B Tech Curriculum – 2022

Flexible Total Credits: 160/168/180/188
Mandatory Learning Courses (MLC): 12 Credits (2+9+1)
Flexible Core - Choice Based Credit System (CBCS)
Provisions for awarding credits to students for their performance in NCC and Major Projects (optional) - OEs
Scope for Component level Self Directed Learning (SDL) in a few courses
Mandatory Mini Project for Minor Specialization

ACADEMIC YEAR	NO. OF CREDITS	REMARKS
FIRST	22 + 22 = 44	EG-I & EG-II – 1 credit each Universal Human Values & professional ethics– 1 credit Human Rights and Constitution – 1 credit
SECOND	22 + 21 = 43	ODD SEM: Core + Labs EVEN SEM: Core + Labs
THIRD	21 + 21 = 42	ODD SEM: FLEXIBLE Core + Labs + OE MANDATORY OE - CPI EVEN SEM: FLEXIBLE Core + OE + PEs + Labs CHOICE BASED CREDIT SYSTEM FOR CORE COURSES
FOURTH	18 + 13 = 31	ODD SEM: PEs + OE EVEN SEM: Project Work/Practice School, Industrial Training

FIRST YEAR B Tech CURRICULUM 2022 (Common to all branches)

PHYSICS CYCLE/GROUP

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I		Engineering mathematics - I	3	1	0	4		Engineering mathematics - II	3	1	0	4
		Engineering Physics	3	0	0	3		Engineering Chemistry	3	0	0	3
		Mechanics of Solids	2	1	0	3		Biology for Engineers	3	0	0	3
		Basic Electronics	3	0	0	3		Basic Electrical Technology	2	1	0	3
		Basic Mechanical Engineering	3	0	0	3		Problem Solving Using Computers	2	1	0	3
		Communication Skills in English	1	0	0	2		Environmental Studies	1	0	2	2
		Universal Human Values and Professional Ethics (MLC)	1	0	0	1		Human Rights and Constitution (MLC)	1	0	0	1
		Engineering Physics Lab	0	0	3	1		Engineering Chemistry Lab	0	0	3	1
		Workshop Practice	0	0	3	1		PSUC Lab	0	0	3	1
		Engineering Graphics - I	0	0	3	1		Engineering Graphics - II	0	0	3	1
		Creativity, Problem Solving & Innovation*(MLC)	1	0	0	--*		Creativity, Problem Solving & Innovation* (MLC)	1	0	0	--*
			17	**2**	**11**	**22**			**16**	**3**	**11**	**22**
	Total Contact Hours (L + T + P)		**30**				**Total Contact Hours (L + T + P)**		**30**			

*After completing a project work along with other activities which are assessed periodically the students would earn 3 credits which would be considered in lieu of an open elective for Fifth semester B Tech

FIRST YEAR B Tech CURRICULUM 2022 (Common to all branches)

CHEMISTRY CYCLE/GROUP

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I		Engineering mathematics - I	3	1	0	4		Engineering mathematics - II	3	1	0	4
		Engineering Chemistry	3	0	0	3		Engineering Physics	3	0	0	3
		Biology for Engineers	3	0	0	3		Mechanics of Solids	2	1	0	3
		Basic Electrical Technology	2	1	0	3		Basic Electronics	3	0	0	3
		Problem Solving Using Computers (PSUC)	2	1	0	3		Basic Mechanical Engineering	3	0	0	3
		Environmental Studies	1	0	2	2		Communication Skills in English	1	0	2	2
		Human Rights and Constitution (MLC)	1	0	0	1		Universal Human Values and Professional Ethics (MLC)	1	0	0	1
		Engineering Chemistry Lab	0	0	3	1		Engineering Physics Lab	0	0	3	1
		PSUC Lab	0	0	3	1		Workshop Practice	0	0	3	1
		Engineering Graphics – I	0	0	3	1		Engineering Graphics - II	0	0	3	1
		Creativity, Problem Solving & Innovation (MLC)*	1	0	0	--*		Creativity, Problem Solving & Innovation (MLC)*	1	0	0	--*
			16	**3**	**11**	**22**			**17**	**2**	**11**	**22**
	Total Contact Hours (L + T + P)		**30**				**Total Contact Hours (L + T + P)**		**30**			

*After completing a project work along with other activities which are assessed periodically the students would earn 3 credits which would be considered in lieu of the open elective for Fifth semester B Tech

B Tech in Data Science and Engineering

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	L	T	P	C
II	MAT 2139	Mathematical Foundations for Data Science-I	3	0	0	3	MAT 2239	Mathematical Foundations for Data Science-II	2	1	0	3
	DSE 2121	Data Analytics	3	1	0	4	DSE 2221	Database Systems	2	1	0	3
	DSE 2122	Data Structures	3	0	0	3	DSE 2222	Fundamentals of Machine Learning	3	0	0	3
	DSE 2123	Object Oriented Programming	3	1	0	4	DSE 2223	Design & Analysis of Algorithms	2	1	0	3
	DSE 2124	Data Communication and Networks	3	0	0	3	DSE 2224	Principles of Data Privacy & Security	3	0	0	3
	DSE 2141	Data Analytics Lab	0	0	3	2	DSE 2225	Operating Systems	2	1	0	3
	DSE 2142	Data Structures Lab	0	0	3	1	DSE 2241	Database Systems Lab	0	0	3	2
	DSE 2143	Object Oriented Programming Lab	0	0	3	1	DSE 2242	Fundamentals of Machine Learning Lab	0	0	3	2
			15	**2**	**9**	**21**			**14**	**4**	**6**	**22**
	Total Contact Hours (L + T + P)						**Total Contact Hours (L + T + P)**					

B Tech in Data Science and Engineering

Year	FIFTH SEMESTER						SIXTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
III	HUM 3021	Engineering Economics & Financial Management	3	0	0	3	HUM 3022	Essentials of Management	3	0	0	3
	MAT 3135	Mathematical Foundations for Data Science-III	3	0	0	3	DSE 3221	Principles of Artificial Intelligence	3	1	0	4
	HUM 3121	Operations Research	3	0	0	3	DSE 3222	Big Data Analytics and Tools	3	0	0	3
	DSE 3121	Deep Learning Techniques	4	0	0	4	DSE ****	PE – 1 / Minor Specialization	3	0	0	3
	DSE 3122	High Performance Computing	3	0	0	3	DSE ****	PE – 2 / Minor Specialization	3	0	0	3
	IPE 4302	Open Elective-1 – Creativity, Problem Solving and Innovation** (MLC) - mandatory	3	0	0	3	*** ****	Open Eective-2	3	0	0	3
	DSE 3141	Deep Learning Techniques Lab	0	0	3	1	DSE 3241	Principles of Artificial Intelligence Lab	0	0	3	1
	DSE 3142	High Performance Computing Lab	0	0	3	1	DSE 3242	Big Data Analytics and Tools Lab	0	0	3	1
						21						**21**
	Total Contact Hours (L + T + P)						**Total Contact Hours (L + T + P)**					

B Tech in Data Science and Engineering

Year	SEVENTH SEMESTER						EIGHTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
IV	DSE ****	Program Elective – III/ Minor Specialization	3	0	0	3	DSE 4291	Industrial Training				1
	DSE ****	Program Elective – IV/ Minor Specialization	3	0	0	3	DSE 4292	Project Work/Practice School				12
	DSE ****	Program Elective – V	3	0	0	3	DSE 4293	Project Work (B. Tech Honours) **				20
	DSE ****	Program Elective – VI	3	0	0	3	DSE ****	B Tech Honours (Theory 1)** (V Semester)				4
	DSE ****	Program Elective – VII	3	0	0	3	DSE ****	B Tech Honours (Theory 2)** (VI Semester)				4
	*** ****	Open Elective-3	3	0	0	3	DSE ****	B Tech Honours (Theory 3)** (VII Semester)				4
	DSE 4191	Mini Project (Minor specialization) ***				8						
						18/26 ***						**13/33 ***
	Total Contact Hours (L + T + P)						**Total Contact Hours (L + T + P)**					

*Applicable to eligible students who opted for and successfully completed the B Tech – honours requirements

***Applicable to students who opted for minor specialization

Program Electives offered by Department of DSCA

	Stream -1 Multimodal Intelligent Systems		Stream-2 Network Analytics	
PE - I	DSE 4401	Information Retrieval	DSE 4405	Cloud Computing
PE - II	DSE 4402	Natural Language Processing	DSE 4406	Internet of Things
PE - III	DSE 4403	Social Network Analysis	DSE 4407	Enterprise Data Architecture
PE - IV	DSE 4404	Computer Vision	DSE 4408	Blockchain Technology

Open Electives offered by Department of DSCA

DSE 4311: Introduction to Database Systems with MySQL

DSE 4312: Introduction to AR and VR

DSE 4313: Introduction to Linux and Shell Scripting

DSE 4314: Introduction to Data Analytics

Program Electives other than Stream Electives

DSE 4441: Bioinformatics

DSE 4442: Biostatistics

DSE 4443: Data Forensics

DSE 4444: Quantum Computing

DSE 4445: Robotics & Automation

DSE 4446: Soft Computing Techniques

DSE 4447: Software Engineering

Program Electives offered by other Departments.

Stream -Advanced Mathematics

MAT **** Applied Graph Theory

MAT **** Matrix Theory

MAT **** Advanced Algorithms and Deep Learning

MAT **** Algebraic Coding Theory

Stream -Business Management

HUM **** Financial Management

HUM **** Human Resource Management

HUM **** Marketing Management

HUM **** Operations and Systems Management

Stream -Fintech

HUM **** Fintech Services

HUM **** Financial Econometrics

HUM **** Technologies for Finance

HUM **** Financial Management

Stream – Material Science

PHY **** Physics of Law Dimensional Materials

PHY **** Physics of Photonic & Energy storage devices

CHM **** Chemical Bonding

CHM **** Chemistry of Carbon compound

Entrepreneurship Development

HUM **** Financial Management

HUM **** Entrepreneurship

HUM **** Design Thinking

HUM **** Intellectual Property Management

People Management

HUM **** Organizational Behaviour

HUM **** Human Resource Management

HUM **** Professionalism & Ethics

HUM **** Leadership & Decision Making

Finance and Investments

HUM **** Financial Management

HUM **** Financial System

HUM **** Security Analysis & Portfolio Management

HUM **** Project Finance

Modern Literature

HUM **** Understanding Literature

HUM **** Twentieth Century Literature

HUM **** Comparative Literature

HUM **** Modern Indian Literature

Professional Communication

HUM **** Public Speaking, I (VI Sem.)

HUM **** Intercultural Communication II (VI Sem.)

HUM **** Corporate Communication III (VII Sem.)

HUM **** Technical and Business Writing

Program Electives offered through Coursera.

CRA **** Introduction to Interactive Programming Python

CRA **** Mathematical Problem Solving Using Python

CRA **** Principles of Computing Using Data Structures

CRA **** Algorithmic Thinking

THIRD SEMESTER

MAT 2139 MATHEMATICAL FOUNDATIONS FOR DATA SCIENCE-I [3 0 0 3]

Statistics: Measures of central tendency – mean, median, mode, measures of dispersion – mean deviation, standard deviation, quartile deviation, skewness and kurtosis. Correlation coefficient, regression, least squares principles of curve fitting. Probability: Introduction, finite sample spaces, conditional probability and independence, Baye's theorem, one dimensional random variable, mean, variance. Two and higher dimensional random variables: mean, variance, correlation coefficient. Mathematical expectation and conditional expectation.
Distributions: Binomial, Poisson, geometric, uniform, normal, gamma, Chi-square and exponential distributions, properties and simple problems. Transformation of random variable. Sampling theory: Central limit theorem and applications. Estimation – methods and goodness of estimators. Testing of hypothesis-one sample, two sample t-test, one way & two-way analysis of variance. Testing for independence of attributes and goodness of fit.

References:

1. Gupta, S.C and Kapoor, V.K. *Fundamentals of Mathematical Statistics*, Sultan Chand & Sons,11th Edition, 2016
2. Probability, Markov Chains, *Queues, and Simulation: The Mathematical Basis of Performance Modeling*, William J Stewart(2009) Princeton University Press
3. George Casella and Roger L Berger , *Cengage Learning*, Statistical Inference (second edition 2021).

DSE 2121 DATA ANALYTICS [3 1 0 4]

Steps in Data Analytics Projects, Data Analytics tasks and methods, Data Gathering and Preparation: Data Formats, Time series data, Parsing and Transformation, Scalability and Real-time Issues; Data Cleaning: Consistency Checking, Noisy and Missing Data, Data Integration, Data Transformation, and Segmentation; Exploratory Analysis: Descriptive and comparative statistics, Hypothesis testing, Statistical Inference. Data Analysis, Market Basket Analysis, Association rule mining: Apriori, FP Growth, Partitioning, measures of pattern interestingness, Recommender Systems, Item-based Recommendation, Collaborative Filtering. Clustering: Partitioning, Hierarchical, Density-based approaches. Anomaly Detection. Visualization: Visual Representation of Data, Tufts & Gestalt Principles, Visualization tools. Relevant case studies

SDL: Case Studies in Recommender Systems, Item-based Recommendation, Collaborative Filtering

References:

1. Anil Maheshwari, *Data Analytics Made Accessible*, McGraw Hill, 2021.

2. Manaranjan Pradhan, U Dinesh Kumar, *"Machine Learning using Python",* Wiley Publication, 2019.
3. Glenn J. Myatt, *"Making Sense of Data: A Practical Guide to Exploratory Data Analysis and Data Mining"*, John Wiley Publication, November 2006.
4. Glenn J. Myatt, Wayne P. Johnson, *"Making Sense of Data II",* John Wiley Publication, 2009.
5. Cole Nussbaumer Knaflic, *"Storytelling With Data: A Data Visualization Guide for Business Professionals",* (1e), John Wiley and Sons, 2015.
6. Jiawei Han and Micheline Kamber, *"Data Mining Concepts And Techniques",* 3rd Edition, Morgan Kauffmann
7. Pang-Ning Tan, Michael Steinbach,Vipin Kumar, *"Introduction to Data Mining"*, Pearson Education, 2nd Edition.

DSE 2122 DATA STRUCTURES [3 0 0 3]

Introduction - Pointers and Pointer Application, Accessing variables through pointers, pointers to pointers, pointer arithmetic and arrays, pointers and functions, **Recursion**-definition, recursive programs, efficiency of recursion, **Stacks, queues,** evaluation of expressions, multiple stacks and queues and its application, **Linked lists representations**-Singly, doubly, header node, circular along with the applications, **Trees**-Binary trees, representation, recursive/ non recursive inorder, preorder and post order tree traversal, level order traversal, Binary search tree, creation, insertion deletion operations on binary search tree, Additional Binary Tree Operations, Threaded Binary Tree and applications and Introduction to the concepts of Optimal Binary Search Trees, Tree variations, Searching and Sorting Techniques, **Graphs**- Storage representations, BFS,DFS, Spanning tree, Minimum spanning tree.

SDL: Graphs- Storage representations, BFS, DFS, Spanning tree, Minimum spanning tree.

References:

1. Behrouz A. Forouzan, Richard F. Gilberg, *A Structured Programming Approach Using C*, (3e), Cengage Learning India Pvt. Ltd, India, 2007
2. Ellis Horowitz, Sartaj Sahni, Susan Anderson and Freed, *Fundamentals of Data Structures in C*, (2e), Silicon Press, 2007
3. Richard F. Gilberg, Behrouz A. Forouzan, *Data structures, A Pseudocode Approach with C,* (2e), Cengage Learning India Pvt. Ltd, India , 2009
4. Tenenbaum Aaron M., Langsam Yedidyah, Augenstein Moshe J., *Data structures using C*, Pearson Prentice Hall of India Ltd., 2007
5. Debasis Samanta, *Classic Data Structures*, (2e), PHI Learning Pvt. Ltd., India, 2010

DSE 2123 OBJECT-ORIENTED PROGRAMMING [3 0 0 3]

Introduction: Object-oriented Paradigm and Pillars such as Abstraction, Encapsulation, Inheritance and Polymorphism; Java Basics: Compilation and Execution of a Java Program, Access Modifiers; Class and Objects: Class Definition, Creating Objects, Role of Constructors, Method Overloading, Argument Passing, Objects as Parameters, Access Control; I/O Basics: Reading Console Input, Writing Console Output; Array and Strings: Arrays in Java, 1-D, 2-D and Dynamic Arrays, String Basics, String Comparison and Manipulation; Inheritance: Inheritance and its Types, Abstract Class, Inner and Outer Class, Super, Final, Static Keywords; Package and Interface: In-Built Packages and User Define Packages, Role of Interface, Polymorphism via Inheritance; Collection Framework & Generics: List, ,Exception Handling: Errors and Exceptions, Types of Exceptions, Handling Exceptions, Multithreading: Thread Class, Runnable, Thread Life Cycle, Synchronization, Thread Priority; Event Handling and GUI Programming: Events, Action Listener, Important Swing Package Classes.

SDL: Event Handling and GUI Programming: Events, Action Listener, Important Swing Package Classes.

References:

1. Schildt H, Java: The Complete Reference, (10e), Tata McGraw-Hill Education Group, 2017.
2. Balagurusamy E, Programming with Java, (5e), Tata McGraw Hill Education Group, 2017.
3. Daniel Liang Y, Introduction to Java Programming, (10e), Pearson Education India, 2018.
4. Horstmann CS, Big Java: Early Objects, (5e), Wiley's Interactive Edition, 2015.

DSE 2124 DATA COMMUNICATION AND NETWORKS [3 0 0 3]

Basic concepts of computer networks, Layered architecture and comparison between ISO/OSI, TCP/IP layered models. Significance of Datalink layer and protocols. Network layer functionalities, classful, classless IP addressing, address allocation and role of forwarding module in forwarding the packet using routing table. Roles played by IP, ARP, RARP, ICMP & IGMP protocols in network layer. Inter-domain and intra-domain routing algorithms for routing tables. Drawbacks of IPv4 addressing and new IP addressing scheme IPv6. Migrating from IPv4 to IPv6**.** Importance of transport layer in achieving process-to-process communication. Insight of connection-oriented protocol TCP and connectionless protocol UDP. Features of TCP in achieving flow control, error control and congestion control. Requirement of different timers in TCP. Introduction to application layer, a client/server application program and a case study. Client-server application program-Dynamic Host Configuration Protocol (DHCP)

References:

1. Behrouz A. Forouzan, *Data Communications and Networking*, 5th Edition, Tata McGraw Hill, 2013.
2. Behrouz A. Forouzan, *TCP/IP Protocol Suite*, 4th Edition, Tata McGraw Hill, 2010.
3. Tannenbaum, A.S, *Computer Networks*, 5th Edition, Prentice Hall of India EE Edition, 2011.
4. Leon Garcia and Widjala, *Communication Networks*, 5th Edition, Tata McGraw Hill, 2017.

DSE 2141 DATA ANALYTICS LAB [0 0 3 2]

Tutorial on tools for Data Analytics & Visualization. Suggested tools are Python, R, MATLAB, WEKA. Experiments with datasets to be defined in lab manual, to implement concepts of data pre-processing, exploratory analysis, comparative statistics, statistical inference, Association, and clustering. Creating Visual Representations- Suggested tools are MS Excel, Power BI, Tableau. MS Excel Pivot Tables and charts, Case Studies.

References:

1. Manaranjan Pradhan, U Dinesh Kumar, "*Machine Learning using Python",* Wiley Publication, 2019.
2. Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, Kevin R. Coombes, John E. Osborn, Garrett J. Stuck, *Guide to MATLAB: For Beginners and Experienced Users*,(2e), Cambridge University Press, 2011.

DSE 2142 DATA STRUCTURES LAB [0 0 3 1]

Reviewing the concepts of pointers, structures and recursion, Studying the operation of stacks and queues and the associated application programs, Creating dynamic allocation of memory for linked list and applying it to examples using singly, doubly and circular linked list and their applications, Creation of binary trees and the application associated with the trees.

References:

1. Behrouz A. Forouzan, Richard F. Gilberg, *A Structured Programming Approach Using C*, (3e), Cengage Learning India Pvt. Ltd, India, 2007
2. Ellis Horowitz, Sartaj Sahni, Susan Anderson and Freed, *Fundamentals of Data Structures in C*, (2e), Silicon Press, 2007
3. Richard F. Gilberg, Behrouz A. Forouzan, *Data structures, A Pseudocode Approach with C*, (2e), Cengage Learning India Pvt. Ltd, India, 2009
4. Tenenbaum Aaron M., Langsam Yedidyah, Augenstein Moshe J., *Data structures using C*, Pearson Prentice Hall of India Ltd., 2007
5. Debasis Samanta, *Classic Data Structures*, (2e), PHI Learning Pvt. Ltd., India, 2010

DSE 2143 OBJECT-ORIENTED PROGRAMMING LAB [0 0 3 1]

Class and Objects: Class Definition, Creating Objects; Array and Strings: Programs Based Upon 1-D, 2-D and Dynamic Arrays, String Comparison and Manipulation; Inheritance: Inheritance and Its Types, Abstract Class, Inner and Outer Class, Super, Final, Static Keywords; Collection Framework & Generics: Using Collection Classes such as Array Lists and Linked Lists Writing Generic Classes; Exception Handling: Errors and Exceptions, Types of Exceptions; Multithreading: Thread Class, Runnable, Synchronization, Thread Priority; Event Handling and GUI Programming: Action Listener, Swing Package.

References:

1. Schildt H, Java: *The Complete Reference*, (10e), Tata McGraw-Hill Education Group, 2017.
2. Balagurusamy E, *Programming with Java*, (5e), Tata McGraw Hill Education Group, 2017.
3. Daniel Liang Y, *Introduction to Java Programming*, (10e), Pearson Education India, 2018.
4. Horstmann CS, *Big Java: Early Objects*, (5e), Wiley's Interactive Edition, 2015.

FOURTH SEMESTER

MAT 2239 MATHEMATICAL FOUNDATIONS FOR DATA SCIENCE-II [2 1 0 3]

Stochastic Processes – types, fundamental concepts, limiting and transient behaviour. Poisson process – properties. Birth-death models, Queueing models-performance measures. Multivariate analysis-normal distribution and its transformed (Wishart)-properties & their uses in testing hypothesis, classification methods and multidimensional scaling. Graphical representation of multivariate data (Self Directed Learning).

References:

1. William J Stewart, *Probability, Markov Chains, Queues, and Simulation: The Mathematical Basis of Performance Modeling*, Princeton University Press, 2009
2. Hardle, W.K & Simar, L, *Applied Multivariate Statistical Analysis*, 2014.
3. Dean W. Wichern and Richard A. Johnson, *Applied Multivariate Statistical Analysis*, Pearson, 2017.

DSE 2221 DATABASE SYSTEMS [2 1 0 3]

Database System Applications, View of data, Database languages, Database users and Administrator, Introduction to Relational Model: database schema, keys, schema diagrams, Relational Query Languages, Introduction to SQL: Data Definition, Basic structure of SQL queries, Basic operations, Set operations, Nested subqueries, Modification of the database. Intermediate SQL: Join expressions, Views, Advanced SQL-PL/SQL, Cursors, Functions, Procedures, Triggers, recursive queries, Entity-Relationship Model: Design Process, ER Model, Reduction to Relational schema, Relational Database design: Functional dependencies, Normal forms, Closure, Canonical cover, Lossless joins, dependency preserving decomposition, File structure, Transactions, Concurrency Control, Unstructured database

SDL: Unstructured database

References:

1. Abraham Silberschatz, Henry Korth, S. Sudarshan, *Database System Concepts*, 7th Edition, McGraw Hill, 2019.
2. Ramez Elmasri, Shamkant Navathe, *Fundamentals of Database System*, 6th Edition, Addison Wesley Publications Co., 2010
3. Raghu Ramakrishnan, Johannes Gehrke, *Database Management System*, 3rd Edition, WCB/McGraw Hill Publisher, 2007
4. Shashank Tiwari, *Professional NOSQL*, Wiley, 2015.
5. Ivan Bayross, *SQL, PL/SQL-The Programming Language of ORACLE*, 4th Edition, BPB Publications, 2010.

6. Benjamin Rosenzweig, Elen Silvestrova, "*Oracle Pl/Sql By Example*",4th Edition, Addion-Wesley,2009.

DSE 2222 FUNDAMENTALS OF MACHINE LEARNING [3 0 0 3]

Machine Learning Basics: Types of Machine Learning, Supervised vs. Unsupervised Learning, Parametric vs. non-parametric models., Instance Based learning – k-nearest neighbors, Simple Regression Models: Linear, Logistic, Cost functions, Gradient Descent, Batch Gradient Descent, Overfitting, Model Selection, No free lunch theorem, bias/variance trade-off, union and Chernoff bounds, VC dimensions. Bayesian Models: Bayesian concept learning, Bayesian Decision Theory, Naïve Bayesian, Laplacian Correction, Bayesian Belief Networks. Tree Models: information theory, decision tree induction, tuning tree size, ID3,C4.5, CHAID, Decision Stump. Support Vector Machines: kernel functions, Regression Models: Ridge and Lasso Regression, GLM and theexponential Family. Bagging algorithm, Random Forests, Grid search and randomized grid search, Partial dependence plots. Ensembling and Boosting Algorithms: Concept of weak learners, Adaptive Boosting, Extreme Gradient Boosting (XGBoost). Artificial Neural Networks: Perceptron, Back propagation, Hopfield Network. Curse of Dimensionality: Factor Analysis, Principal Component Analysis (PCA), Difference between PCAs and Latent Factors

References:

1. K. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
2. G. James, D. Witten, T Hastie, R Tibshirani, *An introduction to statistical learning withapplications in R*, Springer, 2013.
3. J. Han, M. Kamber, J. Pei, *Data Mining concepts and techniques*, (2e), Morgan Kaufmann-Elsevier, 2011.
4. T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning*, (2e), Springer, 2009.
5. T. M. Mitchell, *Machine Learning*, (Indian Edition), MacGraw Hill, 2017.
6. C. Bishop, *Neural Networks for Pattern Recognition*, Oxford University Press, 2019

DSE 2223 DESIGN & ANALYSIS OF ALGORITHMS [2 1 0 3]

Fundamentals of Algorithms, Important Problem Types, Analysis of algorithm efficiency. Analysis Framework: Asymptotic Notations and Basic Efficiency Classes, Mathematical Analysis of Non recursive and Recursive Algorithms. Brute force Techniques, Divide and Conquer, Decrease and Conquer: Insertion Sort, Depth First Search, Breadth First Search, Topological Sorting. Transform and Conquer: Pre-sorting, BST, Heapsort. Space and Time trade-offs: Input Enhancement in String Matching. Dynamic Programming: Warshall's and Floyd's Algorithms, The Knapsack Problem. Greedy Techniques: Prim's, Kruskal's and Dijkstra's Algorithm, Huffman Trees. Coping with limitations of algorithmic power, P, NP,

and NP-complete Problems, Backtracking: n–Queens problem, Hamiltonian Circuit Problem, Subset–Sum Problem. Branch and Bound: Assignment Problem, Knapsack Problem, TSP.

SDL: Branch and Bound: Assignment Problem, Knapsack Problem, TSP.

References:

1. Anany Levitin, *Introduction to the Design and Analysis of Algorithms*, (3e), Pearson Education, 2011
2. Ellis Horowitz and Sartaj Sahni, *Computer Algorithms/C++*, (2e), University Press, 2008.
3. Thomas H. Cormen, Charles E. Leiserson, Ronal L, Rivest, Clifford Stein, *Introduction to Algorithms*, (3e), PHI, 2009

DSE 2224 PRINCIPLES OF DATA PRIVACY AND SECURITY [3 0 0 3]

Security: The OSI Security Architecture, Security Attacks, Services and Mechanisms, Model for Network Security, Classical Encryption techniques, Symmetric Encryption, Public-key cryptography and Message Authentication, Hash Functions, Digital Signatures, System Security, Key Distribution and Authentication, Transport Layer Security, Wireless Network Security, E-mail Security, IP Security, Security Management Systems, Need for IT Security, Intrusion Prevention and Detection Systems, Cyber Security. Data Privacy, types of privacy attacks, Data linking and profiling, access control models, role based access control, privacy policies, their specifications, privacy policy languages, privacy in different domains-medical, financial, etc. Mathematical model for comparing real-world data sharing practices, computing privacy and risk measurements. Demographics and Uniqueness. Protection Models-Null-map, k-map, Wrong map. Survey of Techniques-Protection models (null-map, k-map, wrong map), Disclosure control, Inferring entity identities, entry specific databases. Computation systems for protecting delimited Data-Min Gen, Datafly, Mu-Argus, k-Similar.

SDL: System Security, Key Distribution and Authentication, Transport Layer Security, Wireless Network Security, E-mail Security, IP Security, Security Management Systems, Need for IT Security, Intrusion Prevention and Detection Systems, Cyber Security

References:

1. Ronald Leenes , Rosamunde van Brakel , Serge Gutwirth , De Hert, Paul, *Data Protection and Privacy: The Age of Intelligent Machines (Computers, Privacy and Data Protection)*, Hart Publishing (December 28, 2017)
2. B. Raghunathan, *The Complete Book of Data Anonymization: From Planning to Implementation*, Auerbach Pub, 2016.
3. L. Sweeney, *Computational Disclosure Control: A Primer on Data Privacy Protection*, MIT Computer Science, 2017

4. William Stallings, *Cryptography and Network Security: Principles and Practice*, 7th Edition, Pearson Education, 2017.
5. William Stallings, *Network Security Essentials: Applications and Standards*, 6th Edition, Pearson Education, 2014.
6. Atul Kahate, *Cryptography and Network Security*, 3rd Edition, Tata McGraw-Hill Publishing Company Limited, 2013.

DSE 2225 OPERATING SYSTEMS [3 0 0 3]

Operating System Structure and Operations, Process Management, Memory Management, Storage Management, Operating System Services, User Operating System Interfaces, Types of System Calls, System Programs, Operating System Structure, System Boot ,Overview, Process Scheduling, Operations on Processes, Inter-process Communication, Multithreaded Models, Thread Libraries, Scheduling Algorithms, Thread Scheduling, Linux scheduling, Critical Section Problem, Peterson's Solution, Synchronization Hardware, Semaphores, System Model, Deadlock: Deadlock prevention, Avoidance, Detection, Recovery, Logical Versus Physical Address Space, Segmentation, Contiguous Memory Allocation, Paging, Structure of Page Table, Demand Paging, Copy-On-Write, Page Replacement, Allocation of Frames, Thrashing, Disk Scheduling, Swap-Space Management, , File Concept, Protection.

SDL: The Linux System**:** Design Principles, Kernel Modules, Scheduling, Memory Management.

References:

1. Abraham Silberschatz, Peter B. Galvin, Greg Gagne, *Operating System Concepts*, Wiley (2018).
2. Ramez Elmasri, A.Gil Carrick, David Levine, *Operating Systems*, A Spiral Approach-McGrawHill Higher Education (2010).
3. Remzi H. Arpaci-Dusseau, Andrea C. Arpaci-Dusseau, *Operating Systems*, Three Easy Pieces, Arpaci-Dusseau Books, Inc (2015).
4. Andrew S. Tanenbaum, *Modern Operating Systems*, Pearson, 4th Edition (2016).
5. William Stallings, Operating Systems: Internals and Design Principles, Pearson, 9th Edition (2018).

DSE 2241 DATABASE SYSTEMS LAB [0 0 3 2]

Introduction to basics of front-end developing tools needed for developing mini project. Introduction to SQL, Integrity Constraints in SQL, Simple and complex queries, PL/SQL Basics, Exception Handling, Cursors, exceptions, Procedures, Functions and Packages, Triggers. Design and development of database driven mini project based on database concepts

discussed in the theory. The front-end tool is as per the prerogative of the faculty who is handling the lab.

References:

1. Silberschatz, Korth, Sudarshan, *Database System Concepts*, (6e), McGraw-Hill, 2011
2. Ivan Bayross, *SQL, PL/SQL: The Programming Language of Oracle* ,4th Revised Edition, BPB Publications,2010
3. Steven Feuerstein, Bill Pribyl, *Oracle PL/SQL Programming*, 6th Edition, O'Reilly Media, 2014,

DSE 2242 FUNDAMENTALS OF MACHINE LEARNING LAB [0 0 3 2]

Tutorial on tools for Machine Learning. Python suggested. Experiments with datasets to be defined in lab manual to perform preprocessing and deploy classifiers such as Bayesian, Decision Trees, Support Vector Machines, k-nearest neighbor, Regression Models. Classification accuracy measures, improving classifier performance through ensembling, boosting etc.

References:

1. Hans Peter Langtangen, *Python Scripting for Computational Science*, (3e), Springer Publishers,2014
2. Naomi R. Ceder, *The Quick Python Book*, (2e), Manning Publications Co., 2010
3. Wesley J. Chun, *Core Python Applications Programming*, (3e), Prentice Hall Publishers, 2012
4. G. James, D. Witten, T Hastie, R Tibshirani, *An introduction to statistical learning withapplications in R*, Springer, 2013.

FIFTH SEMESTER

HUM 3021 ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT [2 1 0 3]

Syllabus will be given by the Dept. of Humanities and management.

MAT 3135 MATHEMATICAL FOUNDATIONS FOR DATA SCIENCE –III [3 0 0 3]

Propositional and predicate logic. Number Theory- Divisibility, Euclidean algorithm, prime numbers, Fundamental Theorem of Arithmetic, greatest common divisors, Fermat's little theorem, Congruences, solution of congruences, Chinese remainder theorem, Euler's phi function, Quadratic residues and reciprocity, Jacobi Symbol, binary quadratic forms, equivalence and reduction of binary forms, sums of two squares, greatest integer function, arithmetic functions, Combinatorial number theory, the inclusion-exclusion principle, Techniques of numerical calculation, Public key Cryptography. **Graph Theory**- Introduction to graphs. Order, size, degree. Walks, paths, cycles. Complements. Subgraphs, cliques. Isomorphism. Connectedness and connected components. Trees andspanning trees. Distance, radius, diameter, girth. Vertex connectivity, edge connectivity. Eulerian and Hamiltonian graphs. Measures of centrality – degree centrality, closeness centrality, betweenness centrality. Matrices associated with graphs – adjacency, incidence, Laplacian, and distance matrices. Eigenvalues and eigenvectors. Directed graphs. Graph algorithms – spanning tree algorithm, Dijkstra'salgorithm, Floyd-Warshall algorithm.

References:

1. Chartrand, Lesniak, and Zhang. *Graphs and Digraphs*, Fifth Edition. CRC Press. 2010.
2. D. Jungnickel. Graphs, *Networks and Algorithms*, Fourth Edition. Springer. 2013.
3. Douglas B. West. *Introduction to Graph Theory*, Second Edition. Prentice Hall. 2001.
4. *An Introduction to theory of numbers* (fifth edition), I. Niven, H.S. Zuckerman, H. L.Montgomery, John Wiley & Sons, Inc.
5. *A course in Number theory and Cryptography* (second edition), Neal Koblitz, Springer-Verlag.

HUM 3121 OPERATIONS RESEARCH [3 0 0 3]

Introduction: Definition, Phases, Applications, Advantages and Limitations of Operations Research.

Linear Programming problems: Assumptions, Formulation of LPP for business and non-business applications. Graphical solutions, Special cases – Degeneracy, Infeasible Solution, Unbalanced and Multiple optimal solutions. Minimization and Maximization cases. Simplex algorithm, Concept of dual, Sensitivity analysis with respect to objective function coefficients and R.H.S. values. Transportation problem: Formulation, North-West Corner (NWC) Method, Least Cost (LC) Method, Vogel's Approximation Method (VAM). Testing the solution by Steppingstone, Modified Distribution (MODI) Method. Maximization, Multiple optimal solutions, Degeneracy and Unbalanced problems. Post optimality analysis. Assignment problem: Solution algorithm for Assignment Problems. Unbalanced, multiple optimal solutions, Maximization and Application problems. Travelling salesman / Job sequencing problem: Solution algorithm for Travelling Salesman Problem, Application to job sequencing problem Game theory: Introduction to game theory, Two person- zero sum games, Pure and Mixed Strategies, Solution methods for 2 x 2 games, Graphical method (2 x n games; m x 2 games), Simulation of queuing system - Steps in simulation, Application and Limitations, Monte- Carlo technique-Problems involving Waiting line situations and Selection of crew members.

DSE 3121 DEEP LEARNING TECHNIQUES [4 0 0 4]

Introduction, Neural Network Basics, Shallow Neural Networks: Review, Gradient descent and Activation Function Deep Feed Forward Networks: Forward and Backward Propagation, Hidden units, architecture design, Dimensionality reduction, learning time. Regularization for Deep Learning: Parameter Norm Penalties, Regularization and Under-Constrained Problems, Dataset Augmentation, Noise-Robustness, Bagging and Other Ensemble Methods, Dropout, Adversarial Training. Optimization for Training Deep Models: Challenges in Neural Network Optimization. Deep Neural Networks and the Brain. Convolutional Networks: convolution operation, pooling, Sequence Modelling: Recurrent Auto Encoders: Under complete, Regularized, sparse, de-noising, Monte Carlo Methods. Markov Models, Hidden Markov models: evaluation problem, finding the state sequence, HMM as graphical model. Deep Generative Models: Boltzmann Machines-the physics, randomness, impact on cognitive learning. Deep Boltzmann Machines, Deep Belief Networks-its relationship to Boltzmann Machines, concept of greedy networks, application to drug discovery, Variational Autoencoders, Generative Adversarial Networks, Auto-regressive Networks. Practical Methodology: Performance Metrics, Default Baseline Models, Selecting hyper parameters, Debugging Strategies. Case Studies in: Large Scale Deep Learning, Computer Vision, Speech Recognition, Economics, Fraud detection, Crime detection.

SDL: Case Studies in: Large Scale Deep Learning, Computer Vision, Speech Recognition, Economics, Fraud detection, Crime detection.

References:

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press 2016
2. Andrew NG, Course Notes - *Neural Network and Deep Learning*.
3. Aurelien Geron, *Hands-On Machine Learning with Scikit-Learn Keras & Tensorflow*, OReilly
4. Publications
5. Course Notes- *Deep Learning IIT*, Prof Mitesh Kapra
6. Kevin P. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012
7. Charu C. Aggarwal, *Neural Networks and Deep Learning*, Springer, 2018.

DSE 3122 HIGH PERFORMANCE COMPUTING [3 0 0 3]

Introduction: Modern Processor Architectures, Performance Metrics, Laws of Parallel Programming, Multicore processors, Parallel computers. Introduction to OpenMP; Overview of OpenMP: Terminology, Parallel Construct Sharing the Work among Threads in an OpenMP Program , Clauses to Control Parallel and Work-Sharing Constructs, OpenMP Synchronization Constructs, Interaction with the Execution Environment, More OpenMP Clauses , Advanced OpenMP Constructs; How to Get Good Performance by Using OpenMP: Performance Considerations for Sequential Programs, Measuring OpenMP Performance, Best Practices, Additional Performance Consideration, Open MP Case studies. MPI Processes and Messaging: MPI Processes and Messaging, MPI Operation Syntax, MPI Data Types, MPI Error Handling, Basic MPI Operation, Process-to-Process Communication, Measuring Performances, Collective MPI Communication, Communication and Computation Overlap. Many Core Systems: Types of parallelism, Benefits of using GPUs, CUDA C: A scalable programming model, Kernel, Thread Hierarchy, Memory hierarchy, Heterogeneous Parallel Computing, Development environment, CUDA Program Structure, Device Global Memory and Data Transfer; Data-Parallel Execution Model: Grid, Blocks and threads, Mapping Threads to Multidimensional Data, Matrix-Matrix Multiplication, Synchronization and Transparent Scalability, Assigning Resources to Blocks, Thread Scheduling and Latency Tolerance; CUDA Memories: Importance of Memory Access Efficiency, CUDA Device Memory Types Strategy for Reducing Global Memory Traffic, Tiled Matrix, Memory as a Limiting Factor to Parallelism; Performance Considerations: Warps and Thread Execution, Global memory bandwidth, Dynamic partitioning of execution resources;

SDL: CUDA: Matrix-Matrix Multiplication—A More Complex Kernel, A Tiled Matrix-Matrix Multiplication Kernel

References:

1. Georg Hager Gerhard Wellein, *Introduction to High Performance Computing for Scientists and Engineers*.
2. Boštjan Slivnik Patricio Bulić , Borut Robič, Roman Trobec, *Introduction to Parallel Computing From Algorithms to Programming on State-of-the-Art Platforms.*

3. Barbara Chapman, Gabriele Jost, Ruud van der Pas, *Using OpenMP Portable Shared Memory Parallel Programming.*
4. David B. Kirk and Wen-mei W. Hwu. *Programming Massively Parallel Processors A Hands-on Approach,* Second Edition
5. *CUDA C++ Programming Guide Design GuidE*
6. J. Sanders, E. Kandrot, *"CUDA by example: an introduction to general-purpose GPU programming",* Addison-Wesley Professional, 2010.

DSE 3141 DEEP LEARNING TECHNIQUES LAB [0 0 3 1]

Tutorial on tools for Deep Learning. Tensorflow, Python-Keras suggested. Experiments with datasets to be defined in lab manual to deploy deep learning algorithms. Case studies or mini projects in topics such as Sentiment Analysis, Anomaly Detection, Recommender Systems.

References:

1. Manaranjan Pradhan, U Dinesh Kumar, *Machine Learning using Python,* Wiley Publications
2. Aurelien Geron, *Hands-On Machine Learning with* Scikit-Learn , Keras & Tensorflow, OReilly Publications
3. Ahmed Menshawy, Md. Rezaul Karim, Giancarlo Zaccone, *Deep Learning with TensorFlow,* Packt Publishing
4. *Introduction to Tensorflow*, https://www.tensorflow.org/learn

DSE 3142 HIGH PERFORMANCE COMPUTING LAB [0 0 3 1]

OpenMP: Work sharing constructs, Clauses to control parallel constructs, OpenMP synchronization constructs, Advanced OpenMP clauses, MPI: Point to Point Communications in MPI, Collective communications in MPI, MPI Programs on strings, vectors and matrices, CUDA Programs on arrays and matrices, CUDA programs on strings, Thread synchronization in CUDA

References:

1. Georg Hager Gerhard Wellein, *Introduction to High Performance Computing for Scientists and Engineers*.
2. Boštjan Slivnik Patricio Bulić , Borut Robič, Roman Trobec, *Introduction to Parallel Computing From Algorithms to Programming on State-of-the-Art Platforms.*

3. Barbara Chapman, Gabriele Jost, Ruud van der Pas, *Using OpenMP Portable Shared Memory Parallel Programming.*
4. David B. Kirk and Wen-mei W. Hwu. *Programming Massively Parallel Processors A Hands-on Approach,* Second Edition
5. *CUDA C++ Programming Guide Design Guide*
6. J. Sanders, E. Kandrot, *"CUDA by example: an introduction to general-purpose GPU programming",* Addison-Wesley Professional, 2010.

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SIXTH SEMESTER

HUM 3022 ESSENTIALS OF MANAGEMENT [2 1 0 3]

DSE 3221 PRINCIPLES OF ARTIFICIAL INTELLIGENCE [3 1 0 4]

History of AI, Foundations of AI, AI Approaches - Cognitive Modeling. The Turing Test, Rational thinking – Logic. Intelligent Agents and Environments- the concept of Rationality, Single and Multi-Agents, Performance Evaluation of Agents, and Architecture of Intelligent Agents. AI Problems: Problem Space, Problem analysis. Problem-Solving Techniques; Heuristic Search, Uninformed Search, Local Search, Constraint Satisfaction Problems. Games: Optimal decision in games, Adversarial Search, Minimax, Alpha Beta Pruning, The Wumpus World. Reinforcement learning: Multi-armed bandits, Markov Decision Process, Bellman equations, Dynamic Programming, Monte Carlo methods, Temporal Difference Learning, Policy Gradient Methods. Knowledge and Reasoning, Representation: Logical Agents, First

order logic and inference, Classical Planning. Propositional logic: Propositional Theorem Proving, Representation, Fuzzy Logic. Ontological Engineering, Semantic Technologies, RuleML. Quantifying Uncertainty, Probabilistic Reasoning, Making Simple & Complex Decisions. Applications: NLP, Parsing, Machine translation, speech recognition, Perception: Image formation, Image Processing, Object Recognition, Robotics: software agents, Hardware, perception, software architectures. Future of AI : Cognitive Modeling approach, Layers of Mental Activities, Layered Knowledge Representation, Cognitive Architectures, Brain – Machine Convergence.

SDL: Case Studies in Quantifying Uncertainty, Probabilistic Reasoning, Making Simple & Complex Decisions.

References:

1. Stuart Russell and Peter Norvig, *"Artificial Intelligence A Modern Approach"* , Pearson 2010.
2. Marvin Minsky, "*The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind"*. Simon & Schuster, 2007.
3. Richard S Sutton and Andrew G Barto, "*Reinforcement Learning: An Introduction*", MIT Press
4. Rich E., Knight K., Nair S.B., *"Artificial Intelligence",* Tata McGraw Hill, 2008.
5. Grigoris Antoniou, Paul Groth, Frank van Harmelen and Rinke Hoekstra, A Semantic Web Primer, MIT Press, 2012.

DSE 3222 BIG DATA ANALYTICS AND TOOLS [3 0 0 3]

Introduction to Big Data: evolution, structuring, elements, big data analytics, distributed and parallel computing for big data, Life cycle of Big data, Cloud computing and big data, in-memory computing technology for big data, Big Data Stack, Layer Structure, Big Data Layout. Hadoop: ecosystem, Hadoop Distributed File System (HDFS), MapReduce: MapReduce Framework, optimizing MapReduce jobs, MapReduce Applications, Understanding YARN architecture. Big Data Tools: "PIG": History, Features, Architecture, Components, Data Models, Operators, Running & Executing Modes, Analysing data with Pig, Pig Libraries, Processing Structured Data using Pig. Big Data Tools: "HBASE": History, Characteristics, Features, Architecture, Storage Mechanism, HDFS Versus HBASE, HBase Query writing. Big Data Tools: "Hive": Brief History of Hive, Data Types In Hive, Executing Modes, Writing & Executing Hive queries. Big Data tools: "Apache Spark": Spark Architecture, Components, Features, Spark vs Hadoop, RDD, Need for RDD, Spark memory management & Fault tolerance, Spark's Python and Scala shells, Programming with RDD: RDD Operations, Passing Functions to Spark, Common Transformations and Actions,

SDL: Installation of Different tools in Big data (Pig Hive HBase Spark), Real time Analytics Platform (RTAP), OLAP, OLTP, Types of NO SQL.

References:

1. Vignesh Prajapathi, *Big Data Analytics with R and Hadoop*, Packt Publishing, 2013.
2. Michael Minnelli, Michele Chambers, *Big Data Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses*, Wiley India Pvt. Ltd., 2013.
3. Bill Franks, *Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics*, John Wiley & sons, 2012
4. Chanchal Singh and Manish Kumar, *Mastering Hadoop 3 : Big data processing at scale to unlock unique business insights*, , Packt Publishing Ltd, February 2019
5. Tom White, *Hadoop: The Definitive Guide*, Fourth Edition, April 2015 , O'Reilly Media.
6. Arshdeep Bahga, Vijay Madisetti, Big Data Analytics_ A Hands-On Approach, 2019

Program Elective -I

Program Elective - II

Open Elective – I

DSE 3241 PRINCIPLES OF ARTIFICIAL INTELLIGENCE LAB [0 0 3 1]

Intelligent Agents and case study, Problem Formulation, Search- Informed, Uninformed, Local Search. Game formulation, Game tree and search. Reinforcement Learning- Multiarmed bandits, Markov decision process, dynamic programming, monte carlo, temporal difference learning, policy gradient. Constraint satisfaction problems, Working with sensors. Semantic Networks, Propositional and Predicate Logic: Propositional and Predicate calculus. Case studies- Communicating, Perceiving, and Acting. Fuzzy Logic and its case study.

References:

1. Aurelien Geron, *Hand-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly Publications, 2021.
2. Richard S Sutton and Andrew G Barto, *Reinforcement Learning: An Introduction*, MIT Press
3. Stuart Russell, and Peter Norvig, *Artificial Intelligence: A Modern Approach*, Prentice Hall, 2011.

DSE 3242 BIG DATA ANALYTICS AND TOOLS LAB [0 0 3 1]

Tutorial on tools for Big Data tools and technologies. Apache Hadoop Cluster Based Distributed Processing. Platforms: PIG, HIVE, Spark Scala, Python based experiments with big datasets to be defined in lab manual, to implement machine learning algorithms in Hadoop and spark ecosystem. Analysis: To implement statistical inferences, recommendations, comparative statistics, MapReduce, Recommendation, Anonymous Functions, Method Overloading, Filtering, Classification, Clustering. Case studies: Stock market prediction, Earthquake Prediction, IPL Match Forecasting, Sentimental Analysis, Preference Indicator Analysis, Behavioral Analysis, Learning Performance Prediction.

References:

1. Tom White, *Hadoop: The Definitive Guide* , Fourth Edition, April 2015 , O'Reilly Media.
2. Chanchal Singh and Manish Kumar , *Mastering Hadoop 3 : Big data processing at scale to unlock unique business insights, ,* Packt Publishing Ltd, February 2019

SEVENTH SEMESTER

There are five program electives and one open elective with total of 18 credits to be taught in this semester.

EIGHTH SEMESTER

DSE 4291 INDUSTRIAL TRAINING [0 0 0 1]

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentationof the same. The report should include the certificate issued by the industry.

DSE 4292 PROJECT WORK/PRACTICE SCHOOL 12 CREDITS

The project work may be carried out in the institution/industry/ research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

MINOR SPECIALIZATION STREAMS

PROGRAM ELECTIVES

STREAM - 1: MULTIMODAL INTELLIGENT SYSTEMS

DSE 4401 INFORMATION RETRIEVAL [3 0 0 3]

Introduction to Information Retrieval: Mathematical Basics, Vector spaces and Similarity, Probabilitiesand Statistics, Text Analysis; Pre-processing: Document processing, Stemming, String Matching, Basic NLP tasks – POS Tagging Shallow Parsing; Overview of Text Retrieval Systems: System Architecture, Boolean Models, Inverted Indexes, Document Ranking, IR Evaluation; Retrieval Models and Implementation: Vector Space Models, TF-IDF Weighting, Retrieval Axioms, Implementation Issues,Probabilistic Models; Statistical Language Models: Okapi/BM25, Language Models, KL-divergence, Smoothing; Query Expansion and Feedback: Query Reformulation, Relevance feedback, Pseudo- Relevance Feedback, Language Model Based, Feedback; Web Search Engines: Models of the Web, Web Crawling; Static Ranking: Page Rank HITS, Query Log Analysis, Adversarial IR, Information Filtering: Adaptive Filtering, Collaborative Filtering, User Interfaces, Text Classification, Naïve Bayes, K-nearest neighbors, Feature selection, Semi-supervised Learning; Text Clustering: Vector-space Clustering; K-means, EM algorithm, Text shingling; Graph-Based Methods: WordNet, Document and Word Graphs, Network Analysis, Random Walks, Harmonic Functions.

References:

1. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, *Introduction to InformationRetrieval"*, (2e), Cambridge University Press, 2015.
2. B. Croft, D. Metzler, T. Strohman, *Search Engines: Information Retrieval in Practice*, (3e), MITPress, 2016.
3. Chengxiang Zhai, *Statistical Language Models for Information Retrieval* (Synthesis LectureSeries on Human Language Technologies), (2e), Morgan & Claypool Publishers, 2017.

DSE 4402 NATURAL LANGUAGE PROCESSING [3 0 0 3]

Knowledge in Speech and Language Processing, Ambiguity, Models and Algorithm,Regular Expressions, Finite State Automata, Words And Transducers:Survey of English Morphology, Finite-State Morphological Parsing, Building a Finite-State Lexicon, FSTs for Morphological Parsing, Lexicon-Free FSTs. Words and Sentence tokenization: Normalizing Text, Segmentation , Probablistic Models of Pronunciation and Spelling :Detecting and Correcting Spelling Errors, Noisy Channel Model,Minimum Edit Distance,N-Grams:Unsmoothed N-Grams, Smoothing, Interpolation and Backoff, English Word Classes: Tag-sets for English, Part-of-Speech Tagging, Formal Grammars of English: Context Free Grammars ,Grammar

Rules,TreeBank, Dependency Grammar, Parsing with Context Free Grammars, Dynamic Programming Parsing, CKY algorithm, Statistical Parsing,NLP using NLTK

SDL: NLP using NLTK

References:

1. Daniel Jurafsky & James H. Martin, *Speech and Language Processing*, (2e), Pearson, 2009.
2. Steven Bird,Ewan Klein and Edward Loper, *Natural Language Processing with Python* ,First Edition,O'Reilly Media,2009.
3. J.E.Hopcroft, R.Motwani & J.D.Ullman, *Introduction to Automata Theory Languages, and Computation*, (3rd Edition) , 2006,Pearson Education.

DSE 4403 SOCIAL NETWORK ANALYSIS [3 0 0 3]

Introduction to Social Web, Nodes, Edges and Network Measures, Describing Nodes and Edges, Describing Networks, Layouts, Visualizing network features, The role of Tie strength, MeasuringTie strength and its network structures, network propagation, Link prediction, entity resolution, Case study, Introduction to community discovery, communities in context, quality functions, The Kernighan-Lin algorithm, Agglomerative algorithms, spectral algorithms, multi-level graph partitioning, Markov clustering, Other approaches, Introduction to social influence, Influence related statistics, social similarity and influence, Homophily, Existential Test for social influence, Influence and actions, Influence and interactions, influence maximization in viral marketing.

References:

1. Jennifer Golbeck., *Analysing the Social Web*, Morgan Kaufmann publications, 2013
2. Charu C. Aggarwal, *Social Network Data Analytics*, Springer publications, 2011
3. John Scott, *Social Network Analysis*, (3e), Sage publications limited, 2013
4. Jay Goldman, *Facebook Cookbook*, O'Reilly, 2009
5. Shamanth Kumar, Fred Morstatter, Huan Liu, *Twitter Data Analytics*, Springer publications, 2013
6.

DSE 4404 COMPUTER VISION [3 0 0 3]

Introduction : Image Processing, Components of Image processing system, Image formation and digitization concepts, Neighbours of pixel adjacency connectivity, regions and boundaries, Distance measures, Image processing operations, Arithmetic, Logical, Geometrical, Convolution and Correlation Operations, Applications: Document Image Analysis, Biometrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing, Multimedia, VirtualReality and Augmented Reality,

Image Formation, Image representations (continuous and discrete) , Image pre-processing Techniques, Feature Extraction-Point, Line and Edge Detection, Color, Texture,Shape and structure Features in spatial and frequency domains, Corner Detection, Hough Transform , Image Segmentation: Boundary detection based techniques, Point, line detection, Edge detection, Edge linking, local processing, regional processing, Hough transform, Thresholding, Iterative thresholding, Otsu's method, Moving averages, Multivariable thresholding, Region-based segmentation, Watershed algorithm, Use of motion in segmentation, Computer Vision: Computer Vision, What is Computer Vision - Low-level, Mid-level, High-level , Overview of Diverse Computer Vision Applications,Fundamentals of object recognition, Low-level computer vision-Edges, contours, textures, shapes, andcolors , Motion, optical flow, and tracking Local features, invariance, bag-of-words models, Fisher vector, Middle-level representations of objects: parts, attributes, embedding.

References:

1. David A forsyth & Jean ponce *Computer vision – A modern Approach,* Prentice Hall, PearsonEducation India; Edition: Second.
2. R. C. Gonzalez, R. E. Woods. *Digital Image Processing*. Pearson, Inc., Edition-Fourth.
3. A. K. Jain, *Fundamentals of Digital Image Processing. Prentice-Hall, Pearson*; Edition: First.
4. Bernd Jahne and Horst HauBecker, Computer vision and Applications, Academic press, 2000.

STREAM: NETWORK ANALYTICS

DSE 4405 CLOUD COMPUTING [3 0 0 3].

Cloud Computing Overview: Definition and evolution of Cloud Computing Enabling Technologies, Service and Deployment Models, Popular Cloud Stacks and Use Cases Benefits, Risks, and Challenges of Cloud Computing, Virtualization: Introduction, Characteristics of Virtualized Environment, Types of Virtualization, Implementation Levels of Virtualization, Taxonomy of Virtualization Techniques, Tools and Mechanisms, Pros and Cons of Virtualization. Programming Model: Parallel and Distributed Programming Paradigms, Cloud Platforms in Industry: Amazon Web Services, Google App Engine, Microsoft Azure, Service level agreements; Data in the cloud, MapReduce and extensions, Security In The Cloud: Security Overview, Cloud Security Challenges and Risks, Software-as-a-Service Security, Security Governance, Risk Management, Security Monitoring, Security Architecture Design, Data Security, Application Security , Virtual Machine Security, Identity Management and Access Control, Autonomic Security.

SDL: Cloud Platforms in Industry: Amazon Web Services, Google App Engine, Microsoft Azure, Virtualization Tools and Mechanisms.

References:

1. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, *Mastering cloud computing: foundations and applications programming*, Elsevier Inc, 2013.
2. Gautam Shroff, *ENTERPRISE CLOUD COMPUTING: Technology, Architecture, Applications*, Cambridge University Press, 2010
3. Barrie Sosinsky, *"Cloud Computing Bible*", Wiley India Edition, 2013.
4. Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Dr. Deven Shah, *"Cloud computing black Book",* Dream Tech Press, 2014.
5. Velte Anthony T, Toby J. Velte and Robert E., *"Cloud Computing: A Practical Approach*", Tata McGraw Hill, 2013.

DSE 4406 INTERNET OF THINGS [3 0 0 3]

Internet of Things, Physical Design, Logical Design, IoT Enabling Technologies, IoT Levels & Deployment Templates, Domain Specific IoT Applications. IoT Network Architecture and Design: Drivers Behind New Network Architectures, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack, IoT Data Management and Compute Stack. Smart Objects: The "Things" in IoT, Sensors, Actuators, and Smart Objects, Sensor Networks, Connecting Smart Objects, Communications Criteria, IoT Access Technologies. IP as the IoT Network Layer, Optimizing IP for IoT, Profiles and Compliances, Application Protocols for IoT, The Transport Layer, IoT Application Transport Methods. Data and Analytics for IoT, An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics. Securing IoT, A Brief History of OT Security, Common Challenges in OT Security, Formal Risk Analysis Structures. Prototyping Endpoints - Embedded Computing Basics, Arduino, Raspberry Pi, BeagleBone Black, IoT Use Cases - Industrial Automation, Smart Home, Smart City, Commercial Building Automation.

SDL: Data and Analytics for IoT, An Introduction to Data Analytics for IoT, Machine Learning, Big Data Analytics Tools and Technology, Edge Streaming Analytics, Network Analytics

References:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet Of Things*, 1stEdition, Pearson Education (Cisco Press Indian Reprint).
2. Arshdeep Bahga, Vijay Madisetti, *Internet of Things – A hands-on approach*, Universities Press, 2015.
3. Adrian McEwen, Hakim Cassimally, *Designing the Internet of Things*, Wiley, 2014.
4. Holler J., *From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence*, Academic Press, 2014.

5. Olivier Hersent, David Boswarthick, Omar Elloumi, *The Internet of Things – Key applications and Protocols*, Wiley, 2012.

DSE 4407 ENTERPRISE DATA ARCHITECTURE [3 0 0 3]

Introduction to Enterprise Architecture:- Overview, core elements, Structure of enterprises, Introduction to Enterprise Data Architecture (EDA), Evolution of architecture, Monolithic systems – Mainframes. N-tier Architecture:- Introduction to N-tier architecture, Application Layer, Data Layer – Structured and Unstructured Data, Communication Layer. Service oriented architecture and Micro services:- Service oriented architecture, Web Services, Introduction to Microservices, Components of Microservices, Containers, Orchestration, Mesh, API Design, Data Handling, Architectural principles, Effectiveness of SoA. Data Models and Data governance: - Introduction to Data Models, Performance considerations, rendering, performance testing and monitoring, Disaster Recovery strategies, Fault Tolerance and Recovery, data-sharding, de-duplication in-memory computing, Scaling, Data governance, Security, privacy, value and risk, Repository and Support Tool. Architecture for Modern Technologies: - Hardware, Polycloud, Modern communication, Architecture for AI systems, Architecture for Distributed Financial systems and Architecture for Web 3.0. Enterprise Architectural frameworks: - Open-Source Frameworks, MEGAF, India Enterprise Architecture (IndEA), National Institute of Standards and Technology (NIST), Zachman Framework, Introduction to Enterprise Architectural frameworks- TOGAF, Enterprise Architectural frameworks- TOGAF framework modular structure, TOGAF content framework, architecture styles.

References:

1. Andy Graham, *The Enterprise Data Model: A framework for enterprise data architecture*, Koios Associates Ltd, 2nd edition, 2012.
2. Charles D. Tupper, *Data Architecture: From Zen to Reality*, Morgan Kaufmann, 1 edition, 2011.
3. Scott A. Bernard , *An Introduction to Enterprise Architecture*, AuthorHouse, 3rd edition.

DSE 4408 BLOCK CHAIN TECHNOLOGY [3 0 0 3]

Introduction, Structure of a Block, The Genesis Block, Linking Blocks in the Blockchain, Merkle Trees, Simplified Payment Verification, Using hash functions to chain blocks, for Proof-of-Work, Digital Signatures to sign transactions, Distributed Ledger, Byzantine Agreement, Eventual Consistency & Bitcoin Consistency- Availability and Partitions, Bitcoin,

Smart Contracts, Weak Consistency, Distributed Storage, Consistent Hashing, Hypercubic Networks, Mining and Consensus: Decentralized Consensus, Independent Verification of Transactions Mining Nodes, Aggregating Transactions into Blocks, Constructing the Block Header, Successfully Mining the Block, Validating a New Block, Assembling and Selecting Chains of Blocks, Consensus Attacks, Changing the Consensus Rules, Soft Fork Signaling with Block Version, Consensus Software Development, Ethereum and Bitcoin, block format,mining algorithm, proof-of-stake (PoS) algorithm, account management, contracts and transactions, Solidity language, account management, contracts and transactions, Applications of Blockchain :Case studies

References:

1. Andreas M. Antonopoulos, *Mastering Bitcoin: unlocking digital cryptocurrencies,* O'Reilly Media, (1e) 2014
2. Roger Wattenhofer, *Distributed Ledger Technology, The science of the Blockchain,* Inverted Forest Publishing, (2e), 2017.
3. Antonopoulos, Andreas M. and Wood, Gavin, *Mastering Ethereum*, O'Reilly Media, 2018.
4. George Icahn, *Blockchain:the complete guide to understanding blockchain technology,* Amazon publishers, 2017.

Other Programme Electives

DSE 4441 BIOINFORMATICS [3 0 0 3]

Introduction to Bioinformatics, Central dogma of biology, Digital code of life, database sequence search& Alignment, The evolutionary basis of sequence alignment, The modular nature of proteins, Optimal alignment methods, Substitution scores and gap penalties, Statistical significance of alignments, Structure file formats; Visualizing structural information, Motifs and Pattern, Protein structure prediction, Searching for trees, Rooting trees, Evaluating trees and Data, Phylogenetic software, Phylogenetics on the web, Some simple practical considerations. Introduction to Genomics, Genome annotation, Comparative genomics, Genome compression.

References:

1. Arthur M. Lesk. *Introduction to Bioinformatics*, Oxford University Press, 2002
2. Stuart M. Brown. *BIOINFORMATICS: A biologists guide to biocomputing and the internet*, NYUMedical Center, 2000

DSE 4442 BIOSTATISTICS [3 0 0 3]

Review of descriptive statistics, Sampling techniques, Summarizing Quantitative Data, Summarizing Categorical Data. Distributions- Binomial, Negative binomial , Poisson, Continuous Outcomes, Normal Distributions, Population, Sample, Central Limit Theorem, Standard Error, Confidence Intervals. Sampling Distributions, Confidence Intervals estimates. Role of probability in decision making. p- values and statistical inference, Inferential statistics – Hypothesis tests, Chi-square, ANOVA, ANCOVA. Comparative statistics – correlation tests. Non parametric tests. Survival analysis- survival function, survival curve, Cox Propotional Hazards Regression Analysis-Linear, GLM, stepwise logisticand model selection via AIC and BIC. Prevalence, Incidence, Relative Risk, Risk Difference, SamplingBias. Study Design – observational , randomized, Randomized Block design, Latin Square design. crossover and parallel arm design. Introduction to factorial designs, 2k factorial design, main effects. Screening designs- Fractional factorial designs, Plackett-Burmann screening designs. Model reduction interaction effects. Clinical Trials, Model assumption checking, residual plots. Optimization designs- Response surface methodology concepts & methods, central composite designs and Box-Behnken design. Probability & Screening; Power and Sample Size determination.

References:

1. Sullivan, L.M., *Essentials of biostatistics for the health sciences*, 3rd edition, Jones & BartlettLearning, 2018.
2. Machin, Campbell and Walters, *Medical Statistics*, 4th edition, Wiley, 2007.
3. Motulsky, H., *Intuitive Biostatistics: A nonmathematical guide to statistical thinking*, 3rd edition,Oxford University Press, New York, 2014.
4. Utts, J and Heckard, R., *Mind on statistics*, 5th edition, Cengage Learning, USA.
5. Stephen S. Senn , *Statistical issues in drug development*, 2nd edition, Wiley Publication.
6. David S. Moore , William I. Notz, Michael A. Fligner , *Statistics in practice* , W. H. Freemanpublication, 1st edition, 2014.

DSE 4443 DATA FORENSICS [3 0 0 3]

Introduction, the history of forensics, the objectives of computer forensics, computer forensics flaws and risks, computer forensics- rules, procedures and legal issues, computer forensics lab, essential laboratory tools. Forensics investigation process: Introduction, investigating computer crime, conducting a computer forensics investigation, Recovering Deleted Files and Deleted Partitions, Data Acquisition and Duplication. Hard disk and file systems: Introduction, file systems and hard disks, digital media devices, image file forensics, boot process-windows,linux and macintosh. Advanced forensics: Operating system forensics, Network forensics, Database forensics, Mobile forensics; cloud forensics, Malware forensics, investigating web and email attacks. Forensics analysis, validation and Report writing: Determine what data to collect and analyze, validating forensics data, addressing data hiding techniques, understanding the

importance of reports, guidelines for writing reports, generating report findings with forensics software tools.

References:

1. Nelson, Phillips Enfinger, Steuart, *Computer Forensics and Investigations*, CENGAGE Learning, 2013.
2. Dave Kleiman, *The official CHFI study guide* , Syngress publishing, 2017
3. Chris Pogue, *Unix and Linux forensic analysis DVD toolkit*, Syngress publishing, 2008.
4. John R. Vacca, Charles, *Computer Forensics, Computer Crime Investigation*, River Media, 2005.
5. Eoghan Casey, *Handbook of digital forensics and investigation*, Elsevier Academic press, 2010.
6. Harlan Cavery, *Windows forensic analysis DVD toolkit*, Syngress Publishing, 2009.
7. Keith J. Jones, Richard Bejtiich, Curtis W. Rose, *Real Digital Forensics*, Addison Wesley Pearson Education, 2005.

DSE 4444 QUANTUM COMPUTING [3 0 0 3]

Introduction, Fundamental concepts. Quantum bits, Quantum computation, Quantum algorithms, Quantum Information, Introduction to Quantum Mechanics, Liner algebra, Postulates of quantum mechanics, Quantum Computation, Quantum circuits, Controlled operations, Measurement, Universal quantum gates, The Quantum Fourier Transform, The quantum Fourier transform, Phase estimation, Applications, Quantum Search Algorithms, Quantum counting, Speeding up the solution of NP-Complete problems, Quantum Information, Classical noise and Markov processes, Quantum Operations, Quantum Error Correction, The Shor code, Theory of quantum error correction, Entropy and Information, Shannon entropy, Basic properties of entropy, Von Neumann entropy, Quantum Information Theory, Distinguishing quantum states and the accessible information, Data compression, Classical information versus noisy quantum channels, Quantum information versus noisy quantum channels, Entanglement as a physical resource, Quantum cryptography.

References:

1. Michael A Nielsen, and Isaac L. Chuang "*Quantum Computation & Quantum Information*", (10e), Cambridge University Press, 2011.
2. F. Benatti, M. Fannes, R. Floreanini, and D. Petritis, "*Quantum Information, Computationand Cryptography"* Springer, 2010.
3. Mika Hirvensalo, "*Quantum Computing*", (2e), Springer-Verlag New York, 2004.
4. Jozef Gruska, "*Quantum Computing*", McGraw Hill, 1999.
5. Phillip Kaye, Raymond Laflamme and Michele Mosca, "*An Introduction to QuantumComputing*", Qxford University Press, 2006.

DSE 4445 ROBOTICS AND AUTOMATION [3 0 0 3]

Introduction: Definition, Applications of mobile robotics, History of mobile robotics. Design of system and navigation architecture: Reference control scheme of a mobile robotics environment, Temporal decomposition of architecture, Control decomposition, Hybrid architecture, Mobile architecture, Perception, Representation and the mapping process. Locomotion: Issues for locomotion, Legged mobile robots, Wheeled mobile robots. Kinematics: Kinematics introduction, Forward and reverse kinematics, Wheeled kinematics and its constraints, Mobile system locomotion, Human biped locomotion as a rolling polygon, Representation of robot position through the reference frame. Power Sources and Sensors: Hydraulic, pneumatic and electric drives, determination of HP of motor and gearing ratio, variable speed arrangements, path determination, micro machines in robotics, machine vision, ranging, laser, acoustic, magnetic, fiber optic and tactile sensors. Manipulators, Actuators and Grippers: Construction of manipulators, manipulator dynamics and force control, electronic and pneumatic manipulator control circuits, end effectors, U various types of grippers, design considerations. Navigation: Localization overview, Path planning. Computational intelligence: Swarm intelligence, Evolutionary computation, Artificial immune system, Ant algorithm. Mobile robot programming: This chapter is included to provide hands on introduction to the field of mobile robotics and various issues in designing and planning of robot work environment. It includes construction and programming of roboticagents using robotic kits and microcontrollers applying concepts of locomotion, perception, navigation and computational intelligent algorithms.

References:

1. Ronald Siegwart, Illah R. Nourbakhsh, "*Introduction to Autonomous Mobile Robots*", MITPress,
2. Andries P. Engelbrecht , "*Computational Intelligence: An Introduction*", Wiley 2nd Edition,2007
3. Ronald C. Arkin , "*Intelligent Robotics and Autonomous Agents*", MIT Press, 1997
4. Ulrich Nehmzow, "*Mobile Robotics: A practical Introduction*", Springer-Verlag London,2003
5. Robin R. Murphy, "*Introduction to AI Robotics*", MIT Press, 2000
6. Leandro N. de Castro and Jonathan Timmis, "*Artificial Immune system: A new Computational Intelligence Approach*", Springer-Verlag, Germany 2002.

DSE 4446 SOFT COMPUTING TECHNIQUES [3 0 0 3]

Introduction to Soft Computing: Concept of Computing Systems, Soft Computing Versus Hard Computing, Characteristics of Soft Computing, Some Applications of Soft Computing Techniques; Fuzzy Logic: Introduction to Fuzzy Logic- Fuzzy Sets and Membership Functions, Operations on FuzzySets, Fuzzy Relations, Rules, Propositions, Implications and Inferences,

Defuzzification Techniques - Fuzzy Logic Controller Design, Some Applications of Fuzzy Logic; Artificial Neural Networks: Biological Neurons and its Working, Simulation of Biological Neurons to Problem Solving, Different ANNs Architectures, Training Techniques for ANNs, Applications of ANNs to Solve Some Real Life Problems; Nature Inspired Algorithms: Genetic Algorithms, Concept of "Genetics" and "Evolution" and its Application to Probabilistic Search Techniques, Basic GA Framework and Different GA Architectures, GA Operators- Encoding, Crossover, Selection, Mutation, etc., Solving Single-Objective Optimization Problems Using GAs, Particle Swarm Optimization- Implementation, Operators, Case Studies, Ant Bee Colony Optimization- Implementation, Operators, Case Studies; Multi-Objective Optimization: Problem Solving Concept of Multi-Objective Optimization Problems (MOOPs) and Issues of Solving Them. Multi-Objective Evolutionary Algorithm (MOEA), Non-Pareto Approaches to Solve MOOPs, Pareto-Based Approaches to Solve MOOPs, Some Applications with MOEAs.

References:

1. Martin, F., Neill, Mc. and Thro, E., *Fuzzy Logic: A Practical approach*, AP Professional, 2000.
2. Ross, T, J., *Fuzzy Logic with Engineering Applications*, (3e), Willey India, 2010.
3. Kasabov, N. K., *Foundations of Neural Networks*, Fuzzy Systems, and Knowledge Engineering,MIT Press, 1998.
4. Ibrahim, A. M., *Fuzzy Logic for Embedded Systems Applications*, Elsevier Press, 2004.
5. Mitchell, M., *An Introduction to Genetic Algorithms*, MIT Press, 2000.
6. Goldberg, D. E., *Genetic Algorithms In Search, Optimization And Machine Learning*, PearsonEducation India, 2002.
7. Rajasekaran, S. and Vijayalakshmi Pai, G. A., Neural Networks, *Fuzzy Logic and GeneticAlgorithms: Synthesis, and Application*s, Prentice Hall India, 2007.
8. Pratihar, D. K., *Soft Computing*, (1e), Narosa Publishing, 2008.
9. Jang, J.-S. R., Sun, C.-T. and Mizutani, E., *Neuro-Fuzzy and Soft Computing*", (1e), PHILearning, 2009.
10. Haykin, S., *Neural Networks and Learning Machines*, (3e), Prentice Hall India, 2011.

DSE 4447 SOFTWARE ENGINEERING [3 0 0 3]

Introduction: Software life cycle: Waterfall model, Iterative waterfall model, Prototype model, Evolutionary model, Spiral model, RAD model, Agile models, comparison of different life cycle models. Software project management Requirements analysis and specification: Requirements gathering and analysis, Software requirement specification (SRS), Traceability,Characteristics of a Good SRS Document, IEEE 830 guidelines, overview of formal system development techniques. Software design. Function-oriented andObject Oriented software design: Overview of SA/SD methodology, structured analysis, Data flow diagram, Extending DFD technique to real life systems, Structured design, Detaileddesign, Design review. Unified Modeling Language (UML), UML Diagrams: Static and Dynamic User interface design:. Coding and testing:

Coding, Code testing, Test driven development, testing tools,Introduction to Agile software development and DevOps. Software reliability and quality management: Software reliability, Statistical testing, Software quality and management, ISO9000, SEI capability maturity model, Personal software process (PSP), Six sigma, Software quality metrics Computer aided software engineering: Software maintenance and reuse: Characteristics of software maintenance, Software reverse engineering, Software maintenanceprocesses model, Estimation maintenance cost. Basics issues in any reuse program, Reuse approach, Reuse at organization level.

References:

1. Rajib Mall, "*Fundamentals of Software Engineering*", PHI.
2. Richard Fairley, "*Software Engineering Concepts*", Tata McGraw Hill.
3. Jalote Pankaj, "*An integrated approach to Software Engineering*", Narosa.
4. Pressman R, "*Software Engineering- Practitioner Approach*", McGraw Hill.

OPEN ELECTIVES

DSE 4311 INTRODUCTION TO DATABASE SYSTEMS WITH MYSQL [3 0 0 3]

Modeling and Designing Databases, Database Design Process, Entity-Relationship Model, Basic Concepts, Constraints, Design of ER database schema, Reduction of ER to schema, Relational model, Super, candidate, primary ,foreign key, Schema Diagram, Relational Database design, Functional dependencies, Normal forms, Creating a MySQL Database, Table, Modifying table, constraints, indexes, Basic SQL, Inserting Data, Selecting Data, Updating Data, Deleting Data, MySQL Functions, Numeric, String, Date /Time, Advanced Queries, Sorting, Multiple tables, Inner Join, Left Join, Right Join, Natural Join, Nested queries, Generating summaries, COUNT(), MIN(), MAX(), SUM(), AVG(), Group By, Statistical techniques, Calculating Descriptive statistics, Per-Group Descriptive Statistics, Generating frequency distribution ,Calculating correlation coefficients, assigning ranks, Stored program: Stored routines, stored procedure, stored function, Triggers, Events to schedule Database actions, Managing users and privileges, Importing and Exporting data: importing data with LOAD data and mysql import, importing csv files, exporting query results, tables, importing XML**.**

SDL: Importing and Exporting data: importing data with LOAD data and mysql import, importing csv files, exporting query results, tables, importing XML**.**

References:

1. Paul Dubois, *MySQL Cookbook*, O'REILLY, First Edition, 2007.
2. Larry Ullman, *Visual Quick Start guide MySQL*, Pearson Education, 2nd Edition, 2007.
3. Seyed M. M, Saied Tahaghoghi and Hugh Williams, Learning MySQL, O'Reilly, 2006.
4. Russell J.T. Dyer, *MySQL in a Nutshell*, O'REILLY, 2nd Edition, 2008.
5. Rob, Peter. *Database System Concepts*. Cengage learning, 2008.
6. Silberschatz, A., Korth, H.F. and Sudarshan, S., 2011. *Database system concepts.*.

DSE 4312 INTRODUCTION TO AR AND VR [3 0 0 3]

Introduction: Input Devices: Trackers, Navigation and Gesture interfaces, Output Devices: Graphics, 3D Sound and Haptic Displays. Computing Architectures for VR: The Rendering pipeline, PC Graphics Architecture, Workstation-Based Architectures, Distributed VR Architectures, Modeling: Geometric Modeling, Kinematics Modeling, Physical Modeling, Behavior Modeling, Model Management. VR Programming: Toolkits and Scene Graphs, World Tool kit and other Toolkits. Lights and Optics, Visual Perception, Introduction to VR: Unity 3D Engine, 2D Game concepts and basic scripting, 3D Game concepts, and environment creation. Introduction to Unity AR: Foundation and Vuforia, working with Vuforia in Unity.

SDL: Applications and Impact of AR and VR

References:

1. Grigore C. Burdea, Philippe Coiffet , *Virtual Reality Technology*, Wiley 2016
2. Alan B. Craig, *Understanding Augmented Reality, Concepts and Applications*, Morgan Kaufmann, 2013.
3. Alan Craig, William Sherman and Jeffrey Will, *Developing Virtual Reality Applications*, Foundations of Effective Design, Morgan Kaufmann, 2009.
4. John Vince, "*Virtual Reality Systems* ", Pearson Education Asia, 2007.
5. Anand R., "*Augmented and Virtual Reality*", Khanna Publishing House, Delhi.

DSE 4313 INTRODUCTION TO LINUX AND SHELL SCRIPTING [3 0 0 3]

Introduction to UNIX/LINUX Operating System: Introduction to Operating system concepts, Linux Overview, kernel and shell and the types of the shell, User Interfaces. Basic Shell Commands: Interacting with the shell, Using the bash manual, Traversing the file system, Listing files and directories, Managing files and directories, Viewing file contents, using Unix, input and output, redirection, scripts, pipes, pagers, getting help. Processes and Devices: Process status, Foreground and background, process control, signals, Process Utilities (ps, kill, wait, sleep), Environment variables, Global and local variables, Investigating Shell Types, Understanding the Parent/Child Shell Relationship, Using Subshells Creatively. Investigating Built-in Shell Commands Executable scripts, Job control, Command history list, running job at a specific time, Running programs periodically, big programs, Timing a program, running programs in order, Quotes and escapes, Devices, backquotes. File Systems, File commands.
Linux Editors, Command mode, Regular Expressions and filters, SED, Shell and Shell Scripting, Advanced shell programming, Pattern Scanning, Utility (AWK), Program Control Structures, Bash Shell Features.

References:

1. Richard Blum and Christine Bresnahan, *Linux Command Line Shell Scripting BIBLE*, 3rd Edition, Wiley, 2015.
2. Mark Sobel. *A Practical Guide to Linux commands Editor and shell programming*, Prentice Hall, 2nd Edition, 2010.
3. Stephen G. Kochan. *Unix Shell Programming*, 3rd Edition, SAMS Publications, 2003.
4. Bash Reference Manual Download able from GNU Project.
5. Brian W Kerningham and Rob Pike. *The Unix Programming Environment*, PHI Learning Pvt. Ltd., 2009.

DSE 4314 INTRODUCTION TO DATA ANALYTICS [3 0 0 3]

Introduction - data science, need for analytics, steps in data analysis projects, Data- sources of data, data sets, data warehouses, data types, privacy and confidentiality, samples vs. population. Data summarization and visualization – tables and graphs. Data Preprocessing- cleaning, transformation, dimensionality reduction. Data Analysis and Visualization – descriptive, inferential statistics, uni-variate and multi-variate analysis. Grouping – Cluster Analysis-distance measures, partitioning, hierarchical, density based methods. Market Basket Analysis, Association Analysis, Market Basket Analysis. Classifiers-Bayesian, k-nearest neighbor, neural network, Support Vector Machine, Decision Trees. Prediction- Regression models, Evaluating Classification and Predictive performance, ensemble methods. Anomaly Detection. Forecasting models.

References:

1. Glenn J. Myatt, Wayne P. Johnson, *Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining*, 2nd Edition, John Wiley & Sons Publication, 2014.
2. Glenn J. Myatt, Wayne P. Johnson, *Making Sense of Data II: A Practical Guide to Data Visualization, Advanced Data Mining Methods, and Applications*, John Wiley & Sons Publication, 2009.
3. Galit Shmueli, Nitin R. Patel, and Peter C. Bruce, *Data Mining for Business Intelligence*, John Wiley & Sons, 2014.
4. Ian H. Witten, Eibe Frank, Mark A. Hall, *Data Mining: Practical Machine Learning Tools and Techniques*, Morgan Kaufmann, 2011.
5. Pang-Ning Tan, Michael Steinbach, Vipin Kumar, *Introduction to Data Mining*, Pearson Addison Wesley, 2005.