DELHI TECHNOLOGICAL UNIVERSITY
SCHEME OF TEACHING AND EVALUATION
M.TECH DATA SCIENCE

The following alphanumeric coding scheme has been adoptedCore Courses XXXYMN
Elective Courses XXXYCMN
XXX abbreviates a particular M. Tech. program, Y – (5 for M. Tech. 1 st year, 6 for M. Tech. 2 nd year), C – credit of the course (4), MN – Subject code (Odd number for odd semester and even number for even semester courses

Semester I													
S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	**Total Credit**
1	DSC501	Mathematical Foundations of Computer Science	Department Core -1	4	3	0	2	15	25	20	40	-	**24**
2	DSC503	Data Management and Ethics	Department Core -2	4	3	0	2	15	25	20	40	-	
3	DSC505	Machine Learning	Department Core -3	4	3	0	2	15	25	20	40	-	
4	DSC507	Advanced Data Structures and Algorithms	Department Core -4	4	3	0	2	15	25	20	40	-	
5	DSC5401/ DSC5403/ …….	Elective - 1	Department Elective -1	4	3 / 3	0 / 1	2 / 0	15 / 25	25 / 0	20 / 25	40 / 50	-	
6	DSC509	Seminar	Self-Study	2	2	0	0	-	-	-	100	-	
7	DSC511	Research Paper Writing	Skill Enhancement Course - 1	2	2	0	0	20	-	30	50	-	
8	DSC513	Audit Course	Audit Course	0									
Semester II													
S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	**Total Credit**
1	DSC502	Data Preparation and Analysis	Department Core -5	4	3	0	2	15	25	20	40	-	
2	DSC504	Deep Learning	Department Core -6	4	3	0	2	15	25	20	40	-	

3	DSC5402/ DSC5404/ ……	Elective – 2	Department Elective -2	4	3 / 3	0 / 1	2 / 0	15 / 25	25 / 0	20 / 25	40 / 50	-	**24**
4	DSC5416 /DSC5418/…… …	Elective - 3	Department Elective -3	4	3 / 3	0 / 1	2 / 0	15 / 25	25 / 0	20 / 25	40 / 50	-	
5	UEC	Research Methodology	University Core	4	3	0	2	15	25	20	40	-	
6	DSC506	Python for Data Science	Skill Enhancement Course - 1	4	3	0	2	15	25	20	40	-	
Semester III													
S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	**Total Credi**
1	DSC601	Big Data Analytics	Department Core -7	4	3	1	0	25	-	25	50	-	16
2	DSC6401 /DSC6403/	Elective - 4	Open Elective - I	4	3	0	2	15	25	20	40	-	
3	DSC603	Minor Project/ Research Thesis/ Patent	Core	8	0	0	8	-	50	-	-	50	
Semester IV													
S. No.	**Course Code**	**Course Name**	**Type/Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**	**Total Credits**
1	DSC602	Major Project/ Research Thesis/ Patent	Core	16	0	0	16	-	-	-	100	-	**16**

LIST OF ELECTIVES :

	S.No.	Course Code	Course Name	Type/ Area	Cr	L	T	P	CWS	PRS	MTE	ETE	PRE
Elective -1	1	DSC5401	Advanced Database Management Systems	Elective	4	3	0	2	15	25	20	40	-
	2	DSC5403	Advanced Operating System		4	3	1	0	25	-	25	50	-
	3	DSC5405	Data Warehousing Data Mining		4	3	0	2	15	25	20	40	-
	4	DSC5407	Data Visualization and Predictive Analytics		4	3	0	2	15	25	20	40	-
	5	DSC5409	Intelligent Systems and Interfaces		4	3	1	0	25	-	25	50	-
	6	DSC5411	Introduction to Statistical Methods		4	3	1	0	25	-	25	50	-
	7	DSC5413	Fundamentals of Information Retrieval		4	3	1	0	25	-	25	50	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective -2	1	DSC5402	Artificial Intelligence	Elective	4	3	1	0	25	-	25	50	-
	2	DSC5404	Empirical Software Engineering		4	3	1	0	25	-	25	50	-
	3	DSC5406	Artificial Neural Networks		4	3	1	0	25	-	25	50	-
	4	DSC5408	Business Analytics		4	3	1	0	25	-	25	50	-
	5	DSC5410	Distributed Systems		4	3	1	0	25	-	25	50	-
	6	DSC5412	Multimedia Applications		4	3	0	2	15	25	20	40	-
	7	DSC5414	Semantic Web Mining		4	3	0	2	15	25	20	40	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Elective - 3	1	DSC5416	Natural Language Processing	Elective	4	3	1	0	25	-	25	50	-
	2	DSC5418	Optimization Techniques		4	3	1	0	25	-	25	50	-
	3	DSC5420	Web Analytics and Development		4	3	0	2	15	25	20	40	-
	4	DSC5422	Computer Vision		4	3	0	2	15	25	20	40	-
	5	DSC5424	Intellectual Property Rights		4	3	1	0	25	-	25	50	-

	6	DSC5426	GPU Computing		4	3	0	2	15	25	20	40	-
	7	DSC5428	Recommender System		4	3	1	0	25	-	25	50	-
	S.No.	**Course Code**	**Course Name**	**Type/ Area**	**Cr**	**L**	**T**	**P**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
Open Elective	1	DSC6401	Data Security and Privacy	Elective	4	3	1	0	25	-	25	50	-
	2	DSC6403	Pattern Recognition		4	3	0	2	15	25	20	40	-
	3	DSC6405	Internet of Things		4	3	0	2	15	25	20	40	-
	4	DSC6407	Cloud Computing		4	3	1	0	25	-	25	50	-
	5	DSC6409	Security Analysis		4	3	1	0	25	-	25	50	-
	6	DSC6411	Introduction to Health Care Data Analytics		4	3	0	2	15	25	20	40	-
	7	DSC6413	Swarm and Evolutionary Computing		4	3	1	0	25	-	25	50	-

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DELHI TECHNOLOGICAL UNIVERSITY

SYLLABUS: M.Tech. (Data Science)

SEMESTER I

DSC501 Mathematical Foundations of Computer Science

This course contains topics of Introduction to Probability theory, Through set and Relative Frequency: Experiments and Sample Spaces, Discrete and Continuous Sample Spaces, Events, Probability and Axioms, Probability as a Relative Frequency, Joint and Conditional Probability, Random Variables, Distribution Function, Density Function. Random Samples, sampling distributions, Methods of moments and maximum likelihood. Covariance and correlation, Statistical Inference: Introduction of multivariate statistical models: Classification and regression, principal component analysis, overfitting problem. Graph theory: Isomorphism, planar graphs. permutations and combinations. Computer science and engineering application: software engineering, data mining, machine learning. Recent Trends

S. No.	Course Outcomes (CO)
CO1	Understand fundamental probability theory concepts, including sample spaces, probability axioms, and joint and conditional probabilities, for computational applications.
CO2	Apply statistical inference techniques such as random sampling, distribution functions, and parameter estimation using methods of moments and maximum likelihood.
CO3	Analyze multivariate statistical models, including classification, regression, and principal component analysis, while addressing overfitting challenges.
CO4	Utilize graph theory concepts such as isomorphism, planar graphs, permutations, and combinations for solving computational problems.
CO5	Implement mathematical principles in computer science applications, including software engineering, data mining, and machine learning, while exploring recent trends.

Suggested Books:

1. J. Vince, "Foundation Mathematics for Computer Science", Springer, 2015.
2. Ronald Walpole, Raymond Myers, Sharon Myers, Keying Ye, "Probability and Statistics for Engineers and Scientists", Prentice Hall International, 20 I 6.
3. Joseph F. Hair, William C. Black, Barry J. Babin, Rolph E. Anderson, "Multivariate Data Analysis", Prentice Hall, 2010.
4. Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh, "An Introduction to Probability and Statistics", 3rd Edition, Wiley, 2015.

Reference Books:

1. H.C. Taneja, "Statistical methods for Engineering and Sciences", I.K. International.

DSC503 Data Management and Ethics

The objective of the course is to introduce data management concepts and ethical practices. Database system concepts and its _architecture, Data models schema and instances Data independence and database language and interface, Data definition languages DML. Relational Data Model and Language. Data Base Design: Functional dependencies, normal forms, INF, 2NF, 3NF and BC F multi-valued dependencies fourth normal form, join dependencies and fifth normal form. Functional dependencies, lossless join decompositions, normalization using FD. Transaction processing concepts: Transaction processing system, schedule and recoverability Testing of serializability, Serializability of schedules, conflict & view serializable schedule, recovery from transaction failure deadlock handling. Concurrency Control Techniques: Locking Techniques for concurrency control, time stamping protocols for concurrency control, Database Security Issues. Ethics and Data Management: - Data ethics, need for Data ethics, Data ownership and privacy The Five Cs (Content, Clarity Consistency and Trust, Control and Transparency, Consequences), Implementing 5Cs Ethics and Security Training, Developing Guiding Principles, Building Ethics into a Data-Driven Culture. Ethical issues related to data collection and storage: - ethical responsibilities of a company to its customers. Ethical responsibilities of employees to the company and its customers, Ethical responsibilities of customers to the company. Database Administrator's Code of Ethics: - Database Administrator, Need of Database Administrator, Existing DBA code of ethics, Areas of improvisation in existing code of ethics. Data Ethics Case studies: Academic Data Standards.

S. No.	Course Outcomes (CO)
CO1	Explain database system architecture, data models, schema, and database languages to design and interact with relational databases.
CO2	Analyze functional dependencies and apply normalization techniques (1NF to 5NF) to optimize database design and ensure data integrity.
CO3	Implement transaction management techniques, ensuring recoverability, serializability, and concurrency control to maintain database consistency.
CO4	Evaluate ethical concerns in data management, including data ownership, privacy, and corporate responsibilities, while implementing security measures.
CO5	Understand the role of a Database Administrator, existing ethical guidelines, and best practices for responsible data handling in professional environments.

Suggested Books:

1. R. Elmasri, S. B. Navathe, “Fundamentals of Database systems”, Addision Wesley, 2000.
2. A. Silberschatz, H. F. Korth and S. Sudarshan, “Database System Concepts”, McGraw Hill, 7th edition, 2019.
3. M. Loukides, H. mason and D. J. Patil, “Ethics and data science”, O’Reilly Media, 2018.
4. L. Turner, A. B. Weickgenannt and M. K. Copeland, “Accounting Information Systems: the processes and Controls, John Wiley & Sons, 2016.

DSC505 Machine Learning

The objective is to make the student understand the different supervised, unsupervised and reinforcement learning algorithms and choose the appropriate machine learning tool for different real-world examples. This course contains topics Machine Learning, Types of Machine Learning: Supervised, Unsupervised Learning, Reinforcement Learning, Categories of Supervised Learning; Predictive Modeling, Steps in Model Prediction: Metric Data Analysis, Attribute Reduction, Hypothesis Testing, Performance Evaluation Measures, Model Development, Model Validation, Model Comparison Tests, Decision Trees (ID3, C4.5, CART), Artificial Neural Networks (Single-Layer Networks, Multi-layer Perceptron), Nearest Neighbour, Computing Distance, Support Vector Machine, Dimensionality Reduction, Ensemble Learning. Research applications.

S. No.	Course Outcomes (CO)
CO1	Understand the basic concepts of machine learning, supervised, unsupervised, regression analysis, and machine learning algorithms.
CO2	Apply the learned concepts of machine learning to interpret various problems.
CO3	Analyze different mathematical machine learning models for various systems.
CO4	Evaluate the performance of the machine learning model using various performance measures.
CO5	Develop an efficient machine learning system to solve various real-time problems.

Suggested Books:

1. T. Mitchell, "Machine Learning", McGraw Hill, 1997.
2. S. Shalev-Shwartz, S. Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014.
3. J. D. Kelleher, B. M. Namee, A. D'Arcy, "Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies", MIT Press, 2015.

DSC507 Advanced Data Structures

This course covers topics of Review of Elementary data structures, Sparse matrices, Advanced Data Structures: data structures for combinatorial, Operations on Disjoint Divide and Conquer approach, Graph Algorithms: Definitions and Algorithms, Greedy Method and Dynamic Programming, Dynamic Programming, Advanced Algorithms: NP Complete problems, Approximation algorithms for NP complete problem, Algorithms for matching, Flow and circular problems, Bio Inspired Algorithm-Genetic Algorithm, Particle Swam, Artificial Bee Colony, Firefly Algorithm, Bat Algorithm.

S. No.	Course Outcomes (CO)
CO1	Understand elementary and advanced data structures, including their applications in combinatorial problems
CO2	Apply divide and conquer techniques and operations on disjoint sets to solve computational problems efficiently.
CO3	Analyze and implement graph algorithms, greedy methods, and dynamic programming techniques.
CO4	Understand NP-complete problems and explore approximation algorithms for tackling intractable problems.
CO5	Implement algorithms for matching, flow networks, and circular problems in various applications.

Suggested Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, "Introduction to Algorithms", MIT Press, 2009.
2. R.E. Tarjan, "Data Structures and Network algorithms", SIAM Regional Conference series in Applied Mathematics, 1987.
3. Aho, Hopcraft & Ulman, "The Design and Analysis of Computer algorithms", Addison Wesley,1974.
4. S. Dasgupta, C. H. Papadimitriou, and U.V.V Azirani, "Algorithms", Tata McGraw Hill, 2017.
5. Y. Langsam, M. J. Augenstein, A. M. Tenenbaum, "Data Structures using C and C++", Pearson,2006.

DSC5401 Advanced Database Management System

This course covers topics of Relational Databases Integrity Constraints, Extended ER diagram, Relational Algebra & Calculus, Functional, Multivalued and Join Dependency, Normal Forms, Rules about functional dependencies. Advanced Transaction Processing, Query Processing, Query Optimization: Indexing and Query Optimization, Parallel and Distributed Databases: Distributed Data Storage – Fragmentation & Replication, Location and Fragment Transparency Distributed Query Processing and Optimization, Active Database and Real Time Databases: Triggers in SQL, Event Constraint and Action.

S. No.	Course Outcomes (CO)
CO1	Understand the concepts of DBMS and would have acquired skills to analyse the real-world problem domains in the context of DBMS and demonstrate the same through ER diagram.
CO2	Apply and demonstrate with understanding of relational query languages such as SQL, Relational Algebra and Relational Calculus.
CO3	Relate the concepts of inference rules, data constraints and normalization. Students would also have acquired skills to identify application of the same.
CO4	Familiar with basic database storage structures and access techniques: file and page organizations, indexing methods including B tree, and hashing. To appraise the basic issues of Transaction processing and Serializability.
CO5	Classify various concurrency control techniques and recovery procedures
C06	Familiar with case studies regarding commercial database, Oracle platforms, Postgres and MYSQL

Suggested Books:

1. R. Elmasri, S..B. Navathe, "Fundamentals of Database Systems", Sixth Edition, Pearson Education, 2017.
2. Garcia-Molina, "Database Systems, The complete book", Pearson, 2014.
3. Silberschatz, H. F. Korth, S. Sudarshan, "Database System Concepts", Sixth Edition, McgrawHill, 2013.
4. C.J. Date, A. Kannan, S. Swaminathan, "An Introduction to Database Systems", Eighth Edition, Pearson Education, 2007.

SWE5403 Advanced Operating System

The objective of the course is to learn various concepts related to operating systems. Operating system concepts: history, evolution and philosophy of operating systems. Concurrent processes, process coordination and synchronization, CPU scheduling, deadlocks, memory management, virtual memory, secondary storage and file management, device management, security and protection, networking, and distributed and real-time systems.

S. No.	Course Outcomes (CO)
CO1	Learn about Operating system concepts: history, evolution and philosophy of operating systems.
CO2	Learn about Concurrent processes, process coordination and CPU scheduling.
CO3	Learning about process synchronization and deadlocks
CO4	Understand memory management, virtual memory
CO5	Learn about secondary storage and file management, device management,
CO6	Understand the security and protection, networking, and distributed and real-time systems.

Suggested Books:

1. A Silberschatz, P.B. Galvin, G. Gagne, "Operating Systems Concepts", Eighth Edition, John Wiley Publications, 2008.
2. A.S. Tanenbaum, "Modern Operating Systems", Third Edition, Pearson Education, 2007.
3. W. Stallings, "Operating Systems, Internals & Design Principles", Fifth Edition, Prentice Hall ofIndia, 2008.

DSC5405 Data Warehousing and Data Mining

This course contains topics of Data Warehousing, Data Warehouse Architecture, Design, Implementation & Maintenance, Data Mining Concepts, Mining Association Rules in Large Databases, Classification and Prediction, Cluster Analysis in Data Mining, Mining Complex Types of Data: Multidimensional Analysis and Descriptive Mining of Complex Data Objects, Mining SpatialDatabases, Mining Multimedia Databases, Mining Time Series and Sequence Data, Mining Text Databases, Applications, Trends in Data mining, spatial mining, and Web Mining**.**

S. No.	Course Outcomes (CO)
CO1	Understand Data Warehouse, Need of Data Warehouse, Architecture of Data Warehouse.
CO2	Understand KDD process, applications of Data Mining.
CO3	Understand Classification and various models of Classification like KNN, Rule Based Mining
CO4	Apply Association Rule Mining.
CO5	Analyse and Evaluate various Classification Models on different problems.
C06	Understand clustering and various types of clustering.
CO7	Apply clustering algorithms like k-means, DBSCAN etc.

Suggested Books:

1. P. Ponniah, "Data Warehousing Fundamentals", John Wiley, 2001.
2. M.H. Dunham, "Data Mining Introductory & Advanced Topics", Pearson Education, 2011.
3. H. Kamber, M. Kaufman, J. Pie, "Data Mining Concepts & Techniques", Third Edition, Morgan Kaufmann, 2012.

DSC5407 Data Visualization and Predictive Analytics

This course intends to learn basics of information visualization, scientific visualization, to learn key techniques for data visualization, technological advancements of data visualization, detailed view of visual perception, the visualized data and distorting techniques. The introduction part discuss about the visual perception introduction, visual reference model, visual mapping, information overloads. Creation of visual representations, visualization systems will be covered in next part. Visualization of groups, trees, graphs, clusters, networks and software. Visualization of volumetric data, vector fields, processes, simulators, visualization of maps, graphic information, GIS systems, collaborative visualizations. Recent trends in various perception techniques, various visualization techniques, data structures used in the data visualization. Framework of predictive modeling process to students. Introduction: classification & prediction, key ingredients of predictive models, goals of a regression analysis, regression models, data in a regression analysis. Data preparation: analyzing the metric data, outlier analysis, correlation analysis, attribute reduction methods, attribute extraction. Statistical tests: categories, one-tail and two-tail, Type I and Type II errors, interpreting significance results. Model Development: data partition, attribute reduction, model construction, model validation, hypothesis testing, results interpretation, cross-validation. Hypothesis testing and model-comparison tests. Model evaluation: performance measures for categorical and continuous dependent variables, ROC analysis.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamentals of information and scientific visualization, including visual perception, data distortion techniques, visual reference models, and methods for handling information overload.
CO2	Explore techniques for creating visual representations of various data structures such as groups, trees, graphs, clusters, networks, volumetric data, and geographic information using advanced visualization systems and GIS tools.
CO3	Analyze recent trends and perception techniques in data visualization, as well as the data structures and frameworks supporting effective visual representation.
CO4	Gain proficiency in predictive modeling, focusing on classification, regression analysis, data preparation, attribute reduction/extraction, and the analysis of metric and correlation data.
CO5	Apply statistical tests, hypothesis testing, cross-validation, and performance evaluation techniques (e.g., ROC analysis) for model validation and the assessment of categorical and continuous dependent variables.

Suggested Books:

1. M.O. Ward, G. Grinstein and D. Keim, “Interactive data visualization: foundations, techniques, and applications”, CRC Press, 2010.
2. E. Tufte, “The visual display of quantitative information”, Graphics Press, 2001.
3. M. Kuhn and K. Johnson, “Applied Predictive Modelling”, Springer Verlag, 2013.
4. R. Malhotra, “Empirical Research in Software Engineering: Concepts, Analysis & Applications”, CRC press, 2016.
5. E.E. Frees, E.W. Derrig, and G. Meyers, “Predictive Modeling Techniques in Actuarial Science”, Vol. I: Predictive Modeling Techniques. Cambridge University Press, 2014.

DSC5409 Intelligent Systems and Interfaces

Language Processing: Computational Phonology: Issues, Phonological rules, Mapping text to phones, Prosody in TTS, Probabilistic models of pronunciation and Spelling, N-Grams. Syntax: Word classes and POS tagging, CFG for English, Lexicalized and Probabilistic Parsing. Semantics: Semantic representation, Semantic and Lexical analysis and Word sense disambiguation, IR. Pragmatics: Discourse, Dialogue agents, Natural Language Generation and Machine translation. Machine Learning: Data Mining: Association rules, Clustering, Decision Trees. Text Mining. Synergetic techniques: Genetic algorithms and ANN techniques for machine learning. Applications to bioinformatics. Intelligent Interfaces: Incorporating Intelligence: Requirements, design issues. Applications: Development of Intelligent interfaces for systems - Stand-alone systems like OS, Databases, Physical machines including robots. Web based applications like Tutoring systems, Web Mining, e-shopping.

S. No.	Course Outcomes (CO)
CO1	Understand computational phonology, phonological rules, and probabilistic models of pronunciation and spelling.
CO2	Apply syntactic analysis techniques such as POS tagging, CFG parsing, and probabilistic parsing.
CO3	Explore discourse, dialogue agents, natural language generation, and machine translation methods.
CO4	Implement machine learning and data mining techniques, including clustering, decision trees, and text mining.
CO5	Develop intelligent interfaces for standalone systems, databases, robots, and web-based applications.

Suggested Books:

1. D. Jurafsky and J. H. Martin, Speech and language Processing, Pearson Education, 2000.
2. E. Reiter and R. Dale, Building Natural Language Generation Systems, Cambridge University Press, 2000.
3. T. M. Mitchell, Machine learning, McGraw-Hill 1997.
4. J. Han and M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2000.

DSC5411 Introduction to Statistical Methods

Fundamental concepts of probability, random variables and mathematical expectation, some discrete and continuous probability distributions, joint probability distributions, sampling distributions, estimation and hypothesis testing, correlation and regression, analysis of variance (one- way and two-way classifications), review and applications of statistical tools. Introduction to statistical tools and statistical concepts with various tools such as WEKA, SPSS, R, Python and MATLAB.

S. No.	Course Outcomes (CO)
CO1	Understand fundamental probability concepts, including random variables, mathematical expectation, and probability distributions (discrete and continuous).
CO2	Apply statistical techniques such as joint probability distributions, sampling distributions, estimation, and hypothesis testing in real-world scenarios.
CO3	Analyze relationships between variables using correlation, regression analysis, and analysis of variance (ANOVA) for one-way and two-way classifications.
CO4	Utilize statistical tools such as WEKA, SPSS, R, Python, and MATLAB for data analysis and decision-making.
CO5	Implement statistical methodologies in various domains, including data science, machine learning, and engineering applications.

Suggested Books:

1. Ian H. Witten, Eibe Frank, M. Hall, "DATA MINING, Practical Machine Learning Tools and Techniques, "Morgan Kaufmann Series in Dara Management Systems, 2011.
2. V. K. Rohatgi, A. K. Md.E.Saleh, "An Introduction to Probability and Statistics", Wiley, 2008.
3. S. M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 5th edition, Academic Press, 2014

DSC5413 Fundamentals of Information Retrieval

This course contains topics of Introduction and Search engine architecture, Search engine architecture, Retrieval models, Retrieval evaluation, classical evaluation metrics, e.g., Mean Average Precision, and modern advance, e.g., interleaving. Relevance feedback, Link analysis and Search applications, recommendation, personalization, and online advertising.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamentals of information retrieval and search engine architecture.
CO2	Analyze different retrieval models and their applications in search engines.
CO3	Evaluate retrieval performance using classical and advanced evaluation metrics such as Mean Average Precision and interleaving.
CO4	Apply relevance feedback techniques to improve search results.
CO5	Explore link analysis methods and their role in search applications.

Suggested Books:

1. C. D. Manning, P. Raghavan and H. Schutze. "Introduction to Information Retrieval", Cambridge University Press, 2008.

DSC509 SEMINAR

DSC511 Research Paper Writing

The primary objective of the course is to make one aware of the basics and structure of formal research writing. Introduction: Concept of research writing and its importance, types of a study and its process. Systematic Literature Review: Basic concepts, planning, conducting, reporting. Research paper writing: abstract, introduction, related work, experiment design, research methods, research results, discussion & interpretation of results, validity evaluation, conclusions & future work, acknowledgement, references, index. Research ethics and misconduct.

S. No.	Course Outcomes (CO)
CO1	Understand the basic concepts of research, its importance, and its process.
CO2	Understand and apply basic concepts of how to write systematic literature review (planning, conducting and review).
CO3	Understand the various sections which should be included in a research paper.
CO4	Understand the concepts of research ethics, plagiarism, and misconduct.
CO5	Apply concepts to write research paper in the respective majoring (specialized subject) areas.

Suggested Books:

1. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2013.
2. M. Cargill and P. O'Connor, "Writing Scientific Research Articles: Strategy and Steps", 2nd edition, Wiley Blackwell, 2013.
3. J. Mugah, "Essentials of Scientific Writing", Author House, 2016.

DSC513 Audit Course

SEMESTER II

DSC502 Data Preparation and Analysis

Introduction: Data Collection Strategies, Data Collection from Repositories, Mining Data from Software Repositories, Configuration Management Systems, Importance of Mining Software Repositories. Common Types of Software Repositories, Version Control Systems, Bug Tracking Systems, Open Source Repositories. Types of Variables: Independent and Dependent Variables, Categorical vs Numerical, Nominal Variables, Ordinal Variables, Interval Variables, Ratio Variables, Identifying the dependent and independent variables, Confidence levels. Data Preparation-I: Descriptive Statistics: Summarizing and describing a collection of data, Univariate and bivariate analysis, mean, mode and standard deviation, Percentages and Ratios, Histograms, Identifying randomness and uncertainty in data. Inferential Statistics: Drawing inference from data, Modeling assumptions, Identifying Patterns, Regression analysis, T-test, Analysis of Variance, Correlations, Chi-square. Measures of central tendency, measures of dispersion, data distribution, histogram analysis, normalization, outlier analysis, correlation analysis. Data Preparation-II: Attribute Reduction Methods: Univariate Analysis, Correlation-based Feature Selection, Attribute Extraction: Principal Component Analysis. Case studies for data preparation and analysis.

S. No.	Course Outcomes (CO)
CO1	Understand data collection strategies and mining techniques from software repositories.
CO2	Analyze different types of software repositories, including version control and bug tracking systems.
CO3	Differentiate between types of variables and identify independent and dependent variables in datasets.
CO4	Apply descriptive statistics techniques such as mean, mode, standard deviation, and histogram analysis.
CO5	Perform inferential statistical analyses, including regression, T-tests, ANOVA, correlation, and Chi-square tests.

Suggested Books:

1. M. Kuhn and K. Johnson, "Applied Predictive Modelling", Springer Verlag, 2013.
2. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications", CRC press, 2016.

Reference Books

1. K. S. Sharma, "Predictive Modeling with SAS Enterprise Miner: Practical Solutions for Business Applications", 2nd edition, SAS Institute, 2013.
2. J. Strickland, "Predictive Modeling and Analytics", 2014.

DSC504 Deep Learning

Introduction: Introduction to K-Nearest Neighbors, Deep Feed forward Networks, Regularization of deep learning, Optimization for training deep models, convolutional networks, recurrent networks, Applications. **Convolutional Neural Networks:** Invariance, stability Properties of CNN representations: invertibility, stability, invariance. Variants of the Basic Convolution Function history of CNN and deep learning. **Recurrent and Recursive Nets:** Recurrent and Recursive Nets, Unfolding Computational Graphs, Recurrent Neural Network, Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple, Time Scales, The Long Short-Term Memory and Other Gated RNNs, optimization for Long-Term Dependencies, Explicit Memory. **Linear Factor Model and Autoencoder:** Linear Factor Models, Probabilistic PCA and Factor Analysis Independent Component Analysis (ICA), Slow Feature Analysis, Sparse Coding, Autoencoders, Undercomplete Autoencoders, Regularized Autoencoders, Stochastic Encoders and Decoders, Applications of Autoencoders. **Deep Supervised Learning:** Introduction to Deep Supervised Learning, Convolution & Pooling, Dropout, Transfer Learning Transfer Learning Scenarios, Applications of Transfer Learning, transfer Learning Methods, Fine Tuning and Data Augmentation, Related Research Areas.

S. No.	Course Outcomes (CO)
CO1	Understand Deep Learning and various applications of Deep Learning
CO2	Understand, apply and evaluate performance of CNN for image classification.
CO3	Understand and apply various Object Detection algorithms like Sliding Window Protocol, RCNN, Faster RCNN, YOLO etc.
CO4	Understand and Apply BERT algorithm
CO5	Understand and apply Text processing deep learning models like RNN, LSTM, GRU

Suggested Books:

1. Goodfellow, Y. Bengio and A.Courville, “Deep Learning”, MIT Press, 2015.
2. A. Gibson and J Patterson, “Deep Learning”, O’Reilly Media, Inc., 2017.
3. Russell, Norvig, “Artificial Intelligence: A Modern Approach”, 3rd edition, Prentice Hall, 2010.
4. R.O. Duda, P.E. Hart, and D.G. Stork, “Pattern Classification”, Wiley, 1973.
5. A. M. Bishop, “Neural Networks for Pattern Recognition”. Oxford University Press, 1995.

DSC5402 Artificial Intelligence

This course covers topics of AI Problems, Task Domains of AI, AI Techniques, Basic Problem solving Method: state space search, problem characteristics, Heuristic search Techniques, Knowledge Representation Knowledge Representation: using Predicate Logic: Unification, resolution. Natural deduction, using Rules, Structured Knowledge Representation, Programming Languages: Prolog or Lisp , Symbolic Reasoning under uncertainty, Statistical Reasoning, Concept of learning, learning in problem solving, learning by inductions, genetic algorithm, , Neural Network, Genetic theorem, Expert Systems Research issues in different domains.

S. No.	Course Outcomes (CO)
CO1	Understand AI problems, task domains, and problem-solving methods.
CO2	Apply predicate logic for knowledge representation.
CO3	Demonstrate symbolic reasoning and structured knowledge in languages like Prolog.
CO4	Explain statistical reasoning, learning, and genetic algorithms.
CO5	Analyze neural networks and expert system research.

Suggested Books:

1. J E. Rich. K. Knight, "Artificial Intelligence", Tata McGraw Hill, Second Edition, 1992.
2. N.J. Nilsson, "Principles of AI", Narosa Publ. House, 1990.
3. D.W. Patterson, "Introduction to AI and Expert Systems", PHI, 1992.
4. M. Negnevitsky, "Artificial Intelligence: A Guide to Intelligent Systems", Second Edition, Addison-Wesley, 2005.

DSC5404 Empirical Software Engineering

The goal of the course is to instill the concepts and applications of empirical software engineering. Introduction: What Is Empirical Software Engineering? Overview & Types of Empirical Studies, Empirical Study Process, Ethics, Importance and Basic Elements of Empirical Research, Some Terminologies. Systematic Literature Review, Software Metrics, Experimental Design, Mining Data from Software Repositories, Data Analysis and Statistical Testing, Model Development and Interpretation, Validity Threats, Reporting Results, Mining Unstructured Data, Case Study & Tools.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamental concepts and importance of empirical software engineering.
CO2	Explore different types of empirical studies and the empirical study process, including ethical considerations.
CO3	Conduct systematic literature reviews and analyze software metrics for empirical research.
CO4	Design and execute empirical experiments, including data collection from software repositories.
CO5	Apply data analysis techniques, statistical testing, and model development for empirical studies.

Suggested Books:

1. R. Malhotra, "Empirical Research in Software Engineering: Concepts, Analysis & Applications",CRC press, 2016.
2. B. Boehm, H. D. Rombach, M. V. Zelkowitz, "Foundations of Empirical Software Engineering: The Legacy of Victor R. Basili", Springer, 2010.

DSC5406 Artificial Neural Networks

Introduction: A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks. Learning Process: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process. Convolutional Neural Network. Single Layer Perceptron: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate Annealing Techniques, Perceptron –Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment Multilayer Perceptron: Back Propagation Algorithm XOR Problem, Heuristics, Output Representation and Decision Rule, Computer Experiment, Feature Detection. Back Propagation: Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues, and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamentals of neural networks, their architecture, and their relation to artificial intelligence.
CO2	Analyze different learning processes, including error correction, Hebbian learning, and competitive learning.
CO3	Explore the statistical nature of learning and concepts such as memory, adaptation, and credit assignment.
CO4	Implement single-layer perceptron models, including adaptive filtering, least mean square algorithms, and perceptron convergence.
CO5	Develop multilayer perceptron networks using the backpropagation algorithm and apply heuristics for optimization.

Suggested Books:

1. Simon S. Haykin, “Neural Networks”, Pearson, 3rd Edition, 2009.
2. B. Yegnanarayana, “Artificial Neural Networks”, Prentice Hall of India Pvt. Ltd 2005.
3. L. M. Fu, “Neural Networks in Computer Intelligence”, TMH 2003.
4. J. A. Freeman and D. M. Skapura, “Neural Networks”, Pearson Education 2004.

DSC5408 Business Analytics

Introduction and Data Visualization: Decision making, Business analytics defined, Big data, Business analytics in practice. Data Visualization: Overview, Tables, Charts, Advanced data visualization, data dashboards. Spreadsheet Models and Linear Optimization Models: Building good spreadsheet models, what if analysis, excel functions for modeling, auditing spreadsheet models. Linear optimization models: Minimization problem, solving the par. Inc problem, maximization problem, special cases of linear program outcomes, sensitivity analysis, general linear programming notation. Integer Linear Optimization Models and Nonlinear optimization Models: Types of Integer linear optimization models, eastborne realty example, solving using excel solver, application involving binary variables, modeling flexibility provided by binary variables, generating alternatives. Nonlinear optimization models: a production application, local and global optima, a location problem, Markowitz portfolio model, forecasting adoption of a new product. Monte Carlo Simulation and Decision Analysis: Monte Carlo Simulation: Risk Analysis for Santonics LLC, Simulation modeling for land Shark Inc., Simulation considerations. Decision analysis: Problem Formulation. Business Analytics Applications: Why resource constraints are important to support business analytics: introduction, business analytics personnel, business analytics data. Prescriptive Analysis: Prescriptive modeling: non-linear optimization. Measures & metrics and Performance Management.

S. No.	Course Outcomes (CO)
CO1	Understand decision-making, business analytics, big data, and data visualization techniques.
CO2	Develop and apply spreadsheet models, linear programming, and optimization using tools like Excel Solver.
CO3	Explore advanced optimization models, including nonlinear and binary variables, for business applications.
CO4	Use Monte Carlo simulation and risk analysis for decision-making and problem-solving.
CO5	Apply resource management, prescriptive modeling, and performance metrics in business analytics.

Suggested Books:

1. J. D. Camm, J. J. Cochran, M. J. Fry, J. W. Ohlmann, D. R. Anderson, D. J. Sweeney and T. A. Williams, “Essentials of Business Analytics”, Cengage Learning, 2nd edition, 2015.
2. R. N. Prasad and Seema Acharya, Fundamentals of Business Analytics, Wiley, 2011.
3. C. M. Starkey, D. G. Schniederjans and M. J. Schniederjans, “Business Analytics: Principles, Concepts and Applications”, Pearson, 2014.

Reference Books:

1. J. Liebowitz, “Business Analytics: An Introduction”, Auerbach Publications, 2013.
2. D. R. Hardoon and G. Shmueli, “Getting Started with Business Analytics”, CRC Press, Taylor & Francis, 2016.
3. P. H. Rao, “Business Analytics: An Application Focus”, Prentice Hall India, 2014.
4. J. K. Sharma and P. K. Khatua, Business Statistics, Pearson, 2012.

DSC 5410 Distributed Systems

This course covers topics of Distributed System Models, Transparency, Scalability, Inter- process Communication, Middleware, issues in design of Distributed systems: current & future, Communications, Process and Synchronization, Serializability, Resource Allocation, Distributed Shared Memory, Process Scheduling, Load Balancing & Load Sharing, Mutual Exclusion, Election algorithms. Distributed File Systems Overview of security techniques, Cryptographic algorithms , Digital signatures, Cryptography pragmatics**.**

S. No.	Course Outcomes (CO)
CO1	Understand the fundamental concepts of distributed systems, including models, transparency, and scalability.
CO2	Analyze inter-process communication, middleware, and synchronization mechanisms.
CO3	Explore resource allocation, process scheduling, and load balancing techniques..
CO4	Implement mutual exclusion and election algorithms in distributed environments.
CO5	Understand distributed file systems and apply cryptographic security techniques.

Suggested Books:

1. S. Taenbaum, M. V. Steen, “Distributed Systems: Principles and Paradigms”, Prentice Hall,2015.
2. G. Coulouris, J. Dollimore, T. Kindberg, “Distributed Systems Concepts and Design”, Addison Wesley, 1994.
3. A. Kshenkalyani, M.Singhal, “Distributed Computing”, Cambridge University Press, 2008.

DSC5412 Multimedia Applications

This course contains topics of Introduction to Multimedia Systems Architecture and Components, Multimedia Distributed Processing Model, Synchronization, Orchestration and Quality of Service Architecture. Usage of Text in Multimedia, Families and Faces of Fonts, Outline Fonts, Bitmap Fonts International Character Sets and Hypertext, Digital Fonts Techniques. Audio and Speech, Images and , Multimedia and Hypermedia, Hypermedia Presentation.

S. No.	Course Outcomes (CO)
CO1	Explain fundamental concepts of multimedia systems, including architecture, components, and distributed processing models.
CO2	Demonstrate knowledge of multimedia elements such as text, sound, digital audio, video capture, and their integration in multimedia applications.
CO3	Implement various data compression algorithms to optimize multimedia storage and transmission.
CO4	Compare different speech, image, and video compression techniques, including JPEG, MPEG, and speech synthesis, for efficient multimedia representation and transmission.
CO5	Demonstrate various tools and technologies for solving real-world problems.

Suggested Books:

1. T. Vaughan, "Multimedia: Making it work", Tata McGraw-Hill, Ninth Edition, 2017.
2. R. Aggarwal, B. B Tiwari, "Multimedia Systems", Excel Publication, 2007.
3. Z. Li & M.S. Drew, "Fundamentals of Multimedia", Pearson Education, 2009.
4. D. Hillman, "Multimedia Technology and Application", Galgotia Publication, 2000.

DSC5414 Semantic Web Mining

Semantic Web Languages, Information Extraction from Text, Web Scraping and Ontology Directed IE, Reasoning Web: Logic, Rules, and Ontologies, Reasoning Web: FOIL and Rule Mining, Web Classification (Decision Trees, NB, Rels), Web Clustering (basic, k-means, density), Community Detection in Graphs, Recommendation Systems, Personalization, Topic Detection (LDA, NMF), Pattern Mining, Web Ranking (HITS, PageRank), Spam/BotNet Detection, Representation Learning (Word2Vec, DeepWalk), Sentiment Analysis and Opinion Mining.

S. No.	Course Outcomes (CO)
CO1	Understand semantic web languages and techniques for information extraction from text.
CO2	Explore ontology-directed information extraction and reasoning methods in the semantic web.
CO3	Apply classification and clustering techniques for web data analysis.
CO4	Analyze community detection, recommendation systems, and personalization techniques.
CO5	Implement web ranking algorithms, pattern mining, and spam/botnet detection methods.
CO6	Utilize representation learning techniques and sentiment analysis for web mining applications.

Suggested Books:

1. Gabriel P. C. Fung, Introduction to the Semantic Web: Concepts, Technologies and Applications", Createspace Independent Pub, 2011.
2. Patricia Ordóñez de Pablos, "Advancing Information Management through Semantic Web Concepts and Ontologies", Idea Group, U.S., 2012.
3. Mahak, "Ontology for Knowledge Discovery in Semantic Web Mining", Mohammed Abdul Sattar, 2024.
4. Mathew A. Russell, Mikhail Klassen, "Mining The Social Web: Data Mining", Shroff/O'Reilly; Third edition, 2019.

DSC5416 Natural Language Processing

This course contains topics Phases in natural language processing, applications. Words and Word Forms, Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields. Morphology, acquisition models, Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality, Web 2.0 Applications.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamental phases of natural language processing and its applications.
CO2	Analyze word morphology, finite state machine-based approaches, and automatic morphology learning.
CO3	Apply parsing techniques and algorithms for robust language processing, including noisy text.
CO4	Explore lexical knowledge networks, WordNet theory, and multilingual dictionaries.
CO5	Implement semantic role labeling and word sense disambiguation techniques.
CO6	Examine NLP applications in Web 2.0, multilinguality, and real-world language processing tasks.

Suggested Books:

1. D. Jurafsky, J. H. Martin, "Speech and Language Processing", Second Edition, Pearson Education,2009.
2. A. James, "Natural Language Understanding", Second Edition, Pearson Education, 1994.
3. Bharati, R. Sangal V. Chaitanya, "Natural Language Processing: A Paninian Perspective", PHI,2000.
4. T. Siddiqui, U.S. Tiwary, "Natural Language Processing and Information Retrieval", OUP, 2008.

DSC5418 Optimization Techniques

This course contains topics of Introduction to Linear Programming, Graphical method, The Simplex Method, Post optimality Analysis, Duality Theory and Sensitivity Analysis, Dynamic Programming, Integer Programming, Nonlinear Programming, Queuing Theory.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamentals of optimization techniques and linear programming.
CO2	Apply graphical and simplex methods for solving optimization problems.
CO3	Analyze post-optimality conditions using duality theory and sensitivity analysis.
CO4	Explore dynamic programming and integer programming techniques.
CO5	Implement nonlinear programming methods and queuing theory for real-world applications.

Suggested Books:

1. H.A. Taha, "Operations Research", Ninth Edition, Pearson Education, 2011.
2. J. K. Sharma, "Operations Research", Third Edition, Mcmillan, 2007.
3. F. Hiller & J. Lieberman, "Operations Research", Eighth Edition, Tata McGraw Hill, 2005.
4. K. Swarup, P. K. Gupta, M. Mohan, "Operations Research", Sultan Chand & Sons, 2017.

DSC5420 Web Analytics and Development

This course intends to explore use of social network analysis to understand growing connectivity and complexity in the world ranging from small groups to WWW. Introduction: Social Network and Web data and methods, Graphs and Matrices, Basic measures for individuals and networks, Information Visualization. Web Analytics Tools: Click Stream Analysis, A/B testing, Online Surveys. Web Search and Retrieval: Search Engine Optimization, Web Crawling and indexing, Ranking Algorithms, Web traffic models. Making Connections: Link Analysis, Random Graphs and Network evaluation, Social Connects, Affiliation and identity. Connection: Connection Search, Collapse, Robustness, Social involvements and diffusion of innovation.

S. No.	Course Outcomes (CO)
CO1	Understand the principles and methods of social network analysis.
CO2	Apply graph theory concepts and network metrics to analyze social and web-based data.
CO3	Utilize web analytics tools for data collection, user behavior analysis, and optimization.
CO4	Examine connection dynamics in networks, including link analysis and network robustness.
CO5	Explore applications of social network analysis in understanding diffusion, affiliation, and innovation.

Suggested Books:

1. D. Hansen, B. Shneiderman and M. A. Smith, “Analyzing social media networks with NodeXL: Insights from a connected world”, . Morgan Kaufmann, 2011.
2. A. Kaushik, “Web analytics 2.0: The Art of Online Accountability”, 2009.
3. D. Easley and J. Kleinberg, “Networks, crowds, and markets: Reasoning about a highly connected world. Significance”, New York: Cambridge University Press.
4. S. Wasserman and K. Faust, “Social network analysis: Methods and applications”, New York: Cambridge University Press, 1994.
5. P. R. Monge, N. S. Contractor, P. S. Contractor, R. Peter and S. Noshir, “Theories of communication networks”, New York: Oxford University Press, USA, 2003.

DSC5422 Computer Vision

This course introduces the theoretical and practical aspects of computer vision, covering both classical and state of the art deep-learning based approaches. This course covers everything from the basics of the image formation process in digital cameras and biological systems, through a mathematical and practical treatment of basic image processing, space/frequency representations, classical computer vision techniques for making 3-D measurements from images, and modern deep-learning based techniques for image classification and recognition.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamentals of image formation in digital cameras and biological systems.
CO2	Apply mathematical and practical techniques for basic image processing.
CO3	Explore space/frequency representations and classical computer vision methods.
CO4	Implement 3D measurement techniques using images.
CO5	Analyze deep learning-based approaches for image classification and recognition.

Suggested Books:

1. R. Szeliski, "Computer Vision: Algorithms and Applications", Second Edition, Springer Nature Switzerland, 2022.
2. A. Torralba, P. Isola, W. T. Freeman, "Foundations of Computer Vision (Adaptive Computation and Machine Learning series)", The MIT Press, 2024.
3. R. Shanmugamani, "Deep Learning for Computer Vision: Expert techniques to train advanced neural networks using TensorFlow and Keras", Packt Publishing, 2018.

DSC5424 Intellectual Property Rights

This course contains topics of Introduction to IPR Overview & Importance IPR in India – Genesis and Development IPR in abroad Some Important examples of IPR Patents and their definition; Projectable subject matter – patentable invention, Procedure for obtaining patent, Provisional and complete specification Rights conferred on a patentee, transfer of patent; granting; infringement ;searching & filing, Copyrights, Trademarks, relationship between unfair competition and intellectual property laws, Research and Intellectual Property Industrial Property Rights, Management Licensing and Enforcing Intellectual Property Industrial Designs: research and rights management; legal issues; enforcement; Case studies in IPR.

S. No.	Course Outcomes (CO)
CO1	Gain a comprehensive understanding of intellectual property rights, including their historical development and various types
CO2	Understand the legal framework governing IPR, including the Indian Patent Act of 1970 and 2002
CO3	Acquire a deep understanding of trademarks and the Indian copyright act 1957
CO4	Acquire a deep understanding of Industrial design and the Industrial act, 2000.
CO5	Gain information about various treaties and case laws relevant to IPR.

Suggested Books:

1. B. L. Wadehra, "Law Relating to Intellectual Property", fourth edition, Universal law publishing co.pvt. Ltd, 2007.
2. A. Parulekar, S. D' Souza, "Indian Patents Law –Legal & Business Implications", Macmillan, 2006.
3. P. Narayanan, "Law of Copyright and Industrial Designs", Eastern law House, 2010.

DSC5426 GPU Computing

This course intends to learn parallel programming with Graphics Processing Units (GPUs). Introduction includes History, Graphics Processor, Graphics Processing Units, GPGPUs, Clock speeds, CPU/GPU comparisons, Heterogeneity, Accelerators, Parallel Programming, CUDA OpenCL/ OpenACC, Hell World Computation Kernels, Launch parameters, Tread hierarchy, Warps/ Wavefronts, Thread blocks/ Workgroups, Streaming multiprocessors, 1D/ 2D/ 3D thread mapping, Device properties, Simple programs. Memory includes Memory hierarchy, DRAM/ global, local/ shared, private. Local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Program switch matrices, Performance evaluation with different measures. Synchronization includes memory consistency, barriers (local versus global), Atomics, Memory fence, Prefix sum, Reduction, Programs for concurrent data structures such as Worklists, Linked-lists, Synchronization across CPU and GPU. Functions include Device Functions, Host Functions, Kernels functions, Using libraries (such as Thrust) and developing libraries. Support includes Debugging GPU Programs, Profiling, Profile tools, and Performance aspects. Streams include Asynchronous processing, tasks, Task-dependence, Overlapped data transfers, Default Streams, Synchronization with streams, Events, Event-based-Synchronization-Overlapping data transfer and kernel execution, pitfalls. Case Studies related to Image Processing, Graph algorithms, Simulations, Deep Learning. Advanced topics covers Dynamic Parallelism, Unified Memory, Multi-GPU processing, Peer access, Heterogeneous processing.

S. No.	Course Outcomes (CO)
CO1	Explain basic concepts of Graphics Processing Units (GPUs), parallel programming models like CUDA and OpenCL.
CO2	Utilize various memory types (global, shared, constant) and synchronization mechanisms to optimize memory allocation.
CO3	Demonstrate the use of device and host functions for efficient GPU programming.
CO4	Identify and resolve parallel programming challenges such as error handling, synchronization issues, and algorithmic efficiency in GPU computing.
CO5	Develop optimized GPU-based solutions for real-world applications.

Suggested Books:

1. D. B. Kirk and W. H. Wen-Mei, “Programming Massively Parallel Processors: A Hands-on Approach”, Morgan Kaufmann, 2010 (ISBN: 978-0-12-415992-1).
2. S. Cook, “C. U. D. A. "Programming: A Developer's Guide to Parallel Computing with GPUs”, Applications of GPU Computing, 2012 (ISBN: 978-0-12-415933-4).

DSC5428 Recommender Systems

This course intends to learn techniques for making recommendations, including non-personalized, content-based and collaborative filtering, automation of variety of choice-making strategies with the goal of providing affordable, personal and high-quality recommendations. Introduction includes Overview of Information Retrieval, Retrieval Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Recommender systems functions, Matrix operations, covariance matrices, Understanding rating, Applications of recommendation systems, Issues with recommender system. Content-based Filtering includes High level architecture of content-based systems, Advantages and drawbacks of content based filtering, Item profiles, discovering features of documents, pre-processing and feature extraction, obtaining item feature form tags, Methods for learning user profiles, Similarity based retrieval, Classification algorithms. Collaborative Filtering includes User-based recommendation, Item-based recommendation; Model based approaches, Matrix factorization, Attacks on collaborative recommender systems. Hybrid approaches includes Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies. Evaluating Recommender System includes Introduction, General properties of evaluation research, Evaluation designs: Accuracy, Coverage, Confidence, Novelty, Diversity, Scalability, Evaluation historical datasets, Offline evaluations. Types of Recommender Systems include Recommender systems in personalized web search, Knowledge-based recommender system, Social tagging recommender systems, Trust-centric recommendations, Group recommender systems.

S. No.	Course Outcomes (CO)
CO1	Understand the fundamental techniques and approaches for building recommender systems.
CO2	Explore various types of recommendation methods such as content-based and collaborative filtering.
CO3	Analyze the advantages, drawbacks, and applications of hybrid recommendation approaches.
CO4	Evaluate recommender systems using metrics like accuracy, diversity, and scalability.
CO5	Gain insights into real-world applications and ethical considerations of recommender systems.

Suggested Books:

1. D. Jannach, M. Zanker and A. Felfernig, “Recommender Systems: An Introduction”, 1st edition. Cambridge University Press, 2010.
2. C. C. Aggarwal, “Recommender Systems”, Cham: Springer International Publishing, 1st edition, 2016.
3. F. Ricci, L. Rokach and B. Shapira, “Introduction to Recommender Systems Handbook”, Springer, Boston, MA, 1st edition, 2011.
4. N. Manouselis, H. Drachsler, K. Verbert and E. Duval, “Recommender systems for learning”, Springer Science & Business Media, 2012.

UEC Research Methodology

DSC506 Python for Data Science

Introduction to Python: Introductory Remark about Python, A Brief History of Python, How Python is different from other languages, Python Version, Installing Python. **Python Basics**: Introduction, Python keywords and Identifiers, Python statements, Comments in python, Basic Syntax, Printing on screen, Getting user input -Reading data from keyboard. Variables and data types. **Arrays in Python**: Lists, Tuples, Dictionary. **Decision making & Loops**: Control flow and syntax, The if statement, Python operators, The while Loop, Break and continue, The for Loop, Pass statement. **Function:** Introduction of Function, Calling a function, Function arguments, Built in function, Scope of variables, Decorators, Passing function to a function. **Modules and Packages:** Introduction of Modules and Packages, Importing Modules, Standard Modules- sys, Standard Modules- OS, The dir() Function, Packages. **Exception Handling:** Introduction of Exception Handling, Errors, Run Time Errors, Handling IO Exception, Try….except statement, Raise, Assert. **File Handling in Python**. **Mathematical Computing using** NumPy. Data Visualization using Matplotlib.

S. No.	Course Outcomes (CO)
CO1	Explain Python's history, features, syntax, keywords, identifiers, variables, data types, and basic input/output operations.
CO2	Utilize Python data structures (lists, tuples, sets, and dictionaries) and apply decision-making statements and loops to control program execution.
CO3	Design and implement functions, use function arguments, decorators, and apply modular programming using built-in and custom modules and packages.
CO4	Manipulate strings using built-in functions, string formatting, regular expressions, and utilize advanced collection modules like dequeue, named tuples, ordered dictionaries, and counters.
CO5	Implement exception handling, logging, and demonstrate object-oriented programming (OOP) concepts in Python.

SEMESTER III

DSC601 Big Data Analytics

Introduction to Big Data. Clustering and Classification: Advanced Analytical Theory and Methods: Overview of Clustering, K-means, Use Cases – Overview of the Method, Determining the Number of Clusters, Diagnostics, Reasons to Choose and Cautions, Classification: Decision Trees Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier. **Association and Recommendation System:** Advanced Analytical Theory and Methods-Association Rules. **Classification: Classification**: Decision Trees, Overview of a Decision Tree, The General Algorithm, Decision Tree Algorithms, Evaluating a Decision Tree, Decision Trees in R, Naïve Bayes, Bayes' Theorem, Naïve Bayes Classifier. **Stream Memory, NoSQL Data Management for Big Data and Visualization:** NoSQL Databases: Schema-less Models: Increasing Flexibility for Data Manipulation-Key Value Stores- Document Stores, Tabular Stores, Object Data Stores, Graph Databases Hive, Sharding, Hbase, Analyzing big data with twitter, Big data for E-Commerce Big data for blogs, Review of Basic Data Analytic Methods using R.

S. No.	Course Outcomes (CO)
CO1	Understand the definition, characteristics, and challenges of Big Data, and explore Big Data technologies and applications.
CO2	Apply clustering techniques like K-means and evaluate methods for determining the number of clusters.
CO3	Analyze decision tree algorithms and Naïve Bayes classifiers for data classification.
CO4	Explain NoSQL databases and their role in Big Data management, including key-value, document, and graph stores.
CO5	Apply data analysis techniques to Big Data using R, with focus on platforms like Twitter and e-commerce.

Suggested Books:

1. C. Eaton and D.deroos et al., "Understanding Big data ", McGraw Hill, 2012
2. A. Rajaraman and J.D. Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
3. B. Lublinsky, K. T. Smith and A.Yakubovich, "Professional Hadoop Solutions", Wiley, 2015.
4. T. White, "HADOOP: The definitive Guide", O Reilly 2012.

DSC6401 Data Security & Privacy

This course contains topics of Introduction to Data Security, Conventional Encryption Principles, Conventional encryption algorithms, cipher block modes of operation, Modern Block Ciphers, Public-key cryptography Principles, Latest Trends and solutions in Information Security, IP Security, Web Security: Secure Socket Layer(SSL) and transport layer security, TSP, Secure Electronic Transaction (SET), Electronic money, WAP security, firewall design principals, Virtual Private Network (VPN) security.

S. No.	Course Outcomes (CO)
CO1	Explain the principles of data security, privacy, and cryptographic techniques in the context of modern computing systems.
CO2	Implement symmetric and asymmetric encryption algorithms, hashing functions, and digital signatures to protect data confidentiality and integrity.
CO3	Analyze security threats, vulnerabilities, and attacks on data systems and propose appropriate risk mitigation strategies.
CO4	Develop security architectures, access control mechanisms, and data protection strategies for cloud, IoT, and enterprise environments.
CO5	Evaluate data privacy laws, regulations (e.g., GDPR, HIPAA), and ethical considerations in handling sensitive data

Suggested Books:

1. W. Stallings, "Cryptography and Network Security", William Stallings, Seventh Edition, PHI, 2017.
2. C. A. Jan, "Basic Methods of Cryptography", Cambridge University Press, 2000.
3. T. Calabrese, "Information Security Intelligence: Cryptographic Principles & Applications", Thomson Learning., 2003.
4. W. Mao, "Modern Cryptography: Theory and Practice", Pearson Education, 2003.
5. D. Elizabeth, R. Denning, "Cryptography and Data Security", Addison Wesley, 1992.

DSC6403 Pattern Recognition

Introduction to Pattern Recognition, Feature Detection, Classification, Review of Probability Theory, Conditional Probability and Bayes Rule, Random Vectors, Expectation, Correlation, Covariance, Review of Linear Algebra, Linear Transformations. Decision Theory, ROC Curves, Likelihood Ratio Test, Linear and Quadratic Discriminants, Fisher Discriminant, Sufficient Statistics, Coping with Missing or Noisy Features. Template-based Recognition, Feature Extraction, Eigenvector and Multilinear Analysis, Training Methods, Maximum Likelihood and Bayesian Parameter Estimation, Linear Discriminant/Perceptron Learning, Optimization by Gradient Descent. Support Vector Machines, K-Nearest-Neighbor Classification, Non-parametric Classification, Density Estimation, Parzen Estimation. Unsupervised Learning, Clustering, Vector Quantization, K-means, Mixture Modelling, Expectation-Maximization. Hidden Markov Models, Viterbi Algorithm, Baum-Welch Algorithm, Linear Dynamical Systems, Kalman Filtering, Bayesian Networks.

S. No.	Course Outcomes (CO)
CO1	Understand fundamental principles, and methodologies of pattern recognition, including real-world applications and models.
CO2	Implement bayesian classifier, discriminant functions, to address issues like missing and noisy features using Bayesian networks.
CO3	Utilize Maximum Likelihood and Bayesian parameter estimation methods, including PCA, Fisher Discriminant Analysis, and Expectation-Maximization for dimensionality reduction.
CO4	Develop models using hidden markov models, dynamic bayesian networks, perceptron, and other non-parametric density estimation techniques.
CO5	Apply clustering techniques like K-means, Mixture Modeling, Hidden Markov Models, and Kalman Filtering for pattern recognition tasks.

Suggested Books:

1. R. O. Duda, P. Hart and D. Stork, "Pattern Classification", Second Edition, Wiley, 2000.
2. C. M. Bishop, "Pattern Recognition and Machine Learning'. Springer, 2007.
3. C. M. Bishop, "Neural Networks for Pattern Recognition", Oxford University Press, 1995.
4. S. Theodoridisand and K. Koutroumbas, "Pattern Recognition", 4th edition. Academic Press, 2008.
5. T. Hastie, R. Tibshirani and J. Friedman, "The Elements of Statistical Learning", Springer, 2009.

DSC6405 Internet of Things

Introduction to Internet of Things: Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, IoT Communication APIs IoT enabaled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols, Embedded Systems, IoT Levels and Templates Domain Specific IoTs – Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle. IoT and M2M: Software defined networks, network function virtualization, difference between SDN and NFV for IoT Basics of IoT System Management with NETCOZF, YANG- NETCONF, YANG, SNMP NETOPEER. Introduction to Python: Language features of Python, Data types, data structures, Control of flow, functions, modules, packaging, file handling, data/time operations, classes, Exception handling Python packages – JSON, XML, HTTPLib, URLLib, SMTPLib. IoT Physical Devices and Endpoints: Introduction to Raspberry PI-Interfaces (serial, SPI, I2C) Programming – Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, and reading input from pins. IoT Physical Servers and Cloud Offerings: Introduction to Cloud Storage models and communication APIs Webserver – Web server for IoT, Cloud for IoT, Python web application framework designing a RESTful web API.

S. No.	Course Outcomes (CO)
CO1	Interpret the impact and challenges posed by IoT networks leading to new architectural models
CO2	Illustrate the smart objects and the technologies to connect them to network
CO3	Compare different Application protocols for IoT.
CO4	Infer the role of Data Analytics and Security in IoT.
CO5	Identify sensor technologies for sensing real world entities and understand the role of IoT in various domains of Industry.

Suggested Books:

1. Bahga and V. Madisetti, “Internet of Things – A Hands-on Approach”, Universities Press, 2015.
2. M. Richardson and S. Wallace, Getting Started with Raspberry Pi, O’Reilly (SPD), 2014.
3. J. Holler, V. Tsiatsis, C. Mulligan, S. Avesand, S. Karnouskos and D. Boyle, “From Machine-toMachine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st edition, Academic Press, 2014.
4. B.S. Reiter and F.Michahelles, “Architecting the Internet of Things”, Springer, 2011.
5. W. Stallings, “Foundations of modern networking: SDN, NFV, QOE, IOT, and cloud” publisher: Addison-Wesley, 2015.

DSC6407 Cloud Computing

The goal of this course is to introduce the concepts and applications of cloud computing. Overview of Computing Paradigm and introduction to cloud computing: Recent trends in computing, Evolution of Cloud Computing, Cloud service providers, Properties, Characteristics & Disadvantages, Cloud computing vs. Cluster computing vs. Grid computing, Role of Open Standards. Cloud computing architecture, Role of networks and web services in cloud computing, Service models, Deployment Models. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Service management in Cloud Computing, Cloud Security.

S. No.	Course Outcomes (CO)
CO1	Demonstrate an understanding of computing paradigms, recent trends, and the evolution of cloud computing, including its properties, characteristics, and limitations.
CO2	Analyze and compare cloud computing with other paradigms like cluster and grid computing, emphasizing the role of open standards and network architecture in cloud computing.
CO3	Understand and explain the core concepts of cloud service models, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS).
CO4	Evaluate different cloud deployment models such as public, private, hybrid, and community clouds, and explore resource and application management techniques in cloud environments.
CO5	Identify and address security challenges in cloud computing, focusing on data privacy, compliance, risk management, and mitigation strategies for secure cloud service operations.

Suggested Books:

1. B. Sosinsky, “Cloud Computing Bible”, Wiley, 2010.
2. R. Buyya, J. Broberg, A. M. Goscinski, “Cloud Computing: Principles and Paradigms”, Wiley, 2011.
3. N. Antonopoulos, L. Gillam, “Cloud Computing: Principles, Systems and Applications”, Springer, 2012.
4. R. L. Krutz, R. D. Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Wiley, 2010.

DSC6409 Security Analysis

The objective of the course is to use analytics techniques to detect security vulnerabilities and prevent security attacks in the best possible manner. Precrime Data Mining: Rivers of Scraps, Data Mining investigative data warehousing, link analysis, software agents, text mining, neural networks, machine learning, precrime, September 11, 2001, Criminal Analysis and data mining. Investigate Data Warehousing: Data Testing, Data Warehouse. Demographic data, Real estate and auto data, credit, data, critical data, government data, Internet data, XML, Data preparation, Interrogating the data, data integration, security and privacy, Choicepoint, Tools for data preparation, Standardizing criminal data. Link Analysis and Intelligent Agents, Machine Learning Profiles: Machine learning: Decision Trees, case studies Criminal Patterns: Money as Data, Financial crimes, money laundering, Insurance crimes, Telecommunication crimes, case studies, Identity crimes, Detecting crimes, Intrusion Detection: Intrusion MOs, Intrusion Patterns, Anomaly and Misuse detection, intrusion detection systems, Case study, Types of IDs, Misuse IDs, Anomaly IDs, Multiple based IDs, Data mining IDs, Advanced IDs, Forensic considerations, Early warning systems, Internet resources.

S. No.	Course Outcomes (CO)
CO1	Understand the role of data mining and machine learning in security analytics.
CO2	Apply investigative data warehousing techniques for criminal analysis.
CO3	Analyze financial and identity crimes using link analysis and anomaly detection.
CO4	Implement intrusion detection systems based on anomaly and misuse patterns.
CO5	Evaluate forensic considerations and early warning systems in cybersecurity.
CO6	Explore advanced intrusion detection techniques using data mining methods.

Suggested Books:

1. J. Mena, "Investigative Data Mining for Security and Criminal Detection", Butterworth-Heinemann, 2002.
2. D. Barbara and S. Jajodia, "Applications of Data Mining in Computer Security", Springer, 2012.
3. Chen, W.W.S. Statistical Methods in Computer Security, Marcel-Dekker, 2005.
4. W. Stallings, Cryptography and Network Security, Pearson Education, Sixth Edition, 2013.

DSC6411 Introduction to Health Care Data Analytics

This course covers Introduction to Quality Improvement and Data Analytics: Discuss the drivers for health care transformation, Identify quality initiatives that have shaped the national health care landscape, Define health care quality and value, Describe the background and evolution of quality and performance improvement, Discuss the quality improvement frameworks that utilize analytics, Define health care data analytics, Discuss how analytics can help transform health care. Health Care Data as an Organizational Asset: Describe the data information, knowledge and wisdom hierarchy, Explain how data can be an organizational asset, List sources of health care data, Describe the challenges HCO's face when using data for quality and performance Improvement, Describe an organizational approach for effective use of data analytics, Describe the role of data governance. Working with Data. Data Analytics Tools and Techniques. Using Data to Solve Problems.

S. No.	Course Outcomes (CO)
CO1	Understand the key drivers of health care transformation and the role of quality initiatives in shaping the national health care landscape.
CO2	Apply quality improvement frameworks that utilize data analytics to enhance health care quality and performance.
CO3	Utilize health care data analytics techniques to improve decision-making and operational efficiency in health care organizations.
CO4	Manage health care data as an organizational asset by understanding the data-information-knowledge-wisdom (DIKW) hierarchy and principles of data governance.
CO5	Evaluate challenges faced by health care organizations in using data for quality and performance improvement and propose effective solutions.
CO6	Implement data analytics tools and techniques to analyze health care data and solve real-world problems in quality improvement and performance management.

Suggested Books:

1. Trevor L. Strome, "Healthcare Analytics for Quality and Performance Improvement", John Wiley & Sons, Inc, 2013.

DSC6413 Swarm and Evolutionary Computing

The course is designed to introduce the basic concepts of evolutionary and swarm computing along with their applications. Introduction to Evolutionary Computing: Components, global optimization, evolution strategies, fitness functions, learning classifier systems, parameter control, multi-modal problems. Swarm Intelligence: Its application to optimization problems, particle swarm optimization. Genetic Algorithm: Basics, reproduction, cross-over and mutation, Genetic algorithm convergence, Genetic programming. Hybrid Methods and Multi-objective Evolutionary Algorithms: Variants of Particle Swarm optimization and Genetic Algorithm, their hybridization, hybrid Multi-objective Optimization algorithms. Other recent algorithms: Cockoo search algorithm, Artificial Bee Colony Optimization, Ant Colony Optimization, Fire-fly algorithm, Bacterial Foraging, Application to the travelling salesman problem. Application to real world optimization problems.

S. No.	Course Outcomes (CO)
CO1	Understand the components and techniques of evolutionary computing, including global optimization and fitness functions.
CO2	Apply swarm intelligence methods like particle swarm optimization and genetic algorithms to optimization problems.
CO3	Analyze hybridization techniques and multi-objective optimization algorithms using evolutionary computing methods.
CO4	Evaluate algorithms like cuckoo search, artificial bee colony, and ant colony optimization for optimization tasks.
CO5	Apply evolutionary computing algorithms to real-world optimization problems like the traveling salesman problem.

Suggested Books:

1. P. Engelbrech, “Computational Intelligence”, Second Edition, John Wiley & Sons, 2008.
2. M. Mitchell, “An Introduction to Genetic Algorithm”, MIT Press, 1996.
3. D. Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning", Addison-Wesley, 1989.
4. A. E. Eiben, J.E. Smith, “Introduction to Evolutionary Computing”, Second Edition, Springer, 2007.
5. K. DeJong, “Evolutionary Computation: A Unified Approach", MIT Press, 2006.

DSC603 Minor Project/ Research Thesis/ Patent

SEMESTER IV

DSC602 Major Project/ Research Thesis/ Patent