SCHEME AND SYLLABUS FOR

PROGRAM

B.TECH

(ARTIFICIAL INTELLIGENCE AND DATA SCIENCE)

Offered by the Department of Data Science & Artificial Intelligence
National Institute of Technology, Kurukshetra

VISION AND MISSION OF THE INSTITUTE

VISION

To be a role-model in technical education and research, responsive to global challenges.

MISSION

To impart technical education that develops innovative professionals and entrepreneurs and to undertake research that generates cutting-edge technologies and futuristic knowledge, focusing on the socio-economic needs.

VISION AND MISSION OF THE DEPARTMENT

VISION

To address societal needs and global industry challenges in the field of Data Science & Artificial Intelligence with state-of-art education & research.

MISSION

M-1: To create a platform for education, research and development by providing sound theoretical knowledge and practical skills in Computer Engineering and Information Technology.

M-2: To produce motivated professional technocrats capable of generating solutions for industry and society.

M-3: To develop the ability to work ethically at individual and team level and be responsive towards socio-economic needs.

VISION AND MISSION OF THE PROGRAM

VISION

To disseminate state-of-the-art education to develop competent professionals in Artificial Intelligence and Data Science with capability to serve the global society**.**

MISSION

To educate and train manpower engaged in cutting-edge research by offering latest in the field of Artificial Intelligence and Data Science for sustainable development of society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Program Educational Objectives (PEOs) of Undergraduate Programme of Artificial Intelligence and Data Science are:

PEOs	Description
PEO 1	Graduates will have adequate knowledge of Artificial Intelligence and Data Science domain to become employable in Industry.
PEO 2	Graduate will have strong fundamentals and problem-solving skills to analyze, design and develop economically feasible solutions for technical and social problems.
PEO 3	Graduate will be aware of recent research trends, higher education and entrepreneurial opportunities, and will work ethically towards society.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Program Specific Outcomes (PSOs) of B. Tech (Artificial Intelligence and Data Science) are:

PEOs	Description
PSO 1	Augmented knowledge of Artificial Intelligence and Data Science related technologies
PSO 2	Enhanced capability to develop computational tools and applications and improved skills to solve contemporary challenges
PSO 3	Exhibit attitude for continuous learning and deliver proactive solutions for futuristic challenges

SEMESTER - I

B.Tech. in Artificial Intelligence and Data Science

w.e.f. Academic Year 2024-25 admitted

Sr. No.	Course Code	Course Title	L_T_P	Credits	Contact Hrs
1.	-	Communication Skills in English OR Financial Education	2 0 2	3	4
2.	-	Differential Calculus and Differential Equations	3 0 0	3	3
3.	-	Engineering Physics	3 0 2	4	5
4.	CSIC 101	Problem solving & Programming Skills I (For CO, IT & AI &ML, AI & DS, M&C)	3 0 2	4	5
6.	-	Energy & Environmental Science	2 0 2	3	4
7.	-	Engineering Practices (P)	1 0 3	2	4
8.	-	AU1	2 0 0	2	2
9.	-	Sports	0 0 2	1	2
10.	-	NCC/NSS/Yoga	0 0 2	1	2
Total				**21**	**31**

SEMESTER – II

B.Tech. in Artificial Intelligence and Data Science

w.e.f. Academic Year 2024-25 admitted

Sr. No.	Course Code	Course Title	L_T_P	Credits	Contact Hrs
1.	-	Economics for Engineers OR Business Studies	3 0 0	3	3
2.	-	Integral Calculus and Difference Equations	3 0 0	3	3
3.	CSIC 100	Digital System Design	3 0 0	3	3
4.	CSIC 102	Web Design*	1 0 2	2	4
5.	CSIC 104	Programming Using Python	3 0 2	4	5
6.	DSPC 100	Data Structures	3 0 2	4	5
7.	-	AU2	2 0 0	2	2
8.	-	Sports	0 0 2	1	2
9.	-	NCC/Yoga/Clubs/NSS	0 0 2	1	2
Total				**21**	**29**

*** Treated as a practical course (not integrated), evaluation will be as per practical course.**

SEMESTER-III

Scheme for B.Tech. in Artificial Intelligence and Data Science
w.e.f. Academic Year 2024-25 admitted

Course Category	SN	Course Code	Course Title	Load Per Week			Credits	Contact Hrs
				L	T	P		
IC	1.	MAIC ***	Mathematics for Data Science	3	0	0	3	3
	2.	MAIC 205	Statistical Distribution	3	0	0	3	3
PC	3.	DSPC 201	Foundations of Data Science	3	0	2	4	5
	4.	DSPC 203	Design and Analysis of Algorithms	3	0	2	4	5
	5.	DSPC 205	Computer Organization and Architecture	3	0	0	3	3
	6.	DSPC 207	Software Engineering	3	0	0	3	3
NC	7.	SWNC 101	NCC/ Sports /Yoga	0	0	2	1**	2
	8.	SWNC 102	NSS/Club/Technical Societies	0	0	2		2
			Total Credits				**20**	**26**

SEMESTER -IV

Scheme for B.Tech. in Artificial Intelligence and Data Science
w.e.f. Academic Year 2024-25 admitted

Course Category	SN	Course Code	Course Title	Load Per Week			Credits	Contact Hrs
				L	T	P		
IC	1	MAIC 207	Optimization Techniques	3	0	0	3	3
PC	2	DSPC 200	Data Mining and Analytics	3	0	2	4	5
	3	DSPC 202	Data Handling and Visualization	3	0	2	4	5
	4	DSPC 204	Artificial Intelligence	3	0	2	4	5
	5	DSPC 206	Database Management Systems	3	0	2	4	5

NC	6	SWNC 101	NCC/ Sports /Yoga	0	0	2	1**	2
	7	SWNC 102	NSS/Club/Technical Societies	0	0	2		2
Total Credits							**19**	**27**

SEMESTER -V

Scheme for B.Tech. in Artificial Intelligence and Data Science
w.e.f. Academic Year 2024-25 admitted

Course Category	**SN**	**Course Code**	**Course Title**	**Load Per Week**			**Credits**	**Contact Hrs**
				L	**T**	**P**		
IC	1.	CSIC 301	Machine Learning	3	0	2	4	5
PC	2.	DSPC 301	Big Data Analytics	3	0	2	4	5
	3.	DSPC 303	Operating Systems	3	0	2	4	5
	4.	DSPC 305	Computer Vision	3	0	2	4	5
	5.	DSPC 307	Computer Network	3	0	2	4	5
	6.	DSPC 309	Seminar and Group Discussion	0	0	2	1	2
OE	7.		Open Elective – I	3	0	0	3	3
Total Credits							**24**	**30**

SEMESTER -VI

Scheme for B.Tech. in Artificial Intelligence and Data Science
w.e.f. Academic Year 2024-25 admitted

Course Category	SN	Course Code	Course Title	Load Per Week			Credits	Contact Hrs
				L	T	P		
PC	1.	DSPC 300	Deep Learning	3	0	2	4	5
	2.	DSPC 302	Distributed Computing	3	0	2	4	5
	3.	DSPC 304	Large Language Models	3	0	2	4	5
DE	4.	DSPE XXX	Program Elective – I	3	0	2	4	5
	5.	DSPE XXX	Program Elective – II	3	0	0	3	3
OE	6.		Open Elective-II	3	0	0	3	3
Total Credits							**22**	**26**

Sr. No.	Course Code	Program Elective -I (Course Title)
1.	DSPE 302	Information Retrieval
2.	DSPE 304	Game Theory and Applications
3.	DSPE 306	Full Stack Development

Sr. No.	Course Code	Program Elective -II (Course Title)
1.	DSPE 308	**Security and Privacy in Artificial Intelligence**
2.	DSPE 310	Bio-Informatics
3.	DSPE 312	Stochastic Processes and Queuing Theory

Course Code	**:**	**CSIC 101**
Course Title	**:**	**Problems Solving and Programming Skills-I**
Number of Credits & L/T/P Scheme	**:**	**4 and 3/0/2**
Prerequisites	**:**	
Course Type	**:**	**IC**

Course Learning Objectives:
The objective of this course is to provide fundamentals of problem-solving using C language programming.

Course Content:
Unit 1 Programming Fundamentals & Control Statements:
Block Diagram of Computer, Hardware vs software, concept of operating system and compiler, Introduction to C programming, basic programming using input and output operators and expressions, programming using if and if-else, Programming using looping-for, while, do-while; use of switch and break.

Unit 2 Arrays based Programming:
Defining and processing 1-D and 2-D Arrays for Problem Solving and Strings.

Unit 3 Modular programming using Functions:
Structured Programming, Defining and calling a function, modular programming using functions, passing arguments and arrays to functions, functions of void and returning values.

Unit 4 Programming using pointers, structures and unions:
Pointers in C: Pointer declaration, Passing Pointer to functions, pointers vs arrays, dynamic memory allocation. Structures and Unions, Programming Using Array of Structures and Unions, Memory Requirements for Unions.

Reference Books:
1. Byron S. Gottfried, Programming with C Language, Schaum Series, Tata McGraw Hill, 2015.
2. E Balaguruswamy, Programming with C, Tata McGraw Hill, 2015.
3. Kernighan & Richie, C Programming, Prentice Hall of India, 2002.

Course Outcomes:
1. Understand the use of software and programming for problem solving.
2. Learn programming using simple concepts of input, output and control statements.
3. Use arrays, functions, strings, structures and pointers for problem solving.

Course Code	**:**	**CSIC 100**
Course Title	**:**	**Digital System Design**
Number of Credits & L/T/P Scheme	**:**	**3 and 3/0/0**
Prerequisites	**:**	
Course Type	**:**	**IC**

Course Learning Objectives:

1. Awareness of intricate design details of components in any digital system.
2. Knowledge of number system and conceptual understanding of different codes.
3. Design fundamentals of computing machinery.
4. Introduction of computational automation process.

Course Content:

Unit 1 Number Systems and Coding Schemes:

Number Systems and Codes Introduction to the positional number system, signed magnitude numbers, floating point numbers, binary arithmetic: addition, subtraction, multiplication and division, Base conversion, conversion formulas with examples, one's and two's compliment arithmetic, Computer codes
– BCD codes, gray codes, excess-3 codes, parity checks, Hamming and alphanumeric codes.

Unit 2 Combinational Logic:

Design Introduction, standard representations for logical functions, Karnaugh map representation, simplification of logical functions using K-map, minimization of logical functions specified in minterms/maxterms or Truth Table, minimization of logical functions not specified in minterms/maxterms, Don't care conditions, design examples, Ex-or and Ex-nor simplification of Kmaps, five and six-variable K-maps, QM method, MEV method, Introduction of multiplexers and their use in combinational logic design, demultiplexers/decoders and their use in combinational logic design, adders and their use as subtractors, digital comparators, parity generators/checkers, code converters, priority encoders.

Unit 3 Synchronous Sequential Circuits:

Introduction, FSM model, memory elements and their excitation functions. Synthesis of synchronous sequential circuits, capabilities and limitation of FSM, state equivalence and minimization, simplification of incompletely specified machines, registers and counters, RAM design, ROM design and programmable logic array.

Unit 4 Asynchronous Sequential Circuits:

Fundamental mode and Pulse mode Circuits Analysis and Design.

Books:

1. M. Morris Mano and Michael D. Ciletti: Digital Logic Design, Sixth Edition, Pearson Education.
2. R.P. Jain: Modern Digital Electronics, Fifth Edition, TMH.
3. Z Kohavi and Niraj. K. Jha: Switching And Finite Automata Theory, Third Edition, Cambridge University Press.
4. Kumar A. Anand: Fundamentals of Digital Circuits, Fourth Edition, PHI.
5. James Bignell and Robert Donovan: Digital Electronics, Fifth Edition, Cengage Learning.

Course Outcomes:

1. Clarity of application of different number system and coding schemes.
2. Proficiency in design and analysis of combinational and sequential circuits.
3. Circuit level understanding of computer addressing and memory layouts.
4. Application of digital circuits for design of finite automaton.

Course Code	**:**	**CSIC 102**
Course Title	**:**	**Web Design**
Number of Credits & L/T/P Scheme	**:**	**2 and 1/0/2**
Prerequisites	**:**	
Course Type	**:**	**IC**

Course Learning Objectives:

1. Introduction and brief history of World Wide Web (WWW).
2. Web essentials: HTML, XHTML, CSS.
3. Addressing web standards, client requirements and principles of web page design.
4. Introduction of Web architecture.

Course Content:

Unit 1 Introduction: Introduction to world wide web, Web Browsers, Web Servers, Hypertext Transfer Protocol, URLs, Domain Names, Internet Service Provider, Basic steps for Developing Website, Choosing the Contents, Planning and Designing Web Site, Creating a Website, Web Publishing, Hosting Site, Types of hosting packages, Five Golden rules of web designing.

Unit 2 Web essentials and standards: Clients, servers, introduction to Markup languages, scripting languages, Introduction to elements of HTML, XHTML and CSS, Introduction to Document object model (DOM), working with text, list, tables, frames, hyperlinks, Images, forms and controls. CSS properties, Id and Class, Box Model.

Unit 3 Javascript: Javascript as programming language, Data types, Values, Variables, Expressions and Operators. JavaScript Statements, loops, arrays, strings, methods, Defining and Invoking functions and their closure, random functions and maths library, representing dates, Pattern Matching and Regular Expressions, difference between server side and client side javascript, embedding javascript in HTML, hiding HTML elements, showing hidden HTML elements. DOM and event handling, error handling, mouse, text, and keyboard events and cookies.

Unit 4 XML: XML: Introduction – benefits of XML, well formed XML documents, XML syntax, XML declaration ,XML schema , XML with CSS, Document Type Definition (DTD),creating DTD –Types(internal DTD, external DTD),XSL.

Reference Books:

1. Thomas A Powell, HTML: The Complete Reference, Tata McGraw Hill Publications.
2. Scott Guelich, Shishir Gundavaram, Gunther Birzniek; CGI Programming with Perl 2/e, O'Reilly
3. Doug Tidwell, James Snell, Pavel Kulchenko; Programming Web Services with SOAP, O' Reilly
4. Robert. W. Sebesta, "Programming the World Wide Web", Fourth Edition, Pearson Education, 2007.
5. Yong, XML Step by Step, PHI.
6. Chris Bales, "Web programming- Building Internet Application".

7. Deitel, Deitel, Goldberg, "Internet & World Wide Web How To Program", Third Edition, Pearson Education, 2006.
8. Marty Hall and Larry Brown, “Core Web Programming” Second Edition, Volume I and II, Pearson Education, 2001.
9. Bayross Ivan, “Web Enabled Commercial Applications Development using HTML, Javascript,
DHTML & PHP”, BPB Publication, 2005.

Course outcomes

1. Knowledge of basic principles of web site design.
2. Design proficiency of websites adhering to current web standards (HTML, XML, CSS).
3. Knowledge of various scripting languages.

Course Code	**:**	**CSIC 106**
Course Title	**:**	**Programming using Python**
Number of Credits & L/T/P Scheme	**:**	**4 and 3/0/2**
Prerequisites	**:**	
Course Type	**:**	**IC**

Course Learning Objectives:

1. Building robust applications using Python programming.
2. Building multithreaded, platform-independent and GUI based python applications for business problems.

Course Content:

Unit 1 The concept of data types:

Variables, Assignments; Immutable Variables; Numerical Types; Arithmetic Operators And Expressions; comments in the program; understanding error messages; Conditions, boolean logic, logical operators; ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation; Strings and text files; manipulating files and directories, os and sys modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab-separated); String manipulations: subscript operator, indexing, slicing a string.

Unit 2 Lists, tuples, and dictionaries:

Basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries; Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments.

Unit 3 Simple Graphics and Image Processing:

"turtle" module; simple 2d drawing - colors, shapes; digital images, image file formats, image processing: Simple image manipulations with 'image' module (convert to bw, greyscale, blur, etc). Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes, data modeling; persistent storage of objects; inheritance, polymorphism, operator overloading (_eq_, _str_, etc); abstract classes; exception handling, try block

Unit 4 Graphical user interfaces:

Event-driven programming paradigm; tkinter module, creating simple GUI; buttons, labels, entry fields, dialogs; widget attributes - sizes, fonts, colors layouts, nested frames.

Reference Books:

1. T.R. Padmanabhan, Programming with Python, Springer, 1st Ed., 2016.
2. Kenneth Lambert, Fundamentals of Python: First Programs, Cengage Learning,, 1st Ed., 2012.

Course outcomes:

1. Programming ability for solving simple business problems.
2. Design of robust and multithreaded python applications.
3. Familiarity of simple GUI interfaces.

Course Code	**:**	**DSPC 100**
Course Title	**:**	**Data Structures**
Number of Credits & L/T/P Scheme	**:**	**4 and 3/0/2**
Prerequisites	**:**	**Problems Solving and Programming Skills-I**
Course Type	**:**	**PC**

Course Learning Objectives

1. This course introduces the concept of Data Structures used in various computer science applications
2. The students are introduced to understand and efficiently apply various data structures such as stacks, queues, linked lists, trees and graphs for solving various computing problems using C programming language.

Course Content

Unit 1 Pointers & File Handling:

Revision of Pointers and Dynamic Memory, Files and related operations.
Searching techniques: Linear and Binary, Sorting techniques: Selection, Bubble, Insertion, Merge sort, Quicksort.

Unit 2 Simple Data Structures

Arrays based Linear Data Structures: Array storage, sparse arrays; Transpose, addition, and multiplication of sparse matrices, Stacks and Queues and their applications, multiple stacks and queues in an array.

Unit 3 Linked Data Structures

Singly, Doubly & Circular Linked Lists; representation, operations and applications, linked stacks and queues. linked lists based polynomial addition.

Unit 4 Advanced Data Structures

Trees, Basic concepts and definitions of a tree and binary tree and associated terminology, Binary tree traversal techniques, some more operations on binary trees, Heaps and heapsort.

Reference Books:

1. E Horowitz and S. Sahni: Fundamentals of Data Structures in C, Second Edition, Universities Press, Hyderabad.
2. R.L. Kruse: Data Structures & Program Design in C, PHI.
3. D.F. Knuth: The art of Computer Programming Vol-1, Narosa Publications, 1985.
4. Byron S. Gottfried & J K Chhabra: Theory and Problems of Programming with C Language, Schaum's Outlines Series, TMH, 2005.

Course Outcomes

1. Develop skill to identify and determine the usage of various data structures, operations, associated algorithms and implement their applications.
2. Apply knowledge of pointers, memory allocation and string handling for solving programming problems.
3. Understand the concept of trees and graphs, their implementation and applications.
4. Able to implement standard algorithms for searching and sorting.
5. Analyze efficiency of different algorithms using time and space complexity.

Course Code	**:**	**MAIC *****
Course Title	**:**	**Mathematics for Data Science**
Number of Credits & L/T/P Scheme	**:**	**3 & 3/0/0**
Prerequisites	**:**	
Course Type	**:**	**IC**

Course Learning Objectives:

The objective of this course is to introduce the various Mathematical concepts to be used in ML and DS.

Course Content:

Unit 1 Review of Set Theory: Number systems; sets and their operations; relations and functions; types of relations; types of functions.

Unit 2: Basics of Linear Algebra: Representation of vectors; vector spaces and subspaces (definition, examples, and concepts of basis); linear transformations; range and null space; matrices associated with linear transformations; special matrices; applications of eigenvalues and eigenvectors to data science problems; least squares and minimum-norm solutions.

Unit 3 Matrix Theory and Canonical Forms: Invariant subspaces; minimal polynomial; adjoint operators (matrices); normal, unitary, and self-adjoint matrices; Schur's lemma; spectral theorem for normal matrices; unitary diagonalization and matrix triangulation; direct-sum decomposition; cyclic subspaces and annihilators; rational canonical form; Jordan canonical form; linear functionals; bilinear mappings and inner product spaces.

Unit 4 Matrix Factorizations and Numerical Methods: LU decomposition; Cholesky decomposition; Householder reflections; QR decomposition; polar decomposition; tridiagonal matrices; Sturm's sequence; projection matrices; singular value decomposition (SVD); generalized inverse (Moore–Penrose pseudoinverse); Perron–Frobenius theorem; Sylvester's inertia theorem.

Text Books:

1. Ignacio Bello, Introductory Algebra: a real-world approach (4th Edition).
2. Clum, Charles. Topics in the Mathematics of Data Science. Diss. The Ohio State University, 2022.
3. Kroese, Dirk P., Zdravko Botev, and Thomas Taimre. Data science and machine learning: mathematical and statistical methods. Chapman and Hall/CRC, 2019.

Course Code	**:**	**MAIC 205**
Course Title	**:**	**Statistical Distribution**
Number of Credits & L/T/P Scheme	**:**	**3 & 3/0/0**
Prerequisites	**:**	
Course Type	**:**	**PC**

Course Learning Objectives:

1. At the end of the course, the students will be able to Understand, analyze.
2. Students will be able to apply probability distributions, random variables, and mathematical expectation.
3. Students will be able to apply hypothesis testing and estimation, including their applications in statistical modeling

Course Content:

Unit 1 Random Variables: Single Random Variables -Discrete and Continuous, Probability distribution function, Probability mass and density functions, mathematical expectation and variance. Multiple Random variables: Discrete and Continuous, Joint probability distribution, Marginal probability density functions, conditional probability distribution function and density functions.

Unit 2 Probability Distributions: Bernoulli distribution, Binomial distribution –properties, mean, variance and recurrence formula for Binomial distribution, Poisson distribution – Poisson distribution as Limiting case of Binomial distribution, properties, mean variance and recurrence formula for Poisson distribution, Normal distribution, Exponential distribution – mean, variance, median, mode and characteristics of Normal distribution.

Unit 3 Correlation and Regression: Bivariate and multivariate distributions, Joint and marginal distributions, Covariance and correlation, Regression- Regression coefficients, Lines of regression.

Unit 4 Sampling and Testing of Hypothesis for Large Samples Sampling: Definitions - Types of sampling - Expected values of sample mean and variance, Standard error - Sampling distribution of means and variance. Estimation – Point estimation and Interval estimation, Maximum Likelihood Estimation method. Testing of hypothesis: Null and Alternative hypothesis - Type I and Type II errors, Critical region - confidence interval - Level of significance, One tailed and Two tailed test. Z- Tests for large samples.

Text Books:

1. S.C. Gupta and V.K. Kapur, Fundamentals of Mathematical Statistics, S. Chand & Sons, New Delhi, 2008.
2. V.K. Rohatgi and A.K. Md. Ehsanes Saleh, An Introduction to Probability Theory and Mathematical Sciences, Wiley, 2001.

Course Code	**:**	**DSPC 201**
Course Title	**:**	**Foundations of Data Science**
Number of Credits & L/T/P Scheme	**:**	**4 & 3/0/2**
Prerequisites	**:**	
Course Type	**:**	**PC**

Course Learning Objectives:

1. Data Science is the study of the generalizable extraction of knowledge from data.
2. Students will be ready for integrated skill set spanning mathematics, probability and statistics.
3. Students will be able to apply concepts of data science, and branches of computer science like databases, machine learning etc.

Course Content:

Unit-1 Course Overview and Introduction to Data Science: Course Motivation, Motivating real-world Applications, Data Preparation and Modelling, Data types (Structured, Unstructured), Relational & NoSQL Basics, Retrieval vs. Mining vs Warehouse vs. Analytics, Type of Analytics, Descriptive, Diagnostic, Predictive, Prescriptive, Data science goals.

Unit-2 Data Lifecycle: Data Quality, Missing/Noisy data. Basic Statistical Description, Centrality (Mean, Median, Mode, Variance, etc.) and Dispersion (Percentile, Quartile, IQR, etc.). Defining research goals, Hypothesis Testing, P-values, Confidence Intervals, Z-test, T-test, ANOVA (Analysis of Variance), Chi-squared test. High-dimensional Data Characteristics, Curse of Dimensionality and Numerosity, Dimensionality Reduction Technique (PCA), Data Sampling, Sample, Sampling Bias, Selection Bias.

Unit-3 Statistical Relationships and Visual Storytelling: Correlation and Covariance, correlation coefficient (Pearson/Spearman). Visual Storytelling and perception, Bar, Line, Histogram, Boxplot. Regression, Simple Linear Regression, Least Squares, Standard Error, R-squared interpretation, Multiple regression equations.

Unit-4 Fundamentals of Predictive Modeling: Introduction to Predictive Modelling, Learning paradigms: Unsupervised, supervised, semi-supervised, transfer learning, etc. Supervised learning-based prediction model, Clustering, Basic K-means algorithm. Supervised learning-based prediction model, Classification, Entropy, Information Gain, Decision Tree Classifier, Prediction Model Evaluation, Confusion Metrics.

Text Books:

1. Blum, Avrim, John Hopcroft, and Ravindran Kannan. Foundations of data science. Cambridge University Press, 2020.
2. Saltz, Jeffrey S., and Jeffrey M. Stanton. An introduction to data science. Sage Publications, 2017.

Course Outcomes

1. Explain the fundamental concepts of data science, data types, data storage systems, data preparation, and different types of analytics for real-world applications.
2. Apply statistical methods, hypothesis testing, confidence intervals, dimensionality reduction, and sampling techniques to analyze data quality and support data-driven decision-making.
3. Analyze statistical relationships using correlation, covariance, and regression, and communicate data insights effectively through appropriate visualizations and storytelling techniques.
4. Apply appropriate machine learning paradigms and clustering techniques, including the K-means algorithm, to identify patterns and structure in datasets.
5. Develop and evaluate predictive models using classification techniques, decision trees, entropy, information gain, and confusion-matrix-based performance metrics.

Course Code	**:**	**DSPC 203**
Course Title	**:**	**Design and Analysis of Algorithms**
Number of Credits & L/T/P Scheme	**:**	**4 & 3/0/2**
Prerequisites	**:**	
Course Type	**:**	**PC**

Course Learning Objectives:

1. Able to design, implement and analysis of standard searching and sorting algorithms.
2. Implement standard divide and conquer, Dynamic programming, Greedy and backtracking algorithms.
3. Able to implement between different data structures i.e., trees, heaps etc. also, able to pick an appropriate data structure for any given design situation.
4. Able to implement the major graph algorithms and their analysis.

Course Content:

Unit-1 Introduction: Concept of Time and space complexity, analysis of algorithms, asymptotic notation, recurrence relations, design and analysis of D & C problems like quick sort etc, heap sort, priority queues, sorting in linear time, hashing, binary search trees.

Unit-2 Graph Algorithms

Graph representation & traversal (search), topological sort, strongly connected components, minimum spanning trees – Kruskal and Prim's, Single source shortest paths, relaxation, Dijkstra's algorithm, Bellman-Ford algorithm, single source shortest paths for directed acyclic graphs, all-pairs shortest path.

Unit-3 B-Trees and Dynamic programming

B-Trees: representation and operations; Elements of Dynamic Programming, structure and steps, Matrix-chain multiplication, longest common subsequence.

Unit-4 Greedy & Backtracking Approaches:

Greedy algorithms – Elements, activity-selection problem, Huffman codes, task scheduling problem, Knapsack Problem, Backtracking – Elements, 8 – Queens, Graph Coloring, Hamiltonian Cycles.

Text Books:

1. Cormen, Leiserson and Rivest: Introduction to Algorithms, 3/e, PHI.
2. Horowitz, Sahni, and Rajasekaran: Fundamentals of Computer Algorithms, Second Edition, Universities Press, Hyderabad.
3. Aho, Hopcroft, and Ullman: The Design and Analysis of Computer Algorithms, Addison Wesley.

Course Outcomes

1. Able to design, implement and analysis of standard searching and sorting algorithms.
2. Implement standard divide and conquer, Dynamic programming, Greedy and backtracking algorithms.
3. Able to implement between different data structures i.e., trees, heaps etc. also, able to pick an appropriate data structure for any given design situation.
4. Able to implement the major graph algorithms and their analysis.

Course Code	**:**	**DSPC 205**
Course Title	**:**	**Computer Organization and Architecture**
Number of Credits & L/T/P Scheme	**:**	**3 & 3/0/0**
Prerequisites	:	**Digital System Design**
Course Type	**:**	**PC**

Course Learning Objectives:

1. Working of Computer Systems & its basic principles.
2. Concepts of processor and control design.
3. Concepts of pipelining techniques.
4. Memory hierarchy and its organization.
5. Concept of I/O devices and working.

Course Content:

Unit 1: Introduction:
Introduction to digital electronics: combinational circuits and sequential circuits. Basic Machine Principle, Structure and representation of real-world data. Subroutine, Branching & Macro facility.

Unit 2: Processor Design
Processor Organization, Information representation and Number format, Instruction cycle and Instruction format, Addressing modes, Arithmetic operation, timed point addition, subtraction, multiplication and division, ALU design, Parallel processing – Performance consideration, Pipeline processor.

Unit 3: Control Design
Instruction sequencing and Interpretation, Hardware Control design method and Micro-programmed Control.

Unit 4: Memory organization
Memory device characteristic, Random access and serial access memories, Virtual memory – memory hierarchies, Page replacement policies, Segments, pages and file organization, High speed memories – cache and associative memory.

Unit 5: System Organization
Programmed I/O, DMA and interrupts, I/O processors & CPU – I/O interaction.

Text Books:

1. John L. Hennessy , David A. Patterson: Computer Architecture: A Quantitative Approach, Sixth Edition, Morgan Kaufmann.
2. Kai Hwang: Computer Architecture and Parallel Processing, McGraw Hill Education.M.M. Mano: Computer System Architecture, 3rd Ed. PHI.

Course Outcome

1. Explain the fundamental concepts of digital electronics, combinational and sequential circuits, basic machine principles, data representation, and assembly-level programming features.
2. Analyze processor organization, instruction formats, addressing modes, arithmetic operations, ALU design, and pipelined architectures to understand processor performance.
3. Design and evaluate instruction sequencing and control units using hardwired and microprogrammed control techniques.
4. Analyze memory organization and hierarchy, including RAM, virtual memory, cache memory, associative memory, paging, segmentation, and page replacement policies.
5. Explain and evaluate input/output organization and data transfer mechanisms, including programmed I/O, DMA, interrupts, I/O processors, and CPU–I/O interactions.

Course Code	**:**	**DSPC 207**
Course Title	**:**	**Software Engineering**
Number of Credits and L/T/P scheme	**:**	**3 & 3/0/0**
Prerequisites (Course code)	**:**	
Course Category	**:**	**PC**

Course Learning Objectives

1. To inculcate software design abilities.
2. Impart knowledge-based awareness of user requirements.
3. To enable the students to conduct feasibility analysis.
4. Knowledge of software quality testing for its sustainability, reliability and durability.

Course Content

Unit 1: Introduction - Software Crisis, Software Characteristics, and Software Processes; Software life cycle models – Build & Fix, waterfall prototype evolutionary, spiral model.

Unit 2: Problem Analysis- DFD, Data dictionaries, ER diagrams, object diagrams; approaches to problems analysis; SRS; specifying behavioral & non-behavioral requirements, software configuration management.

Unit 3: Software Design and Implementation- Modularity, strategy of design, function-oriented design, object-oriented design, User interface design, UML modelling, Software implementation.

Unit 4: Software Quality- Size metrics, data structure metrics, information flow metrics, entropy-based measures, metric analysis, Software Quality Frameworks, ISO 9001 Model, SEI-CMM Model.

Unit 5: Software Validation and Reliability - Software Testing, verification and validation, errors, failures, faults, fault tolerance, Software Maintenance, reliability models – macro, basic, logarithmic Poisson, calendar time component, micro models.

Text Books:

1. Pressman, R.S. and Maxim, B.R., Software Engineering: A Practitioner's Approach, 9th ed., McGraw Hill, 2020.
2. Sommerville, Ian, Software Engineering, 10th ed., Pearson Education 2017.
3. K.K.Aggarwal, Yogesh Singh: Software Engineering, New Age International Ltd, 2001.
4. Pankaj Jalote, An Integrated Approach to Software Engineering 3rd Ed., 2005 Narosa Publishing.

Reference Books:

1. Singh,Y.,Software Testing, Cambridge University Press, 2013.

Course Outcome

1. Explain the fundamentals of software engineering, software characteristics, software processes, and software life cycle models, including waterfall, prototyping, evolutionary, and spiral models.
2. Analyze software requirements using DFDs, data dictionaries, ER diagrams, object diagrams, and Software Requirements Specifications (SRS), and apply software configuration management principles.
3. Apply function-oriented and object-oriented design principles, modularity, UML modeling, and user interface design techniques to develop structured software solutions.
4. Evaluate software quality using software metrics, information flow measures, entropy-based measures, and quality frameworks such as ISO 9001 and SEI-CMM.
5. Apply software verification, validation, and testing techniques, analyze software faults and failures, and assess software reliability and maintenance using appropriate reliability models.

Course Code	**:**	**MAIC 207**
Course Title	**:**	**Optimization Techniques**
Number of Credits & L/T/P Scheme	**:**	**3 & 3/0/0**
Prerequisites	**:**	
Course Type	**:**	**IC**

Course Learning Objectives:

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

1. Comprehend the techniques and applications of engineering optimization.
2. Analyze characteristics of a general linear programming problem
3. Apply basic concepts of mathematics to formulate an optimization problem

Course Content:

Unit 1 Introduction and Basic Concepts: Historical Development; Engineering applications of Optimization; Art of Modeling; Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems; Classification of optimization problems; Optimization techniques – classical and advanced techniques.

Unit 2 Optimization using Calculus: Stationary points; Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values.

Unit 3 Linear Programming: Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Examples; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems.

Unit 4 Dynamic Programming: Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP) ; Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP

Text Books:

1. S.S. Rao,"Engineering Optimization: Theory and Practice", New Age International P) Ltd., New Delhi, 2000.
2. G. Hadley,"Linear programming", Narosa Publishing House, New Delhi, 1990.
3. H.A. Taha,"Operations Research:An Introduction", 5th Edition, Macmillan, New York, 1992.

Course Code	**:**	**DSPC 200**
Course Title	**:**	**Data Mining and Analytics**
Number of Credits and L/T/P scheme	**:**	**4 and 3-0-2**
Prerequisites (Course code)	**:**	
Course Category	**:**	**PC**

Course Learning Objectives:

1. To build foundational competence in the complete data mining pipeline, emphasizing the transition from raw, noisy data to actionable insights through rigorous preprocessing and feature engineering.
2. To develop analytical intuition regarding the mathematical and algorithmic underpinnings of both unsupervised and supervised learning paradigms.
3. To cultivate a model-evaluation mindset, enabling students to critically assess algorithm performance using appropriate validation techniques, metrics, and statistical benchmarks beyond mere predictive accuracy.
4. To explore advanced analytical frameworks, including pattern mining, probabilistic graphical models, and graph-based social network analysis, preparing students for complex, real-world unstructured data scenarios.
5. To foster ethical data handling, ensuring students recognize and mitigate issues like selection bias, data imbalance, and the curse of dimensionality prior to model deployment.

Course Content

Unit-1 Data Mining and Data Pre-processing: Course Motivation. Introduction to Data Mining, Motivating real-world Applications. Issues in Data Mining Applications. Data pre-processing, Data Quality, Outlier Analysis, Handling Imbalanced Data, SMOTE. Feature Engineering, Feature Selection vs Feature Extraction, Curse of Dimensionality and Numerosity, Techniques (PCA, t-SNE), Data Sampling, Sampling vs Selection bias.

Unit-2 Unsupervised Learning: Introduction to Clustering, Applications, Partitioning-based Clustering, K-Means and Fuzzy C-Means, Linkage: Single, Complete, Average, Mean, Hierarchical (Dendrograms), Density-Based (DBSCAN), and Validation metrics (Silhouette Coefficient, DB-Index).

Unit-3 Supervised Learning: Introduction to Regression and Classification, Multilabel vs Multiclass, Train/Test Split, Cross-Validation Basics. Entropy, Information Gain, Gini index, Classifiers: Naïve Bayes, K-Nearest Neighbors (KNN), Decision Trees, and Ensemble methods (Random Forest),Confusion matrix, Accuracy, recall, precision, etc. Multiple Linear Regression, Logistic Regression,

Unit-4 Pattern Mining and Advanced topics: Introduction of Pattern Mining, Applications, Market-Basket Analysis, Frequent Itemsets, Apriori Algorithm, Alternative Methods, FP Growth

algorithm. Introduction to Probabilistic Graphical Models (PGM, BBN, MRF, HMM). *Advanced topics*: Social Network Analysis, Preliminaries and Properties, Homophily, Triadic Closure, Clustering Coefficient, Centrality, Community Detection in Graphs and Networks.

Text Books:

1. J. Han, M. Kamber, "Data Mining Concepts and Techniques", Morgan Kaufmann Publishers Inc., 2022, Fourth Edition.
2. Ning Tan, Vipin Kumar, Michael Steinbach, Pang, "Introduction to Data Mining", Pearson Education, 2018, Second Edition
3. M. Kantardzic, "Data Mining: Concepts, Models, Methods and algorithms, John Wiley and Sons Inc.
4. Pradeep Singh, Tapan K Gandhi and Balasubramanian Raman, "Artificial Intelligence and Machine Learning" McGraw Hill, 2025

Reference Books:

1. Mohammed J. Zaki and Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, First South Asia edition, 2016
2. M. Dunham, "Data Mining: Introductory and Advanced Topics", Pearson Education.

Course Outcomes:

After completion of the course, the student will be able to:

1. Apply rigorous data preprocessing techniques to real-world datasets, including handling missing values, outlier detection, dimensionality reduction, and resampling to rectify imbalanced data distributions.
2. Analyze complex, unlabeled real-world datasets by implementing and comparing clustering algorithms, while evaluating cluster quality using validation metrics.
3. Design and execute supervised learning models for both regression and classification tasks, differentiating between multi-class and multi-label problems, while justifying algorithm selection based on feature space properties.
4. Critique model performance by constructing confusion matrices and calculating advanced evaluation metrics alongside cross-validation strategies to ensure generalizability.
5. Extract actionable association rules from transactional data, and interpret network structures to identify communities, centrality, and triadic closures.
6. Formulate a comprehensive data mining strategy for a given real-world problem/scenario by integrating preprocessing, feature selection, appropriate modeling, and pattern discovery techniques to deliver a data-driven solution.

Course Code	**:**	**DSPC 202**
Course Title	**:**	**Data Handling and Visualization**
Number of Credits and L/T/P scheme	**:**	**4 & 3/0/2**
Prerequisites	**:**	**Programming using PYTHON (CSIC104)**
Course Category	**:**	**PC**

Course Learning Objectives: To understand the principles of data handling, data analysis, and data visualization using Python-based visualization tools.

Course Content

Unit1: Fundamentals Data Handling: Data Handling, Phases in Data Handling Process. Understanding data, Data categorization, Multidimensional data modelling, Data Aggregation and segregation, Data Formats: CSV, JSON, XML,APIs. Data collection methods-Random data generation, web scraping, live data collection.
Data Handling Techniques: Data cleaning, Data transformation, Exploratory Data Analysis, descriptive statistics, High-dimensional data handling- Dimensionality Reduction Techniques, Feature selection and Feature importance.

Unit 2: Fundamentals of Data Visualization: Data representation, Scalar, Vector, & Tensor Visualization, Multivariate Data Visualization, Text Data Visualization, Network Data Visualization, Visualization Techniques, Statistical data visualization, Understanding univariate and multivariate normal distributions. Multidimensional Data Visualization.

Unit 3: Data Analysis Model Building: Curve fitting approach, Measure of quality of Fit-R2 Evaluation, Bias variance trade-off, Regression and classification models. Association analysis, Recommendation Systems.
Unit 4 Temporal Data Handling & Visualization: Time series data, Types of time series, Time series Analysis models: Autoregressive model (AR), Moving Average (MA), Auto-Regressive Moving Average (ARMA). Auto Correlation, Time Series Visualization. Inference in Temporal Models.
Unit 5: Advanced Data Handling and Visualization: Large-scale Data Handling, Big Data characteristics, Chunk Processing, Memory Optimization, Data Integration, Data Fusion. Stream Data Model, Sampling Techniques, Case studies: financial data analysis, weather forecasting and analysis.
Unit 6 Interactive Data Visualization: Introduction to Plotly, creating interactive plots, 3D plots and dashboards, Introduction to Dash, Building interactive web-based data applications, Data analysis with real-world datasets.

Text Books:

1. Gagan Raj Gupta and Naresh Nagwani, “Data Analytics And Visualization”, Prentice Hall of India, 2025.
2. Bishop, Christopher M., and Nasser M. Nasrabadi. Pattern recognition and machine learning. Vol. 4. No. 4. New York: springer, 2006.
3. McKinney, Wes. Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. O'Reilly Media, Inc., 2012.

Reference books:

1. The Elements of Statistical Learning, Data Mining, Inference, and Prediction (2nd Edn.), Trevor Hastie Robert Tibshirani Jerome Friedman, Springer, 2014.
2. Han J & Kamber M, “Data Mining: Concepts and Techniques,” Morgan Kaufmann Publishers, Second Edition, 2006.
3. Jake Vander Plas, “Data Science Python Handbook: Essential Tool for working data” o'Reilly, 2023.
4. AbhaBelorkar, Sharath Chandra Guntuku, Shubhangi Hora, Anshu Kumar, “Interactive Data Visualization with Python: Present your data as an effective and compelling story”, Packt Publishing Ltd, 2020.
5. Jure Leskovec, Anand Rajaraman, and Jeffrey D. Ullman, *Mining of Massive Datasets*, 3rd Edition, Cambridge University Press, 2020

Course Outcomes:

1. Demonstrate the ability to understand the data handling fundamentals and data modeling techniques.
2. Apply appropriate data handling technique to determine insights from the structured data.
3. Apply data visualization methods to multidimensional datasets to interpret visual patterns.
4. Understand to build data analysis models and evaluate their model performance.
5. Analyze real-world datasets involving time series and streaming data
6. Design interactive dashboards and visualization applications for analytical insights

Course Code	**:**	**DSPC 204**
Course Title	**:**	**Artificial Intelligence**
Number of Credits and L/T/P scheme	**:**	**4 & 3/0/2**
Prerequisites	**:**	**Design and analysis of algorithm**
Course Category	**:**	**PC**

Course Learning Objectives

1. Understand the fundamental concepts, principles, and applications of Artificial Intelligence, including intelligent agents, rationality, and problem formulation.
2. Apply classical AI search techniques and constraint satisfaction methods to solve complex computational problems efficiently.
3. Analyze and represent knowledge using logical reasoning, first-order logic, and automated planning techniques for intelligent decision-making.
4. Interpret uncertainty in intelligent systems using probabilistic reasoning and Bayesian Networks for inference and decision support.
5. Explain the principles of Reinforcement Learning, including passive and active learning, policy search, and their applications in real-world AI systems.

Course Content

Unit 1: Introduction:
Definition and Scope of AI, History and Evolution of AI, Applications of AI in Various Fields, AI vs. Human Intelligence, Agent and Environment, Concept of Rationality, Structure of Agent

Unit 2: Problem Solving and Search:
Uninformed Search Strategies, Informed Search Strategies, Local Search Strategies, Adversarial Search, Search for Constraint Satisfaction Problems.

Unit 3: Knowledge and Reasoning: Logical Agents, First-Order Logic Inference in First-Order Logic, Knowledge Representation, Automated Planning.

Unit 4: Uncertain Knowledge and Reasoning:
Acting under Uncertainty, Inference Using Full Joint Distributions, Independence, Bayes' Rule and Its Use, Representing Knowledge in an Uncertain Domain, The Semantics of Bayesian Networks, Efficient Representation of Conditional Distributions, Exact Inference in Bayesian Networks, Approximate Inference in Bayesian Networks

Unit 5: Reinforcement Learning:
Reinforcement Learning: Background, Passive Reinforcement Learning, Active Reinforcement Learning, Generalization in Reinforcement Learning (Concepts), Introduction to Policy Search, Applications of Reinforcement Learning

Text Books:

1. Stuart J. Russell and Peter Norvig, Artificial Intelligence A Modern Approach, Prentice Hall, Fourth Edition, 2022.
2. Bishop, Christopher M., and Nasser M. Nasrabadi. Pattern recognition and machine learning. Vol. 4. No. 4. New York: springer, 2006.
3. Raschka, Sebastian, and Vahid Mirjalili. Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2. Packt publishing ltd, 2019.

Course Outcome

1. Explain the fundamental concepts, history, applications, intelligent agents, rationality, and agent–environment interactions in Artificial Intelligence.
2. Apply uninformed, informed, local, and adversarial search strategies, along with constraint satisfaction techniques, to solve AI problems.
3. Represent knowledge using propositional and first-order logic, perform logical inference, and apply automated planning techniques to solve reasoning problems.
4. Analyze uncertain knowledge using probability theory, Bayes' rule, joint probability distributions, and Bayesian networks, and apply exact and approximate inference techniques.
5. Apply passive and active reinforcement learning, generalization, and policy search concepts to develop and evaluate intelligent agents for real-world applications.

Course Code	**:**	**DSPC 206**
Course Title	**:**	**Database Management Systems**
Number of Credits and L/T/P scheme	**:**	**4 & 3/0/2**
Prerequisites	**:**	
Course Category	**:**	**PC**

Course Learning Objectives:

1. To understand data models and database systems.
2. To understand relational database theory.
3. To learn database design and its normalization.
4. To understand concepts of transaction, its processing, and management.
5. To learn concurrency control techniques.
6. To develop practical skill in using MySQL DBMS.

Course Content:

Unit-1 (Introduction)

Data, Database, Database management system, Historical background from file systems to Database Systems, Data Models, Relational Data Model, ER model, Schemas and Instances, Database users, DBMS architecture.

Unit-2 (Relational Model and Query Language)

Theory of Relational Database, Key Integrity constraint, Relational Algebra, Relational Calculus: Domain Relational Calculus, Tuple Relational Calculus, SQL, queries writing in SQL.

Unit-3 (Database Design)

Normalization, Database Anomalies, Functional Dependencies, Candidate and Super Key, Non-loss Decomposition, Dependency Preservation, First, Second, Third Normal, BCNF, etc.

Unit-4 (Transaction Processing)

Transaction concept, a simple transaction model, states, ACID Properties, implementation of ACID properties, Serializability.

Unit-5 (Concurrency Control)

Need for Concurrency, Lock-based protocols, Deadlock, Starvation, deadlock handling, time-stamp based protocols, validation-based protocols.

Text Books:

1. A Silberschatz, H.F. Korth& S. Sudarshan: Data Base System Concepts, Mc Graw Hill, 4^{th}, 5^{th} or 6^{th} edition.
2. Elmasri &Navathe : Fundamentals of Database Systems, 5^{th}, 6^{th}, or 7^{th} edition Pearson.

Course Outcome

1. Explain the fundamental concepts of database management systems, data models, relational and ER models, database schemas, instances, users, and DBMS architecture.
2. Apply relational algebra, relational calculus, integrity constraints, and SQL queries to retrieve, manipulate, and manage data in relational databases.
3. Design and normalize relational databases using functional dependencies, candidate keys, superkeys, lossless decomposition, dependency preservation, and normal forms up to BCNF.
4. Analyze database transactions using ACID properties, transaction states, and serializability principles to ensure reliable transaction processing.
5. Apply concurrency control techniques, including lock-based, timestamp-based, and validation-based protocols, to manage concurrent transactions and address deadlocks and starvation.

Course Code	**:**	**CSIC 301**
Course Title	**:**	**Machine Learning**
Number of Credits and L/T/P scheme	**:**	**4 and 3/0/2**
Prerequisites (Course Code)	**:**	**CSPC204, MAIC201**
Course Type	**:**	**IC**

Course Learning Objectives:

1. Be able to understand and apply supervised and unsupervised learning algorithms.
2. Understand the fundamental concepts in machine learning and popular machine learning algorithms.
3. Interpretation of data and results using statistics and analysis
4. Be able to solve real-life problems using machine learning algorithms with programming in Python.

Course Contents:

Unit-1 Introduction

Basic definitions, types of learning, hypothesis space and inductive bias, probability distributions and hypothesis testing using statistical tests, data pre-processing.

Unit-2 Regression Techniques and Analysis

Supervised learning using regression, types of regression, linear regression: simple and multiple, logistic regression, overview of other types of regression; model diagnostics and analysis using residual and outlier, handling of multi-collinearity.

Unit-3 Classification

Supervised learning using classification, types of classification, linear models: regression & SVM; non-linear models: decision tree induction, attribute selection measures: information gain, gain ration, Ginni index; tree pruning and scalability; Naive Bayes classifier; kNN; classification model evaluation metrics; improving accuracy using ensemble, random forest, bagging, boosting.

Unit-4 Clustering

Basic Clustering concepts, Standard k-Means clustering, finding optimal number of clusters, Modifications to the k-Means; hierarchical clustering,

Unit-5 Advances in Machine Learning

Gradient descent algorithm, bias-variance, cross-validation, recommender systems: association rules, collaborative filtering, user of similarity, overview of use of neural networks for learning

Reference Books:

1. M. Pradhan, U. Dinesh Kumar, Machine Learning using Python, Wiley India, Latest Edition.
2. J. Han, M. Kamber, J. Pei, Data Mining Concepts and Techniques, Latest Edition
3. Christopher Bishop. Pattern Recognition and Machine Learning. 2e.
4. Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997.

5. Introduction to Machine Learning Edition 2, by Ethem Alpaydin.

Course Outcome:

At the end of this course, a student will be able to:

1. Compare and differentiate among different machine learning techniques
2. Implement the studied regression and classification techniques and analyze the results
3. Apply the suitable supervised and unsupervised techniques and models for real-life problems, and predict the outcome
4. Explain the applicability of advanced concepts for recommender systems.
5. Hands-on problem solving with programming in Python.

Course Code	**:**	**DSPC 301**
Course Title	**:**	**Big Data Analytics**
Number of Credits and L/T/P Scheme	**:**	**4 and 3 0 2**
Prerequisites (Course code)	**:**	**Data Mining and Analytics**
Course Category	**:**	**PC**

Course Learning Objectives

1. To understand the concepts, challenges and applications of big data
2. To gain the knowledge of various concepts and techniques in data stream mining
3. To learn about big data storage technologies and algorithms for big data processing

Course Content

Unit 1 Introduction To Big Data: Why Big Data?, The Four Dimensions of Big Data, Data Streams: Data Stream Models, Basic Streaming Methods, Data Synopsis, Sampling, Histograms, Wavelets, Windowing Models, Tumbling Windows, Sliding Windows, Session Windows, Landmark Windows

Unit 2 Data Stream Analytics and Application - Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Ones in a Window, Decaying Windows

Unit 3 Frequent Pattern Mining and Clustering in Data Streams: Lossy Counting Algorithm, Space-Saving Algorithm, Heavy Hitters, Sticky Sampling, Types of Concept Evolution, StreamKM++, CluStream, DenStream, EStream

Unit 4 Classification from Data Streams: Hoeffding Trees, Very Fast Decision Trees, Ensemble Methods for Streams, Online Bagging, Online Boosting, Concept Drift Detection, ADWIN Algorithm

Unit 5 Big Data Enabling Technologies: Hadoop Stack, MapReduce Paradigm, Apache Spark Framework, PySpark MLlib, Apache Flink, Apache Kafka Architecture.

Text Books:

1. Baesens, Bart. Analytics in a big data world: The essential guide to data science and its applications. John Wiley & Sons, 2014.
2. Gama, Joao. Knowledge discovery from data streams. CRC Press, 2010.
3. Aggarwal, Charu C., ed. Data streams: models and algorithms. Vol. 31. New York: Springer, 2007.
4. Dirk Deroos et al., Hadoop for Dummies, Dreamtech Press, 2014.
5. Lam, Chuck. Hadoop in action. Simon and Schuster, 2010.
6. M. Dunham, “Data Mining: Introductory and Advanced Topics”, Pearson Education.

Reference Books:

1. Rutkowski, Leszek, Maciej Jaworski, and Piotr Duda. Stream data mining: algorithms and their probabilistic properties. Springer International Publishing, 2020.
2. Leskovec, Jure, Anand Rajaraman, and Jeffrey David Ullman. Mining of massive data sets.

Cambridge university press, 2020.
3. Mohammed J. Zaki and Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, First South Asia edition, 2016.

Course Outcomes

At the end of the course student will be able to

1. To analyze the attributes and associated issues of big data as well as will be able to propose solution for them.
2. To design efficient algorithms for mining different patterns from data streams.
3. To develop big data processing pipelines using different big data technologies.

Course Code	**:**	**DSPC 303**
Course Title	**:**	**Operating Systems**
Number of Credits and L/T/P scheme	**:**	**4 & 3/ 0/ 2**
Prerequisites (Course code)	**:**	
Course Category	**:**	**PC**

Course Learning Objectives

1. To understand the services and design of an operating system.
2. To understand the structure and organization of file system
3. To understand the process states and various concepts such as scheduling and synchronization related with it.
4. To understand different memory management approaches.
5. Students should be able to use system calls for managing processes, memory and file system.
6. students should understand the data structures and algorithms for implementation of OS.

Course Content

Unit-I: Computer system architecture and organization, Introduction and evolution of OS, Introduction to distributed OS, Real time systems and multimedia systems. OS structures: OS services, system calls and programs, OS design and implementation. Processes: Process concept, scheduling policies, algorithms, multilevel queuing, operations on process, Inter-process communication. Threads: multithreading models and threading issues. CPU scheduling: Criteria and algorithms, multiprocessor and thread scheduling.

Unit 2: Process synchronization: critical sections, classical two process and n-process solutions, hardware primitives for synchronization, semaphores, monitors, classical problems in synchronization (producer-consumer, readers-writer, dining philosophers, etc.).
Deadlocks: modelling, resource allocation, characterization, prevention and avoidance, detection and recovery.

Unit 3: Memory management: Swapping, contiguous memory allocation, paging, multilevel paging, segmentation, demand paging, page replacement algorithms, allocation of frames, thrashing, working set model. Input/Output: I/O system and services, device controllers and device drivers, disks, scheduling algorithms and management.

Unit 4: File system interface: access methods, access control, directory structures, file organization, file sharing and protection. system performance, protection and security, , OS design considerations for security, access control lists and OS support, internet and general network security. Operating system as service provider: Access control matrix, access control list, capability matrix, encryption and access permissions in Linux and Windows.

Reference Books:

1. A. Silberschatz, Peter B. Galvin and G. Gagne, "Operating System Concepts," (9th or newer edition), Wiley.
2. H. Brinch, "Operating System Principles," Prentice Hall of India.
3. Dhamdhere, "Systems programming & Operating systems," TataMcGrawHil

4. A. N. Habermann, "Introduction to Operating System Design," Galgotia publication, New Delhi.
5. A.S. Tanenbaum, "Modern Operating Systems," Prentice Hall of India.

Course Outcomes

At the end of the course student will be able to

1. Understand functions, structures and history of operating systems
2. Able to know the design issues associated with operating systems
3. Master various process management concepts such as scheduling, synchronization, multithreading and deadlocks
4. Understand the various concepts associated with memory management such as virtual memory, demand paging, page replacements algorithms
5. Be familiar with various protection and security mechanisms
6. Be familiar with virtualization and operating system components

Course Code	**:**	**DSPC 305**
Course Title	**:**	**Computer Vision**
Number of Credits and L/T/P scheme	**:**	**4 and 3-0-2**
Prerequisites (Course code)	**:**	
Course Category	**:**	**PC**

Course Objective:

1. Able to recognize and describe both the theoretical and practical aspects of computing with images.
2. Able to describe the foundation of image formation and image analysis.
3. Understand the geometric relationships between 2D images and the 3D world.
4. Have gained exposure to motion, matching, recognition, extraction, and categorization from images.

Course Content:

Unit-1: Introduction And Digital Image Formation: Overview, Fundamentals of Image Formation, What is computer vision?, A brief history. Image Formation And Image Models: Geometric Camera Models, Geometric Camera Calibration, Radiometry, Measuring Light, Shadows and shading, Color.

Unit-2: Early Vision - Multiple Images: The Geometry of Multiple Views, Stereopsis, Affine Structure from Motion, Projective Structure from Motion. Feature Detection and Matching: Points and patches, Edges, Lines

Unit-3: Mid Level Vision: Segmentation by Clustering, Segmentation by Fitting a Model, Segmentation and Fitting using Probabilistic Methods, Tracking with Linear Dynamic Models.
Feature-Based Alignment: 2D and 3D feature-based alignment, Pose estimation, Geometric intrinsic calibration.

Unit-4: High Level Vision – Geometric Methods: Model-Based Vision, Smooth Surfaces and their Outlines, Aspect Graphs, Range Data. Structure From Motion: Triangulation, Two-frame structure from motion, Factorization, Bundle adjustment, Constrained structure and motion. Probabilistic and Inferential Methods: Recognition by Relations between Templates, Geometric Templates from Spatial Relations, Application, Image Based Rendering.

Unit-5: Dense Motion Estimation: Translational alignment, Parametric motion, Spline-based motion, Optical flow, Layered motion. 3D Reconstruction: Shape from X, Active range finding, Surface representations, Point-based representations - Volumetric representations - Model-based reconstruction - Recovering texture maps.
Recognition: Object detection, Face recognition, Instance recognition, Category recognition, Context and scene understanding.

Text Books:

1. Digital Image Processing, Rafael C. Gonza Lez and Richard E. Woods, Fourth Edition, Pearson, 2018.
2. Computer Vision: A Modern Approach, Forsyth and Ponce, Second Edition, Pearson, 2015.
3. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer-Verlag, 2010.
4. Computer Vision: Models, Learning, and Inference, Dr Simon J. D. Prince, Cambridge University Press, 2012.
5. Multiple View Geometry in Computer Vision, Richard Hartley and Andrew Zisserman, Cambridge University Press, 2004.

Course Outcomes:

1. Understand the basics of 2D and 3D Computer Vision.
2. Design and describe various methods used for motion, registration, alignment, detection, recognition and matching in images.
3. Build computer vision applications.

Course Code	**:**	**DSPC 307**
Course Title	**:**	**Computer Network**
Number of Credits and L/T/P scheme	**:**	**4 & 3 0 2**
Prerequisites (Course code)	**:**	
Course Category	**:**	**PC**

Course Learning Objectives:

1. Understand computer network basic, different models used for study of computer networks, ability to identify different designs, understanding of the issues surrounding wired and wireless Networks.
2. Design, calculate, and apply subnet masks to fulfil networking requirements and building the skills of routing mechanisms.
3. Analyse the features and operations of various application layer protocols such as Http, DNS, SMTP and FTP.
4. Analyse the requirements for a given organizational structure and select the most appropriate networking architecture and technologies.
5. Familiarity with the basic protocols of computer networks, and how they can be used to assist in network design and implementation.

Course Content:

Unit 1: Introduction

History and development of computer networks, Network Functions, Network Topology, Network Services, Switching Approaches, Transmission media and systems, OSI Reference Model, Overview of TCP/IP architecture.

Unit 2: Physical, MAC and Data Link Layer

Different types of transmission media, errors in transmission: attenuation, noise, multiplexing and signalling techniques, Encoding (NRZ, NRZI, Manchester, 4B/5B, etc). Aloha, CSMA, CSMA/CD, CSMA/CA protocols, Ethernet, including Gigabit Ethernet and WiFi (802.11), Token Ring, Bluetooth and Zigbee. Error detection, Sliding Window, Stop and Wait protocols, ARQ, Sliding Window Protocols, HDLC, PPP protocols.

Unit 3: Network layer:

Internet Protocol, IPv6, ARP, DHCP, ICMP, Routing algorithms: Distance vector, Link state, Metrics, Inter-domain routing. Subnetting, Classless addressing, Network Address Translation, IPv4 to IPv6 Translation strategies, Packet network topology, Datagrams and Virtual Circuits, Structure of Switch/Router, Connectionless and Virtual Circuit packet Switching, Traffic management and QoS – FIFO, Priority Queues, Fair Queuing, MPLS.

Unit 4: Transport and Application layer:

UDP, TCP. Connection establishment and termination, sliding window revisited, flow and congestion control, timers, retransmission, TCP extensions, etc. Client Server Model, HTTP, DNS, SMTP, FTP, and TFTP.

Text Books:

1. Behrouz A. Forouzan: Data Communications and Networks, Fifth Edition, McGraw Hill, 2017.
2. Leon Garcia and IndraWidjaja: Communication Networks – Fundamental Concepts and Key Architectures, Second Edition TMH.
3. A.S. Tanenbaum: Computer Networks, Sixth Edition, Pearson Education, 2022.
4. William Stallings: Data and Computer Communications 10/e, Pearson Education.

Course Outcomes:

At the end of the course student will be able to

1. Understand computer network basic, different models used for study of computer networks, ability to identify different designs, understanding of the issues surrounding wired and wireless Networks.
2. Design, calculate, and apply subnet masks to fulfil networking requirements and building the skills of routing mechanisms.
3. Analyse the features and operations of various application layer protocols such as Http, DNS, SMTP and FTP.
4. Analyse the requirements for a given organizational structure and select the most appropriate networking architecture and technologies.
5. Familiarity with the basic protocols of computer networks, and how they can be used to assist in network design and implementation.

Course Code	**:**	**DSPC 300**
Course Title	**:**	**Deep Learning**
Number of Credits and L/T/P scheme	**:**	**4 and 3-0-2**
Prerequisites (Course code)	**:**	**Machine Learning**
Course Category	**:**	**PC**

Course Learning Objectives

The objective Deep Learning course is to cover the fundamentals of neural networks as well as some advanced topics such as recurrent neural networks, long short-term memory cells and convolutional neural networks. This course also covers the basic applications of the deep learning.

Course Content

Unit-1: History of Deep Learning, Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm.

Unit-2: Feedforward Networks: Multilayer Perceptron, Gradient Descent, Backpropagation, Empirical Risk Minimization, regularization, autoencoders. Deep Neural Networks: Difficulty of training deep neural networks, Greedy layerwise training.

Unit-3: Newer optimization methods for neural networks (Adagrad, adadelta, rmsprop, adam, NAG), second order methods for training, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization), Recurrent Neural Networks: Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs.

Unit-4: Convolutional Neural Networks: LeNet, AlexNet, ZF-Net, VGGNet,Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks, Generative models: Restrictive Boltzmann Machines (RBMs), Introduction to MCMC and Gibbs Sampling, gradient computations in RBMs, Deep Boltzmann Machines.

Unit-5: Recent Trends: Variational Autoencoders, Generative Adversarial Networks, Multi-task Deep Learning, Multi-view Deep Learning, Applications: Image based classification, Vision, NLP.

Text Books:

1. Ian J. Goodfellow, Bengio Yoshua, and Aaron Courville. "Deep Learning." An MIT Press book in preparation, 2016.
2. Charu C. Aggarwal “Neural Networks and Deep Learning: A Textbook” Springer Nature, 2018.
3. Seth Weidman “Deep Learning from Scratch: Building with Python from First Principles” O’REILLY, 2019
4. Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola “Dive into Deep Learning: Tools for Engagement” CORWIN, 2019

Reference Books:

1. Ian J. Goodfellow, Bengio Yoshua, and Aaron Courville. "Deep Learning." An MIT Press book in preparation, 2016.

Course outcomes

At the end of the course, student will have understanding of following concepts/ theories/ application:

1. Fundamental Understanding of Neural network.
2. Basic and Advance concept of Deep Learning.
3. Application of Deep Learning.

Course Code	**:**	**DSPC 302**
Course Title	**:**	**Distributed Computing**
Number of Credits and L/T/P scheme	**:**	**4 and 3-0-2**
Prerequisites (Course Code)	**:**	
Course Type	**:**	**PC**

Course Learning Objectives:

1. To understand fundamental concepts of distributed computing.
2. To acquire knowledge to design and develop protocols for distributed systems and networks.

Course content

Unit 1 Fundamental issues in Distributed Systems, Models of Distributed Computations, Handling time through clocks, Physical Time and Hardware Clock Synchronization, Logical Time and Software Clocks, Message Ordering Protocols, Interprocess Communication, Shared Memory Vs Message Passing Models, Distributed and Localized Algorithms, Evaluation of Correctness and Performance.

Unit 2 Protocols for Routing and Designing Virtual Constructs, MST, MIS, and CDS, Distributed Mutual Exclusion, Leader Election,

Unit 3 Distributed Deadlock Detection, Termination Detection, Global State Computation and Snapshot Recording.

Unit 4 Global Predicate Detection, Fault-Tolerance Issues, Basic Techniques for handling Crash Failure in Distributed Systems, Checkpointing and Rollback Recovery, Z-path and Z-cycles, Other Types of Failures in Distributed Computing Systems, Consensus and Agreement Protocols, FLP impossibility, Byzantine Generals Problem, Failure Detectors, Wait Freedom, Self-Stabilization, Peer-to-Peer Computing, Overlay Structures, Distributed Scheduling and Load Balancing, Naming, Security.

Reference Books:

1. A D Kshemkalyani and MukeshSinghal, Distributed Computing: Principles, Algorithms, and Systems, Cambridge University Press 2008.
2. G Colouris, J Dollimore, and T Kindberg, Distributed Systems: Concepts and Design, 3/e Pearson Ed. 2002.
3. A S Tanenbaum and M van Steen, Distributed Systems: Principles and Paradigms, 3/e Pearson Ed. 2002.
4. V K Garg, Principles of Distributed Systems, Kluwer Academic Publishers, 1996.
5. Sukumar Ghosh, Distributed Systems: An Algorithmic Approach, 2/e Chapman& Hall.
6. V K Garg, Principles of Distributed Computing, IEEE Press.
7. Nancy Lynch, Distributed Algorithms, Morgan Kaufmann Press.

Course Outcome

1. Able to apply knowledge of operating systems and networks to distributed systems
2. Design distributed algorithms for complex computing problems
3. Analyze the performance of algorithms and evaluate the scalability of solutions
4. Adapt existing centralized algorithms to distributed set up
5. Simulate the algorithms in distributed environment

Course Code	**:**	**DSPC 304**
Course Title	**:**	**Large Language Models**
Number of Credits and L/T/P scheme	**:**	**4 and 3-0-2**
Prerequisites (Course code)	**:**	**Machine Learning**
Course Category	**:**	**PC**

Course Learning Objectives:

1. Provide a strong foundation in Natural Language Processing (NLP), including linguistic analysis, statistical language modeling, and text representation.
2. Develop an understanding of Large Language Models (LLMs), including transformer architectures, attention mechanisms, contextual embeddings, instruction tuning, and model alignment.
3. Familiarize students with modern LLM applications, including information retrieval, Retrieval-Augmented Generation (RAG), machine translation, and LLM evaluation.

Course Content

Unit-1 Foundations of Natural Language Processing and Statistical Language Modeling: Introduction to Natural Language Processing (NLP), Applications of NLP, Levels of Linguistic Analysis, Words and Tokenization, Regular Expressions, Minimum Edit Distance, N-Gram Language Models, Language Model Evaluations, Smoothing Techniques, Overview of Text Classification using Logistic Regression, Word Representations and Embeddings (Word2Vec, GloVe, fastText), Distributional Semantics.

Unit-2 Transformers and Large language Models: Introduction to Large language Model (LLM), Architectures for Language Models, Conditional Generation of Text, Prompting, Sampling Strategies, Training of LLM, Ethical and Safety Issues with Language Models, Attention Mechanism, Self-Attention, Positional Encoding, Transformer Architecture, Transformer Training and Inference

Unit-3 Pre-trained Language Models: Masked Language Modeling , Bidirectional Transformer Encoders (BERT), Training Bidirectional Encoders, Contextual Embeddings, Fine-Tuning of Bidirectional Encoders for Classification, Instruction Tuning in LLM, Learning via preference, LLM Alignment via Preference-Based Learning (RLHF), Test-time Compute

Unit-4 LLM Applications, Retrieval, and Evaluation: Introduction to Information Retrival, Evaluation of Information-Retrieval Systems, Information Retrieval with Dense Vectors, Retrieval-Augmented Generation (RAG), Language Divergences and Typology, Machine Translation, Beam Search, Bias and Ethical Issues in LLM, Explainability and Interpretability of LLMs, Overview of Recent Foundation Models (GPT, Llama, Claude, Gemini, Mistral).

Reference Books:

1. Lewis Tunstall, Leandro von Werra and Thomas Wolf, Natural Language Processing with Transformers, O'Reilly.
2. Tanmoy Chakraborty, Introduction to Large Language Models, Cambridge University Press.
3. Jacob Eisenstein, Introduction to Natural Language Processing, MIT Press.
4. Daniel Jurafsky and James H. Martin, Speech and Language Processing, 3rd Edition (Draft), Volume I, Stanford University. Source: https://web.stanford.edu/~jurafsky/slp3/ ; Chapters : 1-5, 7-12.

Course Outcomes:

At the end of the course student will be able to:

1. Explain the fundamentals of Natural Language Processing and statistical language models.
2. Apply text representation techniques, embeddings, and basic NLP methods for language understanding.
3. Analyze transformer architectures and the working principles of Large Language Models (LLMs).
4. Fine-tune and evaluate pre-trained language models for NLP tasks.
5. Develop NLP applications using retrieval-augmented generation (RAG), machine translation, and modern foundation models while considering ethical and responsible AI practices.

Course Code	**:**	**DSPE 302**
Course Title	**:**	**Information Retrieval**
Number of Credits and L/T/P scheme	**:**	**4 and 3-0-2**
Prerequisites (Course code)	**:**	
Course Category	**:**	**DE**

Course Learning Objectives

1. **Understand the fundamentals of Information Retrieval**: Gain a foundational understanding of the key concepts, models, and theories in Information Retrieval. Learn about the retrieval process, including indexing, query formulation, relevance ranking, and result presentation.
2. **Familiarity with Information Retrieval models**: Learn about different retrieval models such as Boolean, vector space, probabilistic, and language models. Understand how these models represent and measure the relevance of documents to user queries.
3. **Study retrieval evaluation**: Learn about evaluation metrics and methodologies used to assess the effectiveness of information retrieval systems. Understand how to measure retrieval performance, relevance judgments, and precision, recall, and effectiveness measures like average precision and mean average precision.
4. **Study advanced retrieval techniques and applications**: Explore advanced topics in information retrieval, such as relevance feedback, query expansion, clustering, filtering, and recommendation systems. Understand how these techniques improve the effectiveness and efficiency of retrieval systems. Understand the application of information retrieval techniques in different domains, such as text mining, information extraction, question answering, and recommender systems.
5. **Understand web search and ranking algorithms**: Learn about the unique challenges and techniques involved in web search. Explore web crawling, link analysis, PageRank, and other ranking algorithms used in search engines.

Course Content

Unit-1: Fundamental notions: Data vs Information Processing, DIKW model, data vs information retrieval, search system vs search engine, components of search system, type of search system, role of IR process in search system. design challenges and issues, IR Versus Web search, components of IR process/system, search system computing modules(overview): Text Acquisition, Transformation, Indexing, Relevance Estimation, etc.

Unit 2- Building Blocks of IR (Indexing Process): Text acquisition: Crawling & Feed, type of Crawling, meta-crawlers, Design challenges of crawling process, Text Transformation**:** Stopping, Stemming, Stemming Strategies & Algorithms etc, Link Analysis, Strategies and Algorithms, Indexing: Details of Indexing process & elements, Inverted indices, web indexes, near-duplicate detection, Index Compression, efficient processing with sparse vectors.

Unit-3: Internals of Retrieval Process: Introduction of Retrieval Model, Role of retrieval model in IR, History of model, Types of retrieval strategy and Evolution: Boolean and Vector-space retrieval models, Language Model based IR, Probabilistic IR, Advanced Models, Relevance Estimation: Term weighting scheme, TF-IDF weighting, cosine similarity, etc. Relevance feedback and query expansion. User Interface, Visual Elements: Visualization Accomplishment & Visualization Implications.

Unit-4: Web Search and IR Paradigms: Web Search Overview, Evolution of WEB (ARPANET, Internet, WWW), Characterizing the Web, Meta-search, Web Search Architectures, Search engine optimization (SEO), Link Analysis and Specialized Search: Link Analysis, Hubs and Authorities, Page Rank and HITS algorithms, Searching and Ranking: Relevance Scoring and Ranking for Web Similarity, Advanced Search Paradigms: Recommendation System: Collaborative filtering, Content-based recommendation of documents and products, Hidden Web: handling "invisible", Web-Snippet generation, Summarization, Question Answering System, Cross-Lingual Retrieval & Social Media Search.

Text Books:

1. Ricardo Baeza -Yates and Berthier Ribeiro Neto, Modern Information Retrieval: The Concepts and Technology behind Search 2 nd Edition, ACM Press Books 2011.
2. C. Manning, P. Raghavan, and H. Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008.

Reference Books:

1. Bruce Croft, Donald Metzler and Trevor Strohman, Search Engines: Information Retrieval in Practice, 1 st Edition Addison Wesley, 2009.
2. Mark Levene, An Introduction to Search Engines and Web Navigation, 2 nd Edition Wiley, 2010.

Course Outcomes:

At the end of the course student will be able to:

1. Demonstrate knowledge of various retrieval models, such as Boolean, vector space, probabilistic, and language models.
2. Develop proficiency in implementing indexing techniques to efficiently organize and retrieve information.
3. Evaluate the effectiveness of retrieval systems using appropriate evaluation metrics and methodologies.
4. Understand the challenges and techniques involved in web search, including web crawling, link analysis, and ranking algorithms.
5. Explore the application of information retrieval techniques in areas such as text mining, information extraction, and question answering.

Course Code	**:**	**DSPE 304**
Course Title	**:**	**Game Theory and Applications**
Number of Credits and L/T/P scheme	**:**	**4 and 3/0/2**
Prerequisites (Course code)	**:**	
Course Category	**:**	**DE**

Course Learning Objectives

Objective of the course is to make student understand the concepts of game theory and its applications to various discipline Engineering.

Course Content

Unit 1: Introduction and Outline of The Course: Definitions, Utilities, Rationality, Intelligence, Common Knowledge, Classification of Games and Real-world Scenarios.

Unit 2: Non-Cooperative Game Theory: Extensive Form Game, Strategic Form Games With Illustrative Examples, Dominant Strategy Equilibria, Pure Strategy Nash Equilibrium With Illustrative Examples And Key Results, Mixed Strategy Nash Equilibrium With Illustrative Examples And Key Results Such As The Nash Theorem, Computation Of Nash Equilibria And Introduction To Algorithmic Theory, Matrix Games: Saddle Points, Minimax Theorem, Bayesian Games, Bayesian Nash Equilibrium, Evolutionary Game Theory (Ess Strategies), Repeated Game.

Unit 3: Mechanism Design: The Mechanism Design Environment, Social Choice Functions with Illustrative Examples, Implementation of Social Choice Functions, Incentive Compatibility and Revelation Theorem, Gibbard-Satterthwaite and Arrow Impossibility Theorem, Vickrey-Clarke-Groves (Vcg) Mechanisms, Bayesian Mechanisms (Dagva), Revenue Equivalence Theorem, Myerson Optimal Auction, Further Topics In Mechanism Design.

Unit 4: Cooperative Game Theory: Correlated Strategies and Correlated Equilibrium, The Nash Bargaining Problem, Coalitional Games (Transferable Utility Games), The Core, The Shapley Value, Other Solution Concepts: Kernel, Nucleolus.

Text Book:

1. Martin J. Osborne. An Introduction to Game Theory. Oxford University Press. Indian Edition, 2003.
2. Roger B. Myerson. Game Theory: Analysis of Conflict. Harvard University Press, 1991.
3. Y. Narahari, Dinesh Garg, Ramasuri Narayanam, Hastagiri Prakash. Game Theoretic Problems in Network Economics and Mechanism Design Solutions. Springer, London, 2009.
4. NPTEL website, http://nptel.ac.in/syllabus/106108053/.

Course Outcomes

1. To understand the concepts of game theory and its mathematical foundation
2. To identify fields of application of game theory in real-life
3. To design and implement game theoretic algorithms for automation
4. To apply game theoretic strategies in industrial engineering problems.

Course Code	**:**	**DSPE 306**
Course Title	**:**	**Full Stack Development**
Number of Credits and L/T/P scheme	**:**	**4 and 3/0/2**
Prerequisites (Course code)	**:**	**Software Engineering**
Course Category	**:**	**DE**

Course Learning Objectives

The main objective of the course is to enable the students to develop a complete web application that includes Frontend, Backend and Data-exchange technologies.

Course Content

Unit 1. Planning Your Work

Rise of the Web, Mobile Web, The State of HTML, Applications vs. Web Sites, Identifying Requirements, Defining the Work, Tracking the Work, Scrum, Kanban, Continuous Improvement, Prioritization & Estimation, Managing Bugs, Continuous Delivery

Unit 2. Designing Systems

System Architectures, Identifying Concepts, Identifying User Interactions, Handling Commonalities, Working with Legacy and External Dependencies, Component Interactions, Applications vs. Modules, Cross-Functional Requirements, Caching, Designing for Failure, Designing Modules, Refactoring,

Unit 3: Front End

HTML, From Server to Browser, Styling, Components, Responsive Design, Progressive Enhancement, Search Engine Optimization, Build Tools, Test-Driven Development
JavaScript, JavaScript in the Browser, Offline-First Development, Document Object Model, Server-Side JavaScript, JavaScript Modules, Structuring Your JavaScript, JavaScript Types

Unit 4. Back-End Development and Storing Data

Server-side programming languages (e.g., Node.js, Python, Ruby), APIs, API Responsibilities, Designing a REST API, Securing Your API, Using APIs, Storing DataTypes of Databases, To SQL or NoSQL?, Where to Store Your Data, Accessing Data from Your App, Managing Your Data, Protecting Your Data.

Text Books:

1. Chris Northwood, “The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer”, Apress, 2018.

Reference Books:

1. Jon Duckett, “Web Design with HTML, CSS, JavaScript and JQuery Set”, Wiley, 2014.
2. Nicholas C. Zakas, “Professional JavaScript for Web Developers”, Wiley, 2012

Course Outcomes:

At the end of the course student will be able to:

1. Learn about the most recent web development technologies.
2. Understand the basics of HTML, CSS, and Bootstrap to structure and style web pages.
3. Acquire awareness about the front end and back-end Tools.

Course Code	**:**	**DSPE 308**
Course Title	**:**	**Security and Privacy in Artificial Intelligence**
Number of Credits & L/T/P Scheme	**:**	**3 and 3/0/0**
Prerequisites	**:**	**Basics of Artificial Intelligence, Machine Learning and Computer Networks**
Course Type	**:**	**DE**

Course Learning Objectives

1. Understand the security and privacy challenges associated with AI systems.
2. Explore adversarial attacks and defences in machine learning and deep learning.
3. Gain practical knowledge of analysis and countermeasures.
4. Learn privacy-preserving AI techniques and secure model development.
5. Study AI governance, ethics, regulations, and trustworthy AI.

Course Content

Unit 1 Foundations of AI Security and Privacy

Privacy-Preserving ML Techniques, Anomaly detection, Indicators of Compromise, dynamic and predictive threat intelligence, Security Requirements of AI Systems, Privacy Challenges in AI, CIA Triad in AI Systems, AI Risk Assessment.

Unit 2 Threats and Attacks

Classification of threats, threat Models, types of attacks and address using ML/DL; White-box, Black-box and Grey-box Attacks, Evasion Attacks, Poisoning Attacks, Model Inversion Attacks, Adversarial attacks on ML systems, Tools and Techniques for Scanning Vulnerabilities in AI Models

Unit 3 Analysis and Countermeasures

Static File Analysis, Behavioral Analysis, Static & Behavioral Hybrid Analysis, Forensic Analysis, Sandbox Malware Analysis; Soft authentication and hard authentication, digital signatures, personalization; cybersecurity scenarios; identifying and assessing privacy-preserving countermeasures.

Unit 4 Secure AI Development and Defence Mechanisms

Secure AI Development Lifecycle, Secure Dataset Preparation, AI Model Validation, Secure Model Deployment, Homomorphic Encryption, Data Anonymization, Synthetic Data Generation, Development of intrusion detection systems.

Unit 5 AI Governance, Ethics, and Emerging Trends

Cybercrime for Fake news, Privacy, Ethics, AI Bias and Fairness, AI Regulations and Standards, Quantum AI Security, Future Research Directions

Text Books:

1. William Stallings, Network Security Essentials: Applications and Standards, 7th Edition, Pearson, 2024.

2. Aneesh Sreevallabh Chivukula, Xinghao Yang, Bo Liu, Wei Liu, and Wanlei Zhou, Adversarial Machine Learning: Attack Surfaces, Defence Mechanisms, Learning Theories in Artificial Intelligence, Springer, 1st Edition, 2023.
3. David J. Miller, Zhen Xiang, and George Kesidis, Adversarial Learning and Secure AI, Cambridge University Press, 1st Edition, 2023.

Reference Books

1. Ross J. Anderson, Security Engineering, 3rd Edition, Wiley, Nov 2020.
2. Nataraj Venkataramanan and Ashwin Shriram, Data Privacy: Principles and Practice, 1st Edition, Taylor Francis, 2016.
3. Cynthia Dwork and Aaron Roth, The Algorithmic Foundations of Differential Privacy, Found. Trends Theor. Comput. Sci. 9, 2014.

Course Outcomes

1. Understand AI security fundamentals and Identify vulnerabilities in AI systems.
2. Evaluate AI model robustness and Analyze attack scenarios on ML models.
3. Apply knowledge of privacy-preserving learning techniques.
4. Develop secure AI applications and Implement defence mechanisms against adversarial attacks.
5. Able to understand AI governance frameworks and Analyze legal and ethical aspects of AI.

Course Code	**:**	**DSPE 310**
Course Title	**:**	**Bio-Informatics**
Number of Credits and L/T/P scheme	**:**	**3 and 3/0/0**
Prerequisites (Course code)	**:**	**Design and Analysis of Algorithms**
Course Category	**:**	**DE**

Course Learning Objectives

This course aims to introduce the bioinformatics concepts, techniques and tools related to biological databases, sequence analysis, phylogenetic analysis, genomics and protein analysis to students with a focus on drug discovery application.

Course Content

Unit 1: Introduction: Bioinformatics an Interdisciplinary Approach, Genome, DNA Sequence, Central Dogma, Transcription, Translation, DNA Structure and Modifications.

Unit 2: Biological Databases: Types of Biological Information, Biological Database Search and Data Retrieval, Techniques for Extracting DNA Sequence, Protein Sequence and Protein Structure Information, Conventions for Database Indexing and Specification of Search Terms

Unit 3: Sequence Alignment: Pair wise Alignment of Sequences, Scoring Matrices, and Tools for Similarity Search and Sequence Alignment, Dynamic Programming Algorithms

Unit 4: Phylogenetic Analysis and Genomics: Introduction to Phylogenetics, Comparative Genomics, Orthologs, Paralogs, Methods of Phylogenetic Analysis. Whole Genome Analysis, Gene Prediction, Protein Structure Overview, Search and Visualization, Protein Structure Prediction, Protein Function Prediction

Unit 5: Drug Discovery: Technologies and Strategies, Key to Drug Discovery, Structural Biology and Virtual Screening for Drug Discovery, Emerging Role of Biomarkers in Drug Development, Potential Drug Targets

Text Books:

1. Letovsky, Stanley I., ed. Bioinformatics: databases and systems. Springer Science & Business Media, 2006.
2. Jones, Neil C., and Pavel A. Pevzner. An introduction to bioinformatics algorithms. MIT press, 2004.
3. Baxevanis, Andreas D., Gary D. Bader, and David S. Wishart, eds. Bioinformatics. John Wiley & Sons, 2020.

Reference Books:

1. Sorin Draghici, Bioinformatics Databases: Design, Implementation, and Usage, CRC, 2013
2. Rastogi, S. C., Parag Rastogi, and Namita Mendiratta. Bioinformatics: Methods and Applications-Genomics, Proteomics and Drug Discovery. PHI Learning Pvt. Ltd., 2022

Course Outcomes

At the end of the course student will be able:

1. To search and extract information from different biological databases.
2. To apply different alignment techniques to biological sequences.
3. To perform phylogenetic analysis and genome analysis using different tools.
4. To analyze proteins structure and functions.

Course Code	**:**	**DSPE 312**
Course Title	**:**	**Stochastic Processes and Queuing Theory**
Number of Credits and L/T/P schem	**:**	**3 and 3/0/0**
Prerequisites	**:**	**MAIR13**
Course Type	**:**	**DE**

Course Learning Objectives:

1. It provides an essential base for mathematical modelling which is normally used to solve the problems of pattern recognition and machine learning.
2. It is used in the research of various science and engineering problem.

Course Content:

Unit 1: Random variables, Functions of random variables, joint1y distributed random variables. Expectation, Expectation of functions of more than one random variable, Covariance and Correlation, Auto and Cross Correlation, Correlation Co-efficient, Parameter Estimation – Maximum Likelihood Estimation and Maximum a Posteriori.

Unit 2: Stochastic Processes, Classification of stochastic processes, Stationary Random Processes-First order, second order and nth order, Strict sense stationary process, Ergodic Process, the Bernoulli process, The Poisson process, Renewal process, Advanced Renewal Theory, Renewal Function, Alternating Renewal Processes .

Unit 3: Markov Chains, Computation of n-step transition probabilities, Chapman-Kolmogorov theorem, Classification of states of a Markov Chain, Distribution of times between state changes, Irreducible finite chains with aperiodic states, Birth and Death processes, Pure Birth Process, Pure Death Process, Non-Birth-Death Processes, Analysis of program execution time.

Unit 4: Introduction to Queuing Theory, General Queuing, Components of a queuing system, Deterministic Queues, (M/M/1):(∞/FIFO)-Single server with infinite capacity, Extension to (M/M/2): (∞/FIFO), (M/M/k) : (∞/FIFO)- Multiple server with infinite capacity, Engset Loss Formula, M/G/1 queuing system, M/G/1 with non-FIFO disciplines, M/G/∞, Queues with time-varying arrival rate.

Reference Books:

1. A. Populis and S.U. Pillai, “Probability, Random Variables, and Stochastic Process”, 4th Edition, McGraw-Hill.
2. S. Palaniammal, “Probability and Queueing theory.” Prentice Hall of India.
3. V. Sundarapandian, “Probability, Statistics and Queueing Theory.” Prentice Hall of India.

Course outcomes

1. Develop an understanding to the basic concepts of Random Processes, Expectations and Parameter Estimation.
2. Able to understand and apply the Stochastic processes to Science and Engineering problems and applications.
3. Able to calculate the n-step transition probabilities for any Markov chain and understand about the birth and death of processes.
4. Able to apply Markov chain & Birth Death process to real life problems.
5. Develop an understanding of various Queuing Systems.