficiency, MPEG-4 AVC/H.264 video compression, Scalable video coding (SVC), Error resilient compression, Video over IP.

                                                                                  TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the concept of signals and systems frequency domain image filtering and enhancement.
- Analyze the spatial domain image enhancement
- Evaluate the concept of image compression techniques.
- Apply the video processing methods
- Remember the video compression standards.

TEXT BOOKS:

1. Ed. Al Bovik "Handbook of Image and Video Processing" , Academic Press, 2000. ISBN 0-12- 119790-5 .

2. Gonzalez and Woods "Digital Image Processing", Addison-Wesley, 2001. ISBN 0201-18075-8

REFERENCE BOOKS:

1. J. W. Woods "Multidimensional Signal, Image and Video Processing and Coding", Academic Press, 2006. ISBN 0-12-088516-6 2.

2. Y. Wang, J. Ostermann, and Y.-Q. Zhang "Video Processing and Communications", Prentice Hall, 2002. ISBN 0-13-017547-1

3. A.Tekalp "Digital Video Processing", Prentice Hall, 1995. ISBN 0-13-190075-7.

CO-PO and CO-PSO Mapping

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	1	3	3		2		1					2	2		2	
CO 2	1	2	3		1											
CO 3	1	3	3		2						2				3	
CO 4	1	2	3		1						3	2	2		3	
CO 5	1	3	3		2						3		2			
Average	1	3	3		2		1				3	2	2		3	

1924202   **DATA PREPROCESSING AND OPTIMIZATION**   **L T P C**
                            TECHNIQUES   **3 0 0 3**

OBJECTIVES:
- To understand the concept of data pre-processing
- To analyse the concept of data transformation
- To explore the data pre-processing tools Numpy,Pandas and Matplottilib.
- To learn the concept of optimization techniques.
- To demonstrate the constrained and unconstrained optimization.

UNIT – I: **INTRODUCTION TO DATA PREPROCESSING**   **9**

Introduction to data preprocessing-Data cleaning- Noisy data- Data integration- Data reduction.

UNIT - II: **DATA TRANSFOEMATION**   **9**

Data transformation-Mean removal- Scaling- Normalization- Binarization- One Hot Encoding-
Label Encoding.

UNIT - III: **TOOLS FOR PREPROCESSING**   **9**

Crucial   libraries,   Python   libraries   used   for   preprocessing   in   Machine
Learning UsingNumpy,Pandas,Matplotlib**.**Import the dataset,Identifying and handling the missing
values,Encoding the categorical data,Splitting the dataset,Feature scaling.

UNIT - IV: **OPTIMIZATION**   **9**

optimization - sequences and limits, derivative matrix, level sets and gradients, Taylor series,
unconstrained optimization - necessary and sufficient conditions for optima, convex sets, convex
functions, optima of convex functions, steepest descent, Newton and quasi Newton methods,
conjugate direction methods.

UNIT - V: **CONSTRAINED OPTIMIZATION**   **9**

constrained optimization - linear and non-linear constraints, equality and inequality constraints,
optimality conditions, constrained convex optimization, projected gradient methods, penalty methods

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Analyse the concept of data pre-processing
- Understand and analyses the concept of data transformation
- Explore the data pre-processing tools Numpy, Pandas and Matplottilib.
- Apply the concept of optimization techniques.
- Demonstrate the constrained and unconstrained optimization in data analytics

TEXT BOOKS:

1. E. K. P. Chong and S. H. Zak," An Introduction to Optimization", 2nd Edn., Wiley India Pvt. Ltd., 2010.
2. D. G. Luenberger and Y. Ye, "Linear and Nonlinear Programming", 3rd Edn., Springer, 2010.
3. Luengo, Julián, García, Salvador "Data Pre-processing in Data Mining",(Intelligent Systems Reference Library Book 72) ""Springer

REFERENCE BOOKS:

1. Robert M. Gower &AlexandreGramfort "Optimization for Data Science" Master 2 Data Science, Univ. Paris Saclay
2. Stephen J. Wright"Optimization Algorithms for Data Analysis" IAS/Park City Mathematics Series

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2												2			
CO 2	2	2	2	2										1		
CO 3	2	2	2	2	3											2
CO 4	2	2	2	2											3	
CO 5	2	2	2	2												3
Average	2	2	2	2	3								2	1	3	3

1924203   **ADVANCED DATA VISUALIZATION TECHNIQUES**   **L T P C**

                                                                                 3 0 0 3

OBJECTIVES:

- To understand how to accurately represent voluminous complex data set in web and from other data sources.
- To understand the methodologies used to visualize large data sets.
- To understand the various process involved in data visualization.
- To apply data visualization techniques.
- To understand the different security aspects involved in data visualization

UNIT – I: INTRODUCTION   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: DATA VISUALIZATION TECHNIQUES   9

Mapping - Time series - Connections and correlations - Scatterplot maps - Trees, Hierarchies andRecursion - Networks and Graphs, Info graphics.Univariate data visualization: Bar chart, histograms, frequency polygram, box plots, dot plots - Bivariate data visualization - Multivariate data visualization: Histogram matrix, scatterplot matrix, multiple box plot and trellis plot - Visualizing groups - Dynamic techniques

UNIT - III: VISUALIZING DATA PROCESS   9

Acquiring data, - Where to Find Data, Tools for Acquiring Data from the Internet, Locating Files for Use with Processing, Loading Text Data, Dealing with Files and Folders, Listing Files in a Folder, Asynchronous Image Downloads, Advanced Web Techniques, Using a Database, Dealing with a Large Number of Files. Parsing data - Levels of Effort, Tools for Gathering Clues, Text Is Best, Text Markup Languages, Regular Expressions (regexps), Grammars and BNF Notation, Compressed Data, Vectors and Geometry, Binary Data Formats, Advanced Detective Work.

UNIT - IV: INTERACTIVE DATA VISUALIZATION   9

Drawing with data – Scales – Axes – Updates, Transition and Motion – Interactivity - Layouts – Geomapping – Exporting, Framework – T3, .js, tablo.

UNIT - V: SECURITY DATA VISUALIZATION   9

Port scan visualization - Vulnerability assessment and exploitation - Firewall log visualization - Intrusion detection log visualization -Attacking and defending visualization systems – CreatingSecurity visualization system.

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the representation of complex and voluminous data.
- Design and use various methodologies present in data visualization.
- Understand the various process and tools used for data visualization.
- Use interactive data visualization to make inferences.
- Discuss the process involved and security issues present in data visualization

TEXT BOOKS:

1. Scott Murray, "Interactive data visualization for the web", O"Reilly Media, Inc., 2013.
2. Stephen Few, "Now you see it: Simple Visualization techniques for quantitative analysis",
Analytics Press, 2009.

REFERENCE BOOKS:

1. Ben Fry, "Visualizing Data", O"Reilly Media, Inc., 2007.
2. Greg Conti, "Security Data Visualization: Graphical Techniques for Network Analysis",
   NoStarch Press Inc, 2007.
3. Nathan Yau, "Data Points: Visualization that means something", Wiley, 2013.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2	3	3	2			2									2
CO 2	2	3	3		2		2	2								2
CO 3	2	3	3				2				1					2
CO 4	2	3	2		2		2				2					2
CO 5	2	3	2				2									2
Average	2	3	3	1	2		2	1			2					2

1924210   **DATA VISUALIZATIONLABORATORY**   **L T P C**

                                                                                    0 0 4 2

OBJECTIVES:

- To understand the need of different datasets visualization
- Can perform descriptive and inferential analysis on data sets
- Can create visualization using modern tool
- Can develop analytical products
- Identify opportunities for application of data visualization in various domains

LIST OF EXPERIMENTS:

1. Identification of different types of data on the dataset
2. Visualization of datasets in terms of Line Chat, Area Chart, Bar Chart, Pie Chart, histogram, scatterplot, violin plot etc.
3. Representation of datasets and performing various statistical operation
4. Interactive Development of dashboard
5. Creating Visualization with Tableau
6. Presenting the working of dataset with Pivot Tables and Pivot Chart
7. Making World Map interaction with D3.js and SVG
8. Analysis of Variance (ANOVA)
9. Analysis of Covariance(ANCOVA)
10. Statistics associated with cluster Analysis
11. Design and development of Analytical products

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Design and create data visualizations.
- Conduct exploratory data analysis using visualization.
- Craft visual presentations of data for effective communication.
- Use knowledge of perception and cognition to evaluate visualization design alternatives.
- Use JavaScript with D3.js to develop interactive visualizations for the Web.

LIST OF SOFTWARE FOR A BATCH OF 20 STUDENTS:

SOFTWARE:

1. Tableau/Apache Spark
2. Python Version 3.X
3. JavaScript enabled browser

HARDWARE:

Standalone desktops 20 Nos.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2	3	3		2										2	
CO 2	2	3	3		2										2	
CO 3	2	3	3		2					3					3	
CO 4		3	3		2		2			3	3	2			3	2
CO 5		3	3		2		2			2	3	2			3	2
Average	2	3	3		2		2			3	3	2			3	2

1924301   **DEEP LEARNING**   **L T P C**

                                                          3 0 0 3

OBJECTIVES:

- To understand the basic building blocks and general principles that allow one to design machine learning algorithms
- To become familiar with specific, widely used machine learning algorithms
- To introduce building blocks of deep neural network architecture
- To understand representation and transfer of knowledge using deep learning
- To learn to use deep learning tools and framework for solving real-life problems

UNIT – I: **INTRODUCTION**   **9**

Basic Concepts, Introduction to Machine Learning, Applications of ML, Design Perspective and Issues in ML, Supervised, Unsupervised, Semi-supervised learning with applications and issues.

UNIT - II: **DEEP NETWORKS**   **9**

Deep Networks – Introduction to Neural Networks, Feed-forward Networks, Deep Feed-forward Networks - Learning XOR, Gradient Based learning, Hidden Units, Back-propagation and other Differential Algorithms, Regularization for Deep Learning, Optimization for training Deep Models.

UNIT - III: **CONVOLUTIONAL NETWORKS**   **9**

Convolution operation, Motivation, Pooling, Convolution and Pooling as strong prior, Efficient convolution algorithms, Unsupervised features, Sequence Modeling: Recurrent and Recursive Nets, LSTM Networks, Applications - Computer Vision, Speech Recognition, Natural Language Processing.

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: **DEEP LEARNING FRAMEWORKS**   **9**

Introduction to Keras and Tensorflow, Deep Learning for computer vision - convnets, Deep Learning for Text and Sequences, Generative Deep Learning - Text Generation with LSTM,

Deep Dream, Neural Style Transfer, Generating images with variational auto encoders, Generative Adversarial Networks (GAN).

TOTAL:45 PERIODS

OUTCOMES

At the end of the course, the student should be able to:

- Ability to implement and apply machine learning algorithms to real-world applications.
- Identify the deep learning algorithms which are more appropriate for various types of learning tasks in various domains
- Incorporate transfer of knowledge in machine learning algorithms
- Implement deep learning algorithms and solve real-world problems
- Understand the deep learning tools and framework for solving real-life problems

TEXT BOOKS :

1. Ethem Alpaydin, "Introduction to Machine Learning", PHI, 2005
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", The MIT Press, 2016.

REFERENCE BOOKS:

1. Tom Mitchell, "Machine Learning", McGraw-Hill, 1997
2. Francois Chollet, "Deep Learning with Python", Manning Publications, 2017
3. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", O'Reilly Media; 1 edition (April 9, 2017)
4. Josh Patterson, "Deep Learning: A Practitioner's Approach", O'Reilly Media; 1 edition (August 19, 2017)

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2	2	2	2									2			
CO 2	2	2	2	2										2		
CO 3	2	2	2	2											1	
CO 4	2	2	2	2									3			
CO 5	2	2	2	2											2	
Average	2	2	2	2									3	2	2	

PROFESSIONAL ELECTIVE - I

1924204	IoT TECHNOLOGIES	L T P C
		3 0 0 3

OBJECTIVES:

- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

UNIT – I: FUNDAMENTALS OF IoT   9

Evolution of Internet of Things – Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors,Actuators, Smart Objects and Connecting Smart Objects

UNIT - II: IoT PROTOCOLS   9

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4,802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions,Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo,Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT.

UNIT - III: DESIGN AND DEVELOPMENT   9

Design Methodology – Embedded computing logic – Microcontroller, System on Chips – IoT system building blocks – Arduino – Board details, IDE programming – Raspberry Pi – Interfaces and Raspberry Pi with Python Programming

UNIT - IV: DATA ANALYTICS AND SUPPORTING SERVICES   9

.Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework –Django – AWS for IoT – System Management with NETCONF-YANG.

UNIT - V: CASE STUDIES/INDUSTRIAL APPLICATIONS   9

Cisco IoT system – IBM Watson IoT platform – Manufacturing – Converged Plantwide Ethernet Model (CPwE) – Power Utility Industry – GridBlocks Reference Model – Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Explain the concept of IoT.

- Analyze various protocols for IoT.

- Design a PoC of an IoT system using Rasperry Pi/Arduino

- Apply data analytics and use cloud offerings related to IoT

- Analyze applications of IoT in real time scenario

TEXT BOOKS:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things ", Cisco Press, 2017

REFERENCE BOOKS:

1. ArshdeepBahga, Vijay Madisetti, "Internet of Things – A hands-on approach", Universities Press, 2015

2. Olivier Hersent, David Boswarthick, Omar Elloumi , —The Internet of Things – Key applications and Protocols‖, Wiley, 2012 (for Unit 2).

3. Jan Ho¨ ller, VlasiosTsiatsis , 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..Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), "Architecting the Internet of Things", Springer, 2011.

4. By Michael Margolis, Brian Jepson, Nicholas Robert Weldin, "Arduino Cookbook: Recipes to Begin, Expand, and Enhance Your Projects",2nd Edition, O'Reilly Media, 2011.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3															
CO 2	3	3	2													
CO 3	3	3	3	2	2									2	3	
CO 4	3	2	2											2	3	2
CO 5	3	3	2	2										2	3	
Average	3	3	2	2	2									2	3	2

1924205   **WEB SCRAPING**   **L T P C**

                                                                   3 0 0 3

OBJECTIVES:

- To understand the basic concepts of web scraping.
- To scrap the data from web page
- To understand caching downloads.
- To understand the concept of concurrent downloading & dynamic content
- To interacting with forms & to use the popular high-level Scrapy framework

UNIT – I: INTRODUCTION TO WEB SCRAPING   9

Building Scrapers - First Web Scraper - An Introduction to BeautifulSoup -When is web scraping useful? -Is web scraping legal? -Background research-Crawling your first website-Downloading a web page- Sitemap crawler-ID iteration crawler-Link crawler.

UNIT - II: SCRAPING THE DATA   9

Analyzing a web page - Three approaches to scrape a web page-Regular expressions- Beautiful Soup- Lambda Expressions- Lxml- CSS selectors- Comparing performance - Scraping results.

UNIT - III: CACHING DOWNLOADS   9

Adding cache support to the link crawler - Disk cache : Implementation - Testing the cache - Saving disk space - Expiring stale data- Drawbacks- Database cache: What is NoSQL?- Installing MongoDB - Overview of MongoDB - MongoDB cache implementation- Compression- Testing the cache.

UNIT - IV: CONCURRENT DOWNLOADING & DYNAMIC CONTENT   9

Sequential crawler - Threaded crawler - Cross-process crawler- Performance.- An example dynamic web page- Reverse engineering a dynamic web page- Rendering a dynamic web page-Website interaction with WebKit.

UNIT - V: INTERACTING WITH FORMS & SCRAPY   9

The Login form-Loading cookies from the web browser-Extending the login script to update content-Automating forms with the Mechanize module- Scrapy -Defining a model-Creating a spider-Visual scraping with Portia

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand web scraping and the ways to crawl a website.

- Extract data from web pages.

- Avoid re-downloading by caching results.

- To scrape data faster by downloading in parallel and to extract data from dynamic websites.

- Interacting with Forms and to work with forms to access the data Compare and contrast various memory management schemes.

TEXT BOOKS:

1. Richard Lawson," Web Scraping with Python", Packt Publishing Ltd,2015.
2. Ryan Mitchell," Web Scraping with Python Collecting Data from the Modern Web", First Edition, O'Reilly Media, Inc., 2015.

REFERENCE BOOKS:

1. Vineeth G. Nair, "Getting Started with Beautiful Soup", Packt Publishing Ltd.2015.
2. Katharine Jarmul, Richard Lawson, "Python Web Scraping," second edition, Packt Publishing,2017.
3. Al Sweigart," Automate the Boring Stuff with Python, 2nd Edition: Practical Programming for Total Beginners",2019

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2					1	2	2		1			1			
CO 2	2	2	1	2	2	2		2						2		
CO 3	2	1	1	2	3									2		
CO 4	2	1	1											2	2	
CO 5				2	2					1				2	2	
Average	2	2	1	2	2	2	2	2		1			1	2	2	

1924206   **INFORMATION STORAGE TECHNIQUES**   **L T P C**
                                                                                  3 0 0 3

OBJECTIVES:

- To understand the storage architecture and available technologies
- To learn to establish & manage data centre
- To learn different networked storage options for different application environments
- To understand the security aspects and Key management tasks in data centre
- To learn the common threats in each domain

UNIT – I: STORAGE TECHNOLOGY   9

Review data creation and the amount of data being created and understand the value of data to a business, challenges in data storage and data management, Solutions available for data storage, Core elements of a data center infrastructure, role of each element in supporting business activities.

UNIT - II: STORAGE SYSTEMS ARCHITECTURE   9

Hardware and software components of the host environment, Key protocols and concepts used by each component ,Physical and logical components of a connectivity environment ,Major physical components of a disk drive and their function, logical constructs of a physical disk, access characteristics, and performance Implications, Concept of RAID and its components, Different RAID levels and their suitability for different application environments: RAID 0, RAID 1, RAID 3, RAID 4, RAID 5, RAID 0+1, RAID 1+0, RAID 6, Compare and contrast integrated and modular storage systems ,Iligh-level architecture and working of an intelligent storage system

UNIT - III: INTRODUCTION TO NETWORKED STORAGE   9

Evolution of networked storage, Architecture, components, and topologies of FC-SAN, NAS, and IP-SAN, Benefits of the different networked storage options, understand the need for long-term archiving solutions and describe how CAS full fill the need, understand the appropriateness of the different networked storage options for different application environments.

UNIT - IV: INFORMATION AVAILABILITY, MONITORING &   9
                      MANAGINGDATACENTERS

List reasons for planned/unplanned outages and the impact of downtime, Impact of downtime -Business continuity (BC) and disaster recovery (DR) ,RTO and RPO,Identifysingle points of failure in a storage infrastructure and list solutions to mitigate

these failures, architecture of backup/recovery and the different backup/ recovery topologies, replication technologies and their role in ensuring information availability and business continuity, Remote replication technologies and their role in providing disaster recovery and business continuity capabilities. Identify key areas to monitor in a data center, Industry standards for data center monitoring and management, Key metrics to monitor for different components in a storage infrastructure, Key management tasks in a data center.

UNIT - V: SECURING STORAGE AND STORAGE VIRTUALIZATION   9

Information security, Critical security attributes for information systems, Storage security Domains,List and analyzes the common threats in each domain, Virtualization technologies, block-level and file-level virtualization technologies and processes.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the various storage technologies to suit for required application
- Apply security measures to safeguard storage & farm
- AnalyzeQoS on Storage
- Remember data centre recovery topologies
- Evaluate and identify common threats in each domain

TEXT BOOKS:

1. G.Somasundaram and AlokShrivastava"Information Storage and Management: Storing, Managing, andProtecting Digital Information", EMC Education services, Wiley publishing Inc.2009

REFERENCE BOOKS:

1. Marc Farley, ―Building Storage Networksǁ, Tata McGraw Hill,Osborne, 2001.
2. Robert Spalding, ―Storage Networks: The Complete Reference―, Tata McGraw Hill Osborne, 2003.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2	3	2			2		2		2		2		2		
CO 2	2				3	2		2		2	3					
CO 3	3	3	3	3		3				2					3	
CO 4	3	3		3			3		2			3	3			
CO 5	3	3	3	2				2	2			3	3			
Average	3	3	3	3	3	2	3	2	2	2	3	3	3	2	3	

1924207   **COMPUTATIONAL INTELLIGENCE**   **L T P C**

3 0 0 3

OBJECTIVES:

- To introduce the basic concepts, theories and state-of-the-art techniques of artificial intelligence.

- To provide an understanding of the basic mathematical elements of the theory of fuzzy sets.

- To solve problems that is appropriately solved by neural networks, deep learning.

- To apply Computational Intelligence techniques using genetic algorithms

- To understand Computational Intelligence techniques applications.

UNIT – I: **INTRODUCTION**   **9**

Introduction to Artificial Intelligence-Search-Heuristic Search-A* algorithm-Game Playing-Alpha-Beta Pruning-Expert systems-Inference-Rules-Forward Chaining and Backward Chaining- Genetic Algorithms. Proposition Logic - First Order Predicate Logic – Unification – Forward Chaining -Backward Chaining - Resolution – Knowledge Representation - Ontological Engineering - Categories and Objects – Events - Mental Events and Mental Objects - Reasoning Systems for Categories - Reasoning with Default Information - Prolog Programming.

UNIT - II: **FUZZY SET THEORY**   **9**

Fuzzy Sets, Basic Definition and Terminology, Set-theoretic Operations, Member Function Formulation and Parameterization, Fuzzy Rules and Fuzzy Reasoning using IF-THEN rules, Extension Principle and Fuzzy Relations, Fuzzy Inference Systems.

UNIT - III: **NEURAL NETWORKS & DEEP LEARNING:**   **9**

Artificial Neural Network, Supervised Learning Neural Networks, Perceptrons and its limitations, Adaline, Back propagation learning algorithm MutilayerPerceptrons, Radial Basis Function Networks,Unsupervised Learning Neural Networks, Deep Neural Network, Convolutional Neural Network, Competitive Learning Networks,Kohonen Self- Organizing Networks, Learning Vector Quantization,Hebbian Learning, Hop-field networks.

UNIT - IV: **OPTIMIZATION**   **9**

Derivative-based Optimization, Descent Methods, The Method of Steepest Descent, Classical Newton's Method, Step Size Determination, Derivative-free Optimization, Concepts of Genetic Algorithms, GA techniques, Simulated Annealing, Random Search, Downhill Simplex Search, Evolutionary Computing, Swarm optimization, Green

Computing, Big data mining.

UNIT - V: INTELLIGENCE AND APPLICATIONS 9

Natural language processing-Morphological Analysis-Syntax analysis-Semantic Analysis-All applications – Language Models - Information Retrieval – Information Extraction - Machine Translation – Machine Learning - Symbol-Based – Machine Learning: Connectionist – Machine Learning.

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand concept of knowledge representation and predicate logic and transform the real life information in different representation.
- Apply basic fuzzy inference and approximate reasoning.
- Understand principles of neural networks
- Identify the computational issues and apply suitable algorithms to solve it effectively.
- Understand the applications of computational intelligence

TEXT BOOKS:

1. Stuart Russell, Peter Norvig, ―Artificial Intelligence: A Modern Approach‖, Third Edition, Pearson Education / Prentice Hall of India, 2010.
2. Fuzzy Logic with Engineering Applications, Timothy J. Ross, McGraw-Hill, 1997.

REFERENCE BOOKS:

1. Genetic Algorithms: Search, Optimization and Machine Learning, Davis E. Goldberg,Addison Wesley, N.Y.,1989
2. Neural Networks: A Comprehensive Foundation, Simon Haykin. Prentice Hall
3. Neural Network Design, M. T. Hagan, H. B. Demuth, Mark Beale, Thomson Learning,Vikash Publishing House.
4. Neural Networks, Fuzzy Logic and Genetic Algorithms, S. Rajasekaran and G.A.V.Pai,PHI, 2003.
5. Nils J. Nilsson, "Artificial Intelligence: A new Synthesis", Harcourt Asia Pvt. Ltd., 2000.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	3	3	1									2	2		
CO 2	3	3	2	1								1		2		
CO 3	3	3	2	2								1		2		
CO 4	3	3	2	1								1		2		
CO 5	3	3	2	1										2		2
Average	3	3	2.2	1.2								1		2		

1924208   **OPEN SOURCE TOOLS FOR DATA SCIENCE   L T P C**

3 0 0 3

OBJECTIVES:
- To understand tools applied for data analysis
- To apply the spyder techniques in data science
- To demonstrate editing and navigating in Pycharm
- To analyse dynamic form- display system- interpreter- deployment- security: available security support in apache zeppelin.
- To explore the application of Atom techniques and Jupyterin data science.

UNIT – I: SPYDER   9

Basic Arithmetic and Variable Assignment-Functions and Scoping-Strings, Indexing, and Slicing-Lists-The Idea of Objects-Python Objects-Attributes and Methods and a Few Spyder "Tricks"- Private Data and Encapsulation-Inheritance-Dictionaries-For Loops-If Statements.

UNIT - II: PyCHARM   9

Introduction-editing and navigating- Running Code - Debugging Code - Testing Code - Code Coverage - Scratch File . Version Control - Vagrant - External Tools - CSV files - Writing Documentation with Sphinx - File Watchers –web programming.

UNIT - III: ZEPPELIN   9

Introduction-Dynamic Form- Display System- Interpreter- Deployment- Security: available security support in Apache Zeppelin- Notebook Storage: a guide about saving notebooks to external storage- Operation

UNIT - IV: ATOM   9

Introduction to atom, Atom Packages, Moving in Atom, Atom Selections, Editing and Deleting Text, Find and Replace, Snippets, Autocomplete, Folding, Panes, Pending Pane Items, Tools of the Trade,TheInitFile,Package: Word Count,Package: Modifying Text,Package: Active Editor Info,Creating a Theme Converting from TextMate,Hacking on Atom Core,Contributing to Official Atom PackagesCreating a Fork of a Core Package in atom/atom,Maintaining a Fork of a Core Package in atom/atom.

UNIT - V: JUPYTER NOTEBOOK 9

Introduction - installation and getting started- dashboard- user interface- types of cells-editing - markdown cells - cell magic functions - — plotting- converting notebooks-ipywidgets – Qtconsole.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the tools applied for data analysis
- Apply the spyder techniques in data science
- Demonstrate editing and navigating in Pycharm
- Analyse dynamic form- display system- interpreter- deployment- security: available security support in apache zeppelin.
- Explore the application of Atom techniques and Jupyter in data science

TEXT BOOKS:

1. Dr. Poornima G. Naik , Dr. KavitaS.Oza "Python with Spyder : An Experiential Learning Perspective",sashwat publications,2019 ,India.
2. Pedro Kroger "Modern Python Development With PyCharm",Online material
3. Dan Toomey "Jupyter for Data Science", O'Reilly

REFERENCE BOOKS:(Websites)

1. file:///C:/Users/Admin/Desktop/MTCH%20DATA%20SCIENCE/PyCharmBook.pdf
2. https://jupyter-notebook.readthedocs.io/_/downloads/en/5.3.1/pdf/
3. https://zeppelin.apache.org/docs/0.8.2/
4. https://flight-manual.atom.io/
5. https://zeppelin.apache.org/docs/0.8.2/
6. https://ide.atom.io/

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
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CO 1	2	2	3	3				3					2	2	3	2
CO 2	2	2	3	3				3					2	2	3	2
CO 3	3	2	2			3	3						2	2	3	2
CO 4	3				3	2	3					2	3	2	3	2
CO 5	3				3	2			2	2	2	2	2	2	3	2
Average	3	2	3	3	3	2	3	2	2	2	2	2	2	2	3	2

1924209   **BUSINESS INTELLIGENCE**   **L T P C**

                                                                 3 0 0 3

OBJECTIVES:

- To Understand the concept of business intelligence
- To Get the knowledge on architecture of business intelligence
- To Acquire the knowledge on strategic level
- To Know the various analytical levels
- To Assess the concept of warehousing level

UNIT – I: **INTRODUCTION**   **9**

Business Intelligence: definition, concept and need for Business Intelligence, Case studies BIBasics: Data, information and knowledge, Role of Mathematical models.

UNIT - II: **ARCHITECTURES**   **9**

Effective and timely decisions –Business intelligence architectures: Cycle of a business intelligence analysis – Enabling factors in business intelligence projects – Development of a business intelligence system – Ethics and business intelligence.

UNIT - III: **STRATEGIC LEVEL**   **9**

Business Analytics at the strategic level: Strategy and BA, Link between strategy and Business Analytics, BA supporting strategy at functional level, dialogue between strategy and BAfunctions, information as strategic resource.

UNIT - IV: **ANALYTICAL LEVEL**   **9**

Business Analytics at Analytical level : Statistical data mining, descriptive Statistical methods, lists, reports, automated reports, hypothesis driven methods, data mining with target variables, cluster analysis, Discriminate analysis, logistic regression, principal component analysis.

UNIT - V: **DATA WAREHOUSING LEVEL**   **9**

Business Analytics at Data Warehouse Level, Designing physical database, Deploying andsupporting DW/BI system.

                                                              TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the concept of business intelligence basics and information
- Study the architecture of business intelligence and effective and timely decisions
- Get the knowledge on strategic levels in business
- Understand the various business analytical levels
- Analyse the concept of warehousing level in business

TEXT BOOKS:

1. Turban, Sharda&Delen,"Decision Support and Business Intelligence Systems", Pearson, 9thEdition, 2014.

REFERENCE BOOKS:

1. Olivia Parr Rud, "Business Intelligence Success Factors Tools for aligning your business in the global economy", John Wiley and Sons, 2009
2. Steve Williams and Nancy Williams, "The Profit impact of Business Intelligence", Morgan Kauffman Publishers! Elsevier, 2007
3. Gert H.N. Laursen, JesperThorlund, "Business Analytics for Managers: Taking Business Intelligence beyond reporting", Wiley and SAS Business Series. 2010.

CO - PO and CO - PSO MAPPING:

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CO 1	3													2		
CO 2	3	2		2										2		
CO 3	3		2	2		2								2		
CO 4	3						2							3		
CO 5	3	3												3		
Average	3	3	2	2		2	2							3		

1924302	BIG DATA ANALYTICS FOR IoT	L T P C
		3 0 0 3

OBJECTIVES:

- To learn the concepts of big data analytics
- To learn the concepts about Internet of things
- To understand and implement smart systems
- To apply the use of data analytics in IoT.
- To develop applications of IoT in Industrial contexts.

UNIT – I: **BIG DATA PLATFORMS FOR THE INTERNET OF THINGS**   9

Big Data Platforms for the Internet of Things: network protocol- data dissemination – current state of art- Improving Data and Service Interoperability with Structure, Compliance, Conformance and Context Awareness: interoperability problem in the IoT context- Big Data Management Systems for the Exploitation of Pervasive Environments - Big Data challenges and requirements coming from different Smart City applications.

UNIT - II: **RFID FALSE AUTHENTICATIONS**   9

On RFID False Authentications: YA TRAP – Necessary and sufficient condition for false authentication prevention - Adaptive Pipelined Neural Network Structure in Selfware Internet of Things: self-healing systems- Role of adaptive neural network Spatial Dimensions of Big Data: Application of Geographical Concepts and Spatial Technology to the Internet of Things- Applying spatial relationships, functions, andModels.

UNIT - III: **DATA ANALYTICS IN HYBRID CLOUD EDGE**   9
                ENVIRONMENT

Introduction –System design-terminologies –architecture –programmability-execution model comparison implementation and discussion.

UNIT - IV: **WEB ENHANCED BUILDING**   9

Toward Web Enhanced Building Automation Systems: heterogeneity between existing installations and native IP devices - loosely-coupled Web protocol stack –energysaving in smart building- Intelligent Transportation Systems and Wireless Access inVehicular

Environment Technology for Developing Smart Cities: advantages andachievements-Emerging Technologies in Health Information Systems: GenomicsDriven Wellness Tracking and Management System (GO-WELL) – predictive care –personalized medicine.

UNIT - V: SUSTAINABILITY DATA AND ANALYTICS   9

Sustainability Data and Analytics in Cloud-Based M2M Systems – potential stakeholders and their complex relationships to data and analytics applications – SocialNetworking Analysis - Building a useful understanding of a social network – Leveraging Social Media and IoT to Bootstrap Smart Environments : lightweight Cyber Physical Social Systems - citizen actuation.

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Explain the underlying architectures and models in IoT.
- Analyse different connectivity technologies for IoT.
- Analyze applications of IoT in real time scenario
- Apply data analytics techniques to IoT.
- Study the needs and suggest appropriate solutions for Industrial applications.

TEXT BOOKS:

1. Stackowiak, R., Licht, A., Mantha, V., Nagode, L.," Big Data and The Internet of Things Enterprise Information Architecture for A New Age", Apress, 2015.
2. Dr. John Bates , "Thingalytics - Smart Big Data Analytics for the Internet of Things", john Bates, 2015.

REFERENCE BOOKS:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things", Cisco Press, 2017
2. VigneshPrajapati, "Big Data Analytics with R and Hadoop", Packt Publishing, 2013.

CO - PO and CO - PSO MAPPING:

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CO 1	3													2		
CO 2		3		2											3	
CO 3					3	2										2
CO 4			2	3												3
CO 5	2			3												2
Average	3	3	2	3	3	2										

1924303   **SOCIAL NETWORK ANALYTICS**   **L T P C**

                                                                                      3 0 0 3

OBJECTIVES:

- To understand the component of the social network.
- To gain knowledge from disciplines as diverse as sociology
- To learn information of social web.
- To mine the users in the social network.
- To analysis cascade behaviour for network dynamics

UNIT – I: INTRODUCTION   9

Overview: Social network data-Formal methods- Paths and Connectivity-Graphs to represent social relations-Working with network data- Network Datasets-Strong and weak ties - Closure, Structural Holes, and Social Capital.

UNIT - II: SOCIAL INFLUENCE   9

Homophily: Mechanisms Underlying Homophily, Selection and Social Influence, Affiliation, Tracking Link Formation in On Line Data, Spatial Model of Segregation - Positive and Negative Relationships - Structural Balance - Applications of Structural Balance, Weaker Form of Structural Balance.

UNIT - III: INFORMATION NETWORKS AND THE WORLD WIDE   9
                       WEB

The Structure of the Web- World Wide Web- Information Networks, Hypertext, and Associative Memory- Web as a Directed Graph, Bow-Tie Structure of the Web- Link Analysis and Web Search Searching the Web: Ranking, Link Analysis using Hubs and Authorities- Page Rank- Link Analysis in Modern Web Search, Applications, Spectral Analysis, Random Walks, and Web Search.

UNIT - IV: SOCIAL NETWORK MINING   9

Clustering of Social Network graphs: Betweenness, Girvan newman algorithm-Discovery of communities- Cliques and Bipartite graphs-Graph partitioning methods-Matrices-Eigen values Simrank.

UNIT - V: NETWORK DYNAMICS   9

Cascading Behavior in Networks: Diffusion in Networks, Modeling Diffusion - Cascades

and Cluster, Thresholds, Extensions of the Basic Cascade Model- Six Degrees of Separation-Structure and Randomness, Decentralized Search- Empirical Analysis and Generalized Models- Analysis of Decentralized Search.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Work on the internals components of the social network.
- Learn knowledge from disciplines as diverse as sociology.
- Learn information in social web.
- Mine the behaviour of the users in the social network.
- Predict the changes in dynamic network.

TEXT BOOKS:

1. Easley and Kleinberg, "Networks, Crowds, and Markets: Reasoning about a highly connected world", Cambridge Univ. Press, 2010.
2. Robert A. Hanneman and Mark Riddle, "Introduction to social network methods", University of California, 2005.
3. Wasserman, S., & Faust, K, "Social Network Analysis: Methods and Applications", Cambridge University Press; 1 edition, 1994.

REFERENCE BOOKS:

1. Jure Leskovec, Stanford Univ. AnandRajaraman, Milliway Labs, Jeffrey D. Ullman, "Mining of Massive Datasets", Cambridge University Press, 2 edition, 2014.
2. Borgatti, S. P., Everett, M. G., & Johnson, J. C., "Analyzing social networks", SAGE Publications Ltd; 1 edition, 2013.
3. John Scott , "Social Network Analysis: A Handbook" , SAGE Publications Ltd; 2nd edition, 2000.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2					2	2			2			1		2	
CO 2	2					2	2	1		2					2	
CO 3	2	2	2			2	2	2		2					2	
CO 4	2	2	2	2		2	2	2		2					2	
CO 5	2	2	2	2											2	
Average	2	2	2	2		2	2	2		2			1		2	

TECHNIQUES IN IMAGE AND VIDEO ANALYTICS   **L T P C**

1924304   **3 0 0 3**

OBJECTIVES:

- To teach the fundamentals of digital image processing, image and video analysis.
- To understand the real time use of image and video analytics.
- To demonstrate real time image and video analytics applications and others
- To get knowledge on object detection and recognition.
- To explore the OpenCv in image processing.

UNIT – I: **DIGITAL IMAGE REPRESENTATION**   **9**

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

UNIT - II: **FUNDAMENTALS OF SPATIAL FILTERING**   **9**

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

UNIT - III: **COLOUR MODELS AND TRANSFORMATIONS**   **9**

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

UNIT - IV: **OBJECT DETECTION AND RECOGNITION**   **9**

Object detection and recognition in image and video-Texture models Image and Video 25 classification models- Object tracking in Video

UNIT - V: **ANALYSIS USING Open CV**   **9**

Introduction to OpenCV, Gui Features in OpenCV, Basic Operations on Images, Arithmetic Operations on Images, Image Processing in OpenCV, Feature Detection and Description, Video analysis (video module), Machine Learning.

                                                 TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Describe the fundamental principles of image and video analysis and have an idea of their application.
- Apply image and video analysis in real world problems.
- Analyse the real time image and video analytics applications and others
- Understand the concept of object detection and recognition.
- Explore the OpenCv in image processing.

TEXT BOOKS:

1. References: 1. R.C. Gonzalez and R.E. Woods." Digital Image Processing". 3rd Edition. Addison Wesley, 2007.
2. W. Härdle, M. Müller, S. Sperlich, A. Werwatz, "Nonparametric and Semi parametric Models", Springer, 2004.

REFERENCE BOOKS:

1. Rick Szelisk, "Computer Vision: Algorithms and Applications", Springer 2011.
2. Jean-Yves Dufour, "Intelligent Video Surveillance Systems", Wiley, 2013.
3. Caifeng Shan, Fatih Porikli, Tao Xiang, Shaogang Gong, "Video Analytics for Business Intelligence", Springer, 2012. 6
4. Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio GarcíaZuazola, "Intelligent Transport Systems: Technologies and Applications", Wiley, 2015.
5. Basudeb Bhatta, "Analysis of Urban Growth and Sprawl from Remote Sensing Data", Springer, 2010

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3														2	
CO 2					3		2									3
CO 3					3										2	
CO 4	2	2	2			1									2	
CO 5		2		2	2											3
Average	3	2	2	2	3	1	2								2	3

1924305   **SOFT COMPUTING**   **L T P C**
                                                                     3 0 0 3

OBJECTIVES:
- To learn the basic concepts of Soft Computing
- To become familiar with various techniques like neural networks, genetic algorithms and fuzzy systems.
- To be familiar with the basic concepts of genetic programming.
- Be exposed to neuro-fuzzy hybrid systems and its applications
- To apply soft computing techniques to solve problems

UNIT – I: INTRODUCTION TO SOFT COMPUTING   9

Introduction-Artificial Intelligence-Artificial Neural Networks-Fuzzy Systems-Genetic Algorithm and Evolutionary Programming-Swarm Intelligent Systems-Classification of ANNs-McCulloch and Pitts Neuron Model-Learning Rules: Hebbian and Delta- Perceptron Network-Adaline Network-Madaline Network

UNIT - II: ARTIFICIAL NEURAL NETWORKS   9

Back propagation Neural Networks – Kohonen Neural Network -Learning Vector Quantization -Hamming Neural Network – Hopfield Neural Network- Bi-directional Associative Memory -Adaptive Resonance Theory Neural Networks- Support Vector Machines – Spike Neuron Models.

UNIT - III: FUZZY SYSTEMS   9

. Introduction to Fuzzy Logic, Classical Sets and Fuzzy Sets – Classical Relations and Fuzzy Relations -Membership Functions -Defuzzification – Fuzzy Arithmetic and Fuzzy Measures -Fuzzy Rule Base and Approximate Reasoning – Introduction to Fuzzy Decision Making

UNIT - IV: GENETIC ALGORITHMS   9

. Basic Concepts- Working Principles -Encoding- Fitness Function – Reproduction -Inheritance Operators – Cross Over – Inversion and Deletion -Mutation Operator – Bit-wise Operators -Convergence of Genetic Algorithm.

UNIT - V: HYBRID SYSTEMS   9

Hybrid Systems -Neural Networks, Fuzzy Logic and Genetic -GA Based Weight Determination – LR-Type Fuzzy Numbers – Fuzzy Neuron – Fuzzy BP Architecture -

Learning in Fuzzy BP- Inference by Fuzzy BP – Fuzzy ArtMap: A Brief Introduction – Soft Computing Tools – GA in Fuzzy Logic Controller Design – Fuzzy Logic Controller

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Apply various soft computing concepts for practical applications
- Choose and design suitable neural network for real time problems
- Use fuzzy rules and reasoning to develop decision making and expert system
- Integrate various soft computing techniques for complex problems.
- Review the various hybrid soft computing techniques and apply in real time problems

TEXT BOOKS:

1. N.P.Padhy, S.P.Simon, "Soft Computing with MATLAB Programming", Oxford University Press, 2015.
2. S.N.Sivanandam ,S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt. Ltd.,2nd Edition, 2011.
3. S.Rajasekaran, G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications ", PHI Learning Pvt. Ltd., 2017.

REFERENCE BOOKS:

1. Jyh-Shing Roger Jang,Chuen-Tsai Sun, EijiMizutani, "Neuro-Fuzzy and Soft Computing", Prentice-Hall of India, 2002.
2. KwangH.Lee, "First course on Fuzzy Theory and Applications", Springer, 2005.
3. George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic-Theory and Applications",Prentice Hall, 1996.James A. Freeman and David M. Skapura, "Neural Networks Algorithms,Applications, and Programming Techniques", Addison Wesley, 2003.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
CO 1	1	1	3													2
CO 2	2	2	3		1											2
CO 3	2	2	3													3
CO 4	1	1	2													3
CO 5	2	2	3													3
Average	2	2	3		1											3

1924306   **PRINCIPLES OF ETHICAL HACKING**   **L T P C**

                                                                          3 0 0 3

OBJECTIVES:

- To critically evaluate the potential countermeasures to advanced hacking techniques
- To analyze and critically evaluate techniques used to break into an insecure web application and identify relevant countermeasures.
- To demonstrate a critical evaluation of an advanced security topic with an independent project
- To understand the web application security.
- To learn the concept of attacking authentication methods.

UNIT – I: INTRODUCTION   9

Introduction: Understanding the importance of security, Concept of ethical hacking and essential Terminologies-Threat, Attack, Vulnerabilities, Target of Evaluation, Exploit. Phases involved in hacking, Foot printing, Scanning, System Hacking, Session Hijacking.

UNIT - II: BUFFER OVER FLOWS AND SNIFFERS   9

Buffer Overflows: Significance of Buffer Overflow Vulnerability, Why Programs/Applications are vulnerable. Reasons for Buffer Overflow Attacks. Methods of ensuring that buffer overflows are trapped. Sniffers: Active and passive sniffing. ARP poisoning and countermeasures. Man in the middle attacks, Spoofing and Sniffing attacks. Sniffing countermeasures.

UNIT - III: SQL INJECTION   9

SQL Injection: Attacking SQL Servers, Sniffing, Brute Forcing and finding Application Configuration Files, Input validation attacks. Preventive Measures. Web Application Threats, Web Application Hacking, Cross Site Scripting / XSS Flaws / Countermeasures Correct Web Application Set-up.

UNIT - IV: WEB APPLICATION SECURITY   9

Web Application Security: Core Defence Mechanisms. Handling User Access, Authentication, Session Management, Access Control. Web Application Technologies: HTTP Protocol, Requests, Responses and Methods. Encoding schemes.Server side

functionality technologies (Java, ASP, PHP).

UNIT - V: **ATTACKING AUTHENTICATION**   **9**

Attacking Authentication: Attacking Session Management, Design Flaws in Authentication Mechanisms Attacking Forgotten Password Functionality, attacking Password change functions. Countermeasures to authentication attacks Attacking other users: Reflected XSS Vulnerabilities, Stored XSS Vulnerabilities, DOM-Based XSS Vulnerabilities, HTTP Header Injection. Countermeasures to XSS.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Evaluate the potential countermeasures to advanced hacking techniques
- Analyze and critically evaluate techniques used to break into an insecure web application and identify relevant countermeasures.
- Demonstrate a critical evaluation of an advanced security topic with an independent project
- Understand the web application security.
- Analyse the concept of attacking authentication methods

TEXT BOOKS:

1. Patrick Engebretson, "The Basics of Hacking and Penetration Testing", Elsevier, 2013.
2. RajatKhare,"Network Security and Ethical Hacking",,Luniver Press, 2006.

REFERENCE BOOKS:

1. AnkitFadia, Manu Zacharia,"Network intrusion alert: an ethical hacking guide to intrusion detection", Thomson Course Technology PTR, 2007.
2. Thomas Mathew "Ethical Hacking", OSB Publisher, 2003.
3. Stuart McClure, Joel Scambray and George Kurtz," Hacking Exposed: Network Security Secrets & Solutions", McGraw-Hill, 2005.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	1	2	1		3								2			
CO 2	2	2	1		3								2			
CO 3	1		2	3									2			
CO 4				2									2			
CO 5	2			3									2			
Average	2	2	2	3	3								2			

1924307   **BUSINESS ANALYTICS CASE STUDIES**   **L T P C**

                                                                                                3 0 0 3

OBJECTIVES:

- To understand the marketing analytics
- To know the financial analytics
- To acquire the knowledge on supply chain analytics
- To Get the knowledge on web analytics
- To understand the health care analytics

UNIT – I: MARKETING & RETAIL ANALYTICS   9

Marketing and Retail Terminologies: Review- Customer Analytics- KNIME- Retail Dashboards- Customer Churn- Association Rules Mining.

UNIT - II: FINANCE & RISK ANALYTICS   9

Why Credit Risk-Using a market case study - Comparison of Credit Risk Models - Overview of Probability of Default (PD) Modeling- PD Models, types of models, steps to make a good model- Market Risk- Value at Risk- using stock case study- Fraud Detection.

UNIT - III: SUPPLY CHAIN & LOGISTICS ANALYTICS   9

Introduction to Supply Chain - Dealing with Demand Uncertainty- Inventory Control & Management- Inventory classification Methods (EOQ)- Inventory Modeling (Reorder Point, Safety Stock)- Advanced Forecasting Methods- Procurement Analytics.

UNIT - IV: WEB ANALYTICS   9

Web Analytics: Understanding the metrics- Basic & Advanced Web Metrics- Google Analytics: Demo & Hands on- Campaign Analytics- Text Mining

UNIT - V: HEALTH DATA SUMMARY AND VISUALIZATION   9
**   TECHNIQUES**

Statistics – the basics all healthcare data scientists should know-Data summary techniques (for measurement and categorical data)-Visualization techniques (for measurement and categorical data)-Interactive visualization techniques-Common misuses of data visualization- Techniques for Statistical Inference – the 95% Confidence Interval- General principles involving test of statistical significance – Null Hypothesis, p-value and interpreting test outcomes.

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Acquire the knowledge on the marketing analytics techniques
- Analyse the financial and risk models
- Acquire the concept of supply chain analytics
- Understand the web and social analytics
- Study the health care analytics and its summary

TEXT BOOKS:

1. Ramaswamy, V. S., Namakumari, S. "Marketing Management Global Perspective", Indian Context. New Delhi: Macmillan India Limited. 3rd edition, 2009

REFERENCE BOOKS:

1. M Y Khan and P H Jain, "Management accounting", McGraw hill, 5th edition.
2. Palepu Healy and Bernard, "Business analysis & valuation", South western college publication, 2nd edition
3. S.L. Goel, "Healthcare Management and Administration", Deep & Deep Publications Pvt. Ltd. New Delhi, 7th edition, 2007.
4. Tom Tullis, Bill Albert, "Measuring the User Experience: Collecting, Analyzing, and
5. Presenting Usability Metrics", Morgan Kaufmann; 1 edition (28 April 2008).
6. Brian Clifton, "Advanced Web Metrics with Google Analytics", John Wiley & Sons; 3rd edition (30 Mar 2012)
7. GeradFeigin, "Supply Chain planning and analytics – The right product in the right place at the right time", Business Expert Press, 2011

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3		3												2	
CO 2				2					1						2	
CO 3				2				1								3
CO 4		2			2						2					3
CO 5							3					1				3
Average	3	2	3	2	2	2		3	1	1	2	1			2	3

PROFESSIONAL ELECTIVE - III

1924308   **HEALTH CARE ANALYTICS**   **L T P C**

                                                                            3 0 0 3

OBJECTIVES:

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

UNIT – I: INTRODUCTION   9

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

UNIT - II: BIOMEDICAL IMAGE ANALYSIS   9

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

UNIT - III: ANALYTICS   9

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

UNIT - IV: ADVANCED DATA ANALYTICS   9

Advanced Data Analytics: Advanced Data Analytics for Healthcare– Review of ClinicalPrediction Models- Temporal Data Mining for Healthcare Data- Visual Analytics forHealthcare- Predictive Models for Integrating Clinical and Genomic Data- InformationRetrieval for Healthcare- Privacy-Preserving Data Publishing Methods in Healthcare

UNIT - V: APPLICATIONS   9

Applications: Applications and Practical Systems for Healthcare– Data Analytics forPervasive Health- Fraud Detection in Healthcare- Data Analytics for PharmaceuticalDiscoveries- Clinical Decision Support Systems- Computer-Assisted Medical ImageAnalysis Systems- Mobile Imaging and Analytics for Biomedical Data.

OUTCOMES:

At the end of the course, the student should be able to:

- Analyse 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.
- Understand the bio medical image analysis process
- learned the applications of health care analytics

TEXT BOOKS:

1. Chandan K. Reddy and Charu C Aggarwal, "Healthcare data analytics", Taylor & Francis, 2015

REFERENCE BOOKS:

2. Hui Yang and Eva K. Lee, "Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, Wiley, 2016.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	2	2														2
CO 2			3													2
CO 3		2	3											2		
CO 4				3	2	2										3
CO 5							3					3				3
Average	2	2	3	3	2	2	3					3				

1924309   **SECURITY FOR DATA SCIENCE**   **L T P C**

                                                                                3 0 0 3

OBJECTIVES:

- To understand the basics of data Security
- To know the legal, ethical and professional issues in Information Security
- To know the aspects of risk management
- To become aware of data authentication
- To know the technological aspects of data Security

UNIT – I: INTRODUCTION   9

Security Policies - Model of network security – Security attacks, services and mechanisms –substitution techniques, transposition techniques, steganography. What is Information Security?, Critical Characteristics of Information, NSTISSC Security Model, Balancing Security and Access, The SDLC, The Security SDLC

UNIT - II: SECURITY INVESTIGATION AND DATA PROTECTION   9
**   TECHNIQUES**

Need for Security, Business Needs, Threats, Attacks, Legal, Ethical and Professional Issues - An Overview of Computer Security - Access Control Matrix, Symmetric Key Cipher: DES, AES. Asymmetric cipher :RSA

UNIT - III: SECURITY ANALYSIS AND LOGICAL DESIGN   9

Risk Management: Identifying and Assessing Risk, Assessing and Controlling Risk - Systems: Access Control Mechanisms, Blueprint for Security, Information Security Policy, Standards and Practices

UNIT - IV: DATA AUTHENTICATION AND INTEGRITY   9

Authentication function – MAC – Hash function – Security of hash function and MAC – SHA –Digital signature and authentication protocols – DSS- Entity Authentication: Biometrics, Passwords, Challenge Response protocols- Authentication applications - Kerberos, X.509

UNIT - V: PHYSICAL DESIGN   9

Security Technology, IDS, Scanning and Analysis Tools, Cryptography, Access Control Devices, Physical Security, Security and Personnel, Intruders – Malicious software – viruses –Firewalls

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Discuss the basics of Data security

- Illustrate the legal, ethical and professional issues in informationsecurity

- Demonstrate the aspects of riskmanagement.

- Apply the various Authentication schemes to simulate differentapplications

- Design and implementation of data SecurityTechniques.

TEXT BOOKS:

1. Michael E Whitman and Herbert J Mattord, "Principles of Information Security", Vikas Publishing House, New Delhi, 2003

2. William Stallings,"Cryptography and Network Security: Principles and Practice", PHI 3rd Edition, 2006.

REFERENCE BOOKS:

1. Micki Krause, Harold F. Tipton,"Handbook of Information Security Management", Vol 1-3 CRCPress LLC, 2004.

2. Stuart McClure, Joel Scambray and George Kurtz," Hacking Exposed: Network Security Secrets & Solutions", McGraw-Hill, 2005.

3. MattBishop,"ComputerSecurityArt and Science", Pearson/PHI, 2002.

CO - PO and CO - PSO MAPPING:

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CO 1	3	1		1									3			
CO 2		1		1									2			
CO 3			2										2			
CO 4		2	2	1	3								2			
CO 5				2									2			
Average	3	2	2	1	3								2			

1924310   **BLOCKCHAIN TECHNOLOGY**   **L T P C**

                                                                            3 0 0 3

OBJECTIVES:

- Understand emerging abstract models for Blockchain Technology.
- Identify major research challenges and technical gaps existing between theory and practice in crypto currency domain.
- It provides conceptual understanding of the function of Blockchain as a method of securing distributed ledgers, how consensus on their contents is achieved, and the new applications that they enable.
- Apply hyperledger Fabric and Etherum platform to implement the Block chain Application.
- To develop familiarity of current technologies, tools, and implementation strategies.

UNIT – I: INTRODUCTION TO BLOCKCHAIN   9

Blockchain- Public Ledgers, Blockchain as Public Ledgers -Bitcoin, Blockchain 2.0, Smart Contracts, Block in a Blockchain, Transactions-Distributed Consensus, The Chain and the Longest Chain –Cryptocurrency to Blockchain 2.0 - Permissioned Model of Blockchain, Cryptographic -Hash Function, Properties of a hash function-Hash pointer and Merkle tree

UNIT - II: BITCOIN AND CRYPTOCURRENCY   9

A basic crypto currency, Creation of coins, Payments and double spending, FORTH – the precursor for Bitcoin scripting, Bitcoin Scripts , Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay, Consensus introduction, Distributed consensus in open environments-Consensus in a Bitcoin network

UNIT - III: BITCOIN CONSENSUS   9

Bitcoin Consensus, Proof of Work (PoW)- HashcashPoW , BitcoinPoW, Attacks on PoW ,monopoly problem- Proof of Stake- Proof of Burn - Proof of Elapsed Time - Bitcoin Miner, Mining Difficulty, Mining Pool-Permissioned model and use cases, Design issues for Permissioned Blockchains, Execute contracts- Consensus models for permissioned blockchain-Distributed consensus in closed environmentPaxos

UNIT - IV: DISTRIBUTED CONSENSUS   9

RAFT Consensus-Byzantine general problem, Byzantine fault tolerant system-Agreement

Protocol, Lamport-Shostak-Pease BFT Algorithm-BFT over Asynchronous systems, Practical Byzantine Fault Tolerance

UNIT - V: HYPER LEDGER FABRIC & ETHERUM   9

Architecture of Hyperledger fabric v1.1-Introduction to hyperledger fabric v1.1, chain code- Ethereum: Ethereum network, EVM, Transaction fee, Mist Browser, Ether, Gas, Solidity, Smart contracts, TruffleDesign and issue Crypto currency, Mining, DApps, DAO. Internet of Things-Medical Record Management System-Blockchain in Government and Blockchain Security-Blockchain Use Cases –Finance.

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

Understand block chain technology.

- Develop block chain based solutions and write smart contract using Hyper ledger Fabric and Ethereum frameworks.

- Build and deploy block chain application for on premise and cloud based architecture.

- Integrate ideas from various domains and implement them using block chain technology in different   perspectives.

- Analyze the incentive structure in a block chain based system and critically assess its functions, benefits and vulnerabilities

TEXT BOOKS:

1. Melanie Swan, "Blockchain: Blueprint for a New Economy", O'Reilly, 2015.

2. Josh Thompsons, "Blockchain: The Blockchain for Beginners- Guide to Blockchain Technology and Leveraging Blockchain Programming", 2017

REFERENCE BOOKS:

1. Bashir, Imran "Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks",2017.

2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. "Bitcoin and crypto currency technologies: a comprehensive introduction". Princeton University Press, 2016.

3. Joseph Bonneau et al, "SoK: Research perspectives and challenges for Bitcoin and crypto currency", IEEE Symposium on security and Privacy, 2015.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**	**4**
CO 1	3												2			
CO 2		2	3	2										3	3	
CO 3		2	2	2	2											2
CO 4	2	2	2	2												3
CO 5		3	2	2										3		
Average	3	2	2	2	2								3	3	3	3

1924311   **FOG COMPUTING**   **L T P C**

3 0 0 3

OBJECTIVES:

- To remember the fundamental concepts of Fog.
- To understand the architecture and components of Fog.
- To analyze the protocols of Fog.
- To understand the data management and Fog security principles.
- To apply the case studies related to Fog Computing

UNIT – I: INTRODUCTION TO FOG COMPUTING   9

Fog Computing-Definition-Characteristics- Application Scenarios - Issues -Fog Computing and Internet of Things–Fog Computing,Components - Fog Computing and Cloud Computing- Simple Case Studies (STLS and Wind Farm) –HighLevel and Software Architecture

UNIT - II: ARCHITECTURE   9

Fog Computing Fundamentals: Introduction – Background and Motivation of Fog Computing – Fog Computing Basics – Fog Computing Services. IoT Resource Estimation Challenges and Modeling in Fog: Fog Resource estimation and its challenges. Extra Reading (Keyword): Designing Framework.

UNIT - III: FOG PROTOCOLS   9

Tackling IoT Ultra Large Scale Systems: Fog Computing in Support of Hierarchical Emergent Behaviors: Introduction – Fog Computing – Hierarchical Emergent Behaviors, a Fresh Approach for ULSS - Two Autonomous Vehicles Primitives Case Study. The Present and Future of Privacy-Preserving Computation in Fog Computing: Introduction – Block Chain – Multi-Party Computation – Multi-Party Computation and Block Chain. Extra Reading (Keyword): Protocol usage.

UNIT - IV: FOG SECURITY PRINCIPLES.   9

Self-aware Fog Computing in Private and Secure Sphere: Cloud, Fog and Mist Computing Networks- Self-aware Data Processing - Case study: Health monitoring – Patient Safety monitoring and training support – Smart house. Urban IoT Edge Analytics: Design challenges – Edge-assisted Architecture – Information Acquisition and Compression – Content-aware wireless networking – Information availability. Extra Reading (Keyword): Implementation of Security principles.

UNIT - V: **IMPLEMENTATION OF REAL TIME APPLICATIONS AS**   **9**
                           SERVICES

Control-as-a-Service in Cyber-Physical Energy Systems over Fog Computing: Power Grid and Energy Management - Energy Management Methodologies - Cyber-Physical Energy Systems - Internet-of-Things and Fog Computing - Control-as-a-Service - Residential CyberPhysical Energy System. Leveraging Fog Computing for Healthcare IoT: Introduction – Healthcare Services in the Fog Layer – Data management – Event Management – Resource Efficiency – Device management – Personalization – Privacy and Security – System Architecture of Healthcare IoT.

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Discuss the fundamental concepts in Fog.
- Analyze the architectures available in Fog.
- Know and explain the Protocols related to Fog.
- Comprehend the Data Management and Security Principles.
- Examine the case studies of Fog.

TEXT BOOKS:

1. Amir VahidDastjerdi and RajkumarBuyya, "Fog Computing: Helping the Internet of Things Realize its Potential", University of Melbourne.

2. Shanhe Yi, Cheng Li, Qun Li, "A Survey of Fog Computing: Concepts, Applications and Issues", Mobidata'15, ACM 978-1-4503-3524-9/15/06, DOI: 10.1145/2757384.2757397, June 21, 2015, Hangzhou, China.

3. .Amir M. Rahmani ,PasiLiljeberg, Preden, Axel Jantsch, "Fog Computing in the Internet of Things - Intelligence at the Edge", Springer International Publishing, 2018.

REFERENCE BOOKS:

1. IvanStojmenovic, Sheng Wen, "The Fog Computing Paradigm: Scenarios andSecurity Issues", Proceedings, Federated Conference on Computer Science and Information Systems, pp. 1–8, 2014.

2. FlavioBonomi, Rodolfo Milito, PreethiNatarajan and Jiang Zhu, "Fog Computing: A Platform for Internet of Things and Analytics", Big Data and Internet of Things: A Roadmap for Smart Environments, Studies in Computational Intelligence 546, DOI: 10.1007/978-3-319- 05029-4_7, © Springer International Publishing Switzerland 2014.

3. Hazar, Yanru Zhang, Nguyen H. Tran, DusitNiyato, and Zhu Han, "Multi – Dimensional payment Plan in Fog Computing with Moral", IEEE, 2016.

4. FarhoudHosseinpour, JuhaPlosila, HannuTenhunen, "An Approach for Smart management of Big Data in the Fog Computing Context", IEEE 8th International Conference on Cloud Computing Technology and Science, 2016.

CO - PO and CO - PSO MAPPING:

CO	PO												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO 1	3	2												1	2	
CO 2		3	2												2	
CO 3		2	2	2												
CO 4		2		2									3			
CO 5		2		3										1		3
Average	3	2	2	2									3	1	2	3

1924312   **DATA ANALYTICS AND NATURAL LANGUAGE**   **L T P C**
                            PROCESSING   **3 0 0 3**

OBJECTIVES:

- To understand the need for morphological processing and their representation
- To know about the various techniques used for speech synthesis and recognition
- To appreciate the syntax analysis and parsing that is essential for natural language processing
- To learn about the various representations of semantics and discourse
- To have knowledge about the applications of natural language processing

UNIT – I: MORPHOLOGY AND PART-OF-SPEECH PROCESSING   9

Introduction –Regular Expressions and Automata-Non-Deterministic FSAs. Transducers – English Morphology -Finite-State Morphological Parsing -Porter Stemmer -Tokenization- Detection and Correction of Spelling Errors. N-grams –Perplexity -Smoothing - Interpolation -Backoff . Part-of-Speech Tagging –English Word Classes -Tagsets -Rule- Based -HMM -Transformation-Based Tagging -Evaluation and Error Analysis. Hidden Markov and Maximum Entropy Models

UNIT - II: SPEECH PROCESSING   9

Phonetics –Articulatory Phonetics -Phonological Categories -Acoustic Phonetics and Signals -Speech Synthesis –Text Normalization –Phonetic and Acoustic Analysis - Diphone Waveform synthesis –Evaluation-Automatic Speech Recognition –Architecture - Hidden Markov Model to Speech -MFCC vectors -Acoustic Likelihood Computation - Evaluation. Triphones –Discriminative Training -Modeling Variation. Computational PhonologyFinite-State Phonology –Computational Optimality Theory -Syllabification - Learning Phonology and Morphology.

UNIT - III: SYNTAX ANALYSIS   9

Finite-State and Context-Free Grammars -Dependency Grammars. Syntactic Parsing – Ambiguity -Dynamic Programming Parsing Methods –CKY-Earley and Chart Parsing- Partial Parsing-Evaluation. Statistical Parsing – Probabilistic Context-Free Grammars – Probabilistic CKY Parsing of PCFGs –Probabilistic Lexicalized CFGs – Collins Parser – Shallow parsers – Dependency parsing

UNIT - IV: **SEMANTIC AND PRAGMATIC INTERPRETATION** **9**

Representation of Meaning –Desirable Properties -Computational Semantics -Word Senses -Relations Between Senses –WordNet -Event Participants-Proposition Bank -Frame Net -–Metaphor. Computational Lexical Semantics –Word Sense Disambiguation-Supervised Word Sense Disambiguation -Dictionary and Thesaurus Methods-Word Similarity -Minimally Supervised WSD -Hyponymy and Other Word Relations -Semantic Role Labeling -Unsupervised Sense Disambiguation. Computational Discourse -Discourse Segmentation - Unsupervised Discourse -Segmentation -Text Coherence -Reference Resolution –Phenomena –Features and algorithms -Pronominal Anaphora Resolution

UNIT - V: **APPLICATIONS** **9**

Information Extraction –Named Entity Recognition -Relation Detection and Classification – Temporal and Event Processing -Template-Filling -Biomedical Information Extraction. Question Answering and Summarization - Information Retrieval -Factoid Question Answering -Summarization -Single and Multi-Document Summarization -Focused Summarization -Evaluation. Dialog and Conversational Agents –Properties of Human Conversations -Basic Dialogue Systems

TOTAL:45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to:

- Identify the different linguistic components of natural language
- Design a morphological analyser for a given natural language
- Decide on the appropriate parsing techniques necessary for a given language and application
- Design new tagset and a tagger for a given natural language
- Design applications involving natural language

TEXT BOOKS:

1. Jurafsky and Martin, "Speech and Language Processing", Pearson Prentice Hall, Second Edition, 2008.
2. Christopher D. Manning and HinrichSchütze, "Foundations of Statistical Natural Language Processing", MIT Press, 1999.

REFERENCE BOOKS:

1. Stevan Bird, "Natural Language Processing with Python", Shroff, 2009.

2. James Allen, "Natural Language Understanding", Addison Wesley, Second Edition, 2007.

3. NitinIndurkhya, Fred J. Damerau, "Handbook of Natural Language Processing", (Chapman & Hall/CRC Machine Learning & Pattern Recognition), Second Edition, 2010.

4. Alexander Clark, Chris Fox, Shalom Lappin, "The Handbook of Computational Linguistics and Natural Language Processing", Wiley-Blackwell, 2012.

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CO 1	1		1		2	1				1		2		1		
CO 2	1	2	3		3							1	1	2	1	
CO 3	1				2								1			
CO 4	1	2	3		3							2		2	1	
CO 5	1	2	3		3				1		1			2	1	
Average	1	2	3		3	1			1	1	1	2	1	2	1	

1924313   **PRINCIPLES OF GREEN COMPUTING**   **L T P C**

                                                                             3 0 0 3

OBJECTIVES:

 • To understand the concept of green IT
 • To learn the environmental perspectives on IT use
 • To learn the standards and certifications related to sustainable IT products
 • To analyse energy efficient super computer.
 • To evaluate Energy Savings and Reliability in Storage Systems.

UNIT – I: FUNDAMENTALS   9

Green IT Fundamentals: Business, IT, and the Environment –Green computing: carbon foot print, scoop on power –Green IT Strategies: Drivers, Dimensions, and Goals – Environmentally Responsible Business: Policies, Practices, and Metrics.

UNIT - II: GREEN ASSETS AND MODELING   9

Green Assets: Buildings, Data Centers, Networks, and Devices - Green Business Process Management: Modeling, Optimization, and Collaboration –Green Enterprise Architecture –Environmental Intelligence Green Supply Chains –Green Information Systems: Design and Development Models.

UNIT - III: GREEN FRAMEWORK   9

Virtualizing of IT systems –Role of electric utilities, Telecommuting, teleconferencing and teleporting –Materials recycling –Best ways for Green PC –Green Data center –Green Grid framework.

UNIT - IV: ENERGY-EFFICIENT SUPERCOMPUTERS   9

Voltage Scaling in Hardware Technologies- Blue Gene Hardware- System Software- Compiling for Performance versus Energy- Energy-Aware I/O Optimizations- Energy-Aware NoC Optimizations.

UNIT - V: IMPROVING ENERGY EFFICIENCY   9

An Adaptive Run-Time System for Improving Energy Efficiency- Energy-Efficient Multithreading through Run-Time Adaptation- Exploring Trade-Offs between Energy Savings and Reliability in Storage Systems.

OUTCOMES:

At the end of the course, the student should be able to:

- Understand the concept of green IT and relate it to sustainable development.
- Apply the green computing practices to save energy
- how the choice of hardware and software can facilitate a more sustainable operation
- Use methods and tools to measure energy consumption
- Design and develop frameworks for various sectors like IT and Telecommunications

TEXT BOOKS:

1. BhuvanUnhelkar, "Green IT Strategies andApplications-Using Environmental Intelligence", CRC Press, June 2011
2. Woody Leonhard, Katherrine Murray, "Green Home computing for dummies", August 2009.
3. Wu-chunFeng ,"The Green Computing Book: Tackling Energy Efficiency at Large Scale", CRC Press,2014.

REFERENCE BOOKS:

1. Alin Gales, Michael Schaefer, Mike Ebbers, "Green Data Center: steps for the Journey", Shoff/IBM rebook, 2011.
2. John Lamb, "The Greening of IT", Pearson Education, 2009.
3. Jason Harris, "Green Computing and Green IT-Best Practices on regulations & industry", Lulu.com, 2008. Carl Speshocky, Empowering Green Initiatives with IT, John Wiley & Sons, 2010.
4. Wu Chun Feng (editor), "Green computing: Large Scale energy efficiency", CRC Press, 2012

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CO 2		2	3				2								2	
CO 3				2	3	-	2							2		
CO 4		2	3			2									2	
CO 5						2		2				3		3		
Average	2	2	3	2	3	2	2	2				3				