SSN SCHOOL OF ENGINEERING
Department of Computer Science and Engineering
B. Tech – AI & DS

SEMESTER-WISE COURSE STRUCTURE

SEMESTER I							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
EN1001	Communicative English	HS	3	2	1	0	3
MA1001	Linear Algebra	BS	4	3	1	0	4
PH1001T	Engineering Physics	BS	3	3	0	0	3
BS1001	Environmental Science and Engineering	BS	2	2	0	0	2
CS1001	Programming in C	ES	3	3	0	0	3
CS1703	Digital Design + Lab	ES	4	2	0	2	3
EA1001T	Extra Academic Activity	AEA*	2	0	0	0	1
CS1801	Programming in C Lab	ES	4	0	0	4	2
PH1801T	Engineering Physics Lab	BS	4	0	0	4	2
						Total Credits	**23**

SEMESTER II							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
EN1002	English for Engineers	HS	3	2	1	0	3
MA1004	Statistical Foundations of Data Science	BS	3	3	0	0	3
CS1002	Programming in Python	ES	2	2	0	0	2
CS1006T	Data Structures	PC	3	3	0	0	3
CS1004	Computer Organization and Architecture	ES	3	3	0	0	3
CS1704	Foundations of Data Science + Lab	PC	5	3	0	2	4
EA1001T	Extra Academic Activity	AEA*	2	0	0	0	1
CS1804T	Data Structures Lab	PC	4	0	0	4	2
CS1802	Programming in Python Lab	ES	4	0	0	4	2
						Total Credits	**23**

SEMESTER III							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
MA2003	Discrete Mathematics	BS	4	3	1	0	4
CS2003	Object Oriented Programming	PC	3	3	0	0	3
CS2701	Operating Systems + Lab	PC	5	3	0	2	4
CS2007	Artificial Intelligence	PC	3	3	0	0	3
CS2009	Exploratory Data Analysis and Data Visualization	PC	2	2	0	0	2
HS2001	Cognitive Psychology	HS	2	2	0	0	2
CS2803	Object Oriented Programming Lab	PC	4	0	0	4	2
CS2805	Exploratory Data Analysis and Data Visualization Lab	PC	4	0	0	4	2
						Total Credits	**22**

SEMESTER IV							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
CS2004	Design and Analysis of Algorithms	PC	3	3	0	0	3
CS2001T	Database Management Systems	PC	3	3	0	0	3
MA2002	Statistical Inference	BS	3	3	0	0	3
CS2012	Machine Learning Techniques	PC	3	3	0	0	3
CS2010	Data Mining	PC	1	1	0	0	1
	Open Elective - I	OE	3	3	0	0	3
CS2801T	Database Management Systems Lab	PC	4	0	0	4	2
CS2808	Machine Learning Techniques Lab	PC	4	0	0	4	2
						Total Credits	**21**

SEMESTER V							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
MA3001	Optimization Techniques	BS	3	3	0	0	3
CS3005	Web Technologies	PC	3	3	0	0	3
CS3701	Computer Networks + Lab	PC	5	3	0	2	4
CS3007	Deep Learning	PC	3	3	0	0	3
BM3003	Principles of Management	HS	2	2	0	0	2
CS3011	Introduction to Robotics	ES	3	3	0	0	3
CS3009	Introduction to Digital Signal Processing	ES	1	1	0	0	1
CS3807	Deep Learning Lab	PC	4	0	0	4	2
CS3801	Web Technologies Lab	PC	2	0	0	2	2
						Total Credits	**21**

SEMESTER VI							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
CS3008	Image and Video Processing	ES	3	3	0	0	3
CS3012	Natural Language Processing	PC	3	3	0	0	3
CS3010	Introduction to Speech Signal Processing	ES	1	1	0	0	1
	Professional Elective I	PE	3	3	0	0	3
	Professional Elective II	PE	3	3	0	0	3
	Open Elective - II	OE	3	3	0	0	3
CS3804	Image and Video Processing Lab	ES	4	0	0	4	2
CS3806	Natural Language Processing Lab	PC	4	0	0	4	2
						Total Credits	**20**
SEMESTER VII							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
CS4007	Big Data Analytics	PC	3	3	0	0	3
CS4009	Speech Technology	ES	3	3	0	0	3
	Professional Elective III	PE	3	3	0	0	3
	Professional Elective IV	PE	3	3	0	0	3
	Open Elective III	OE	3	3	0	0	3
CS4803	Big Data Analytics Lab	PC	4	0	0	4	2
CS4997	Capstone Project I	EEC	6	0	0	6	3
						Total Credits	**20**
SEMESTER VIII							
Course Code	**Course Title**	**Category**	**Contact Hours**	**L**	**T**	**P**	**C**
	Professional Elective V	PE	3	3	0	0	3
	Professional Elective VI	PE	3	3	0	0	3
CS4996	Capstone Project II	EEC	12	0	0	12	6
						Total Credits	**12**

PROFESSIONAL ELECTIVES (PE)

SEMESTER VI - ELECTIVE I

Sl. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	CS3674	Advanced Machine learning	PE	3	3	0	0	3
2	CS3672	Data Science for Business	PE	3	3	0	0	3
3	CS3670	Sensors and Actuators	PE	3	3	0	0	3
4	CS3691T	Data Preprocessing	PE	3	3	0	0	3
5	CS3668	Parallel Processing	PE	3	3	0	0	3
6	CS3699T	Introduction to Cyber Security	PE	3	3	0	0	3

SEMESTER VI - ELECTIVE II

Sl. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	CS3666	Data Visualization	PE	3	3	0	0	3
2	CS3664	Industry 4.0	PE	3	3	0	0	3
3	CS3686	Digital Forensics	PE	3	3	0	0	3
4	CS3662	Control Systems	PE	3	3	0	0	3
5	CS3660	Pattern Recognition and ANN	PE	3	3	0	0	3
6	CS3658	High Performance Computing	PE	3	3	0	0	3

SEMESTER VII - ELECTIVE III

Sl. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	CS4687	Semantic Web Technology	PE	3	3	0	0	3
2	CS4685	Media Planning and Strategies	PE	3	3	0	0	3
3	CS4683	Cryptography and Network Security	PE	3	3	0	0	3
4	CS4689	Augmented and Virtual Reality	PE	3	3	0	0	3
5	CS4681	Graphs - Algorithms and Mining	PE	3	3	0	0	3
6	CS3689	Quantum computing	PE	3	3	0	0	3

SEMESTER VII - ELECTIVE IV

Sl. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	CS4679	Reinforcement Learning	PE	3	3	0	0	3
2	CS4677	Ethics for Data Science	PE	3	3	0	0	3
3	CS4675	Data Security and Privacy	PE	3	3	0	0	3
4	CS4673	Microcontrollers for IoT	PE	3	3	0	0	3
5	CS4671	Bioinformatics	PE	3	3	0	0	3
6	CS4669	GPU Architectures and Programming	PE	3	3	0	0	3

SEMESTER VIII - ELECTIVE V

Sl. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	CS4674	Information Retrieval	PE	3	3	0	0	3
2	CS4672	Developing Data Products	PE	3	3	0	0	3
3	CS4698	Vulnerability Assessment and Penetration testing	PE	3	3	0	0	3
4	CS4692	Drone Technology	PE	3	3	0	0	3
5	CS4670	Time Series Analysis	PE	3	3	0	0	3
6	CS4668	Distributed Computing for Data Science and AI	PE	3	3	0	0	3
7	CS4650	Fundamentals of AR and VR	PE	3	3	0	0	3

SEMESTER VIII - ELECTIVE VI

Sl. No.	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	CS4666	Nature Inspired Computing	PE	3	3	0	0	3
2	CS4664	Simulation Techniques in Finance	PE	3	3	0	0	3
3	CS4662	Cognitive Cyber Security	PE	3	3	0	0	3
4	CS4660	AI for Robotic Communication	PE	3	3	0	0	3
5	CS4658	Social Media Mining	PE	3	3	0	0	3
6	CS4656	Functional Programming	PE	3	3	0	0	3
7	CS4648	User Interface Design	PE	3	3	0	0	3

DETAILED SYLLABUS / MODULE CONTENT

SEMESTER I

Course Code	Course Title		Credits
EN1001	Communicative English		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	SHARING INFORMATION RELATED TO ONESELF/FAMILY & FRIENDS	Reading: Short comprehension passages, Practice in skimming-scanning and predicting. Writing: Completing sentences, developing hints. Speaking: Introducing oneself, exchanging personal information. Listening: Listening comprehension of short texts, including formal and informal conversations. Language Development: Asking and answering Wh- Questions and Yes/No questions. Vocabulary Development: Prefixes and suffixes, polite expressions.	12
II	GENERAL READING AND FREE WRITING	Reading: Reading short narratives and descriptions from newspapers including dialogues and conversations. Writing: Paragraph writing - topic sentence, main ideas, organization and cohesive devices. Listening: Telephonic conversations, short presentations and TV news. Speaking: Sharing information of a personal kind, greeting and taking leave. Language Development: Prepositions, conjunctions and clauses. Vocabulary Development: Guessing meanings of words in context.	12
III	GRAMMAR AND LANGUAGE DEVELOPMENT	Reading: Short texts and longer passages (close reading). Writing: Understanding text structure, use of reference words and discourse markers, coherence markers and reordering jumbled sentences. Listening: TED talks and longer texts, product description and narratives from different sources. Speaking: Asking about routine actions and expressing opinions, making short presentations. Language Development: Degrees of comparison, pronouns and direct vs indirect speech. Vocabulary Development: Idioms and phrases, single word substitutes and adverbs.	12
IV	READING AND LANGUAGE DEVELOPMENT	Reading: Reading longer texts and different types of texts (journalistic, literary). Writing: Letter writing, informal or personal letters, e-mails and conventions of personal email. Listening: Listening to dialogues or conversations and completing exercises based on them. Speaking: Speaking about oneself and one's friend, role-plays. Language Development: Tenses - simple and continuous. Vocabulary Development: Synonyms, antonyms and phrasal verbs.	9
V	EXTENDED WRITING	Reading: Longer academic texts including comparison and contrast texts. Writing: Brainstorming, developing an outline, identifying main and subordinate ideas, dialogue writing and writing short essays. Listening: Listening to talks and lectures. Speaking: Participating in conversations and short group discussions. Language Development: Modal verbs, perfect and	

		perfect continuous tenses. Vocabulary Development: Collocations and fixed/semi-fixed expressions.	
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Board of Editors	Using English: A Course Book for Undergraduate Engineers and Technologists	Orient BlackSwan Limited, Hyderabad	-	2015

Course Outcome	
CO	**Course Outcome**
CO1	Apply reading strategies to comprehend articles of a general kind (ex. magazines and newspapers).
CO2	Participate effectively in informal conversations; introduce themselves and their friends and express opinions in English.
CO3	Comprehend conversations and short talks (formal and informal).
CO4	Write short general essays and personal letters and emails.

Course Code	**Course Title**		**Credits**
MA1001	Linear Algebra		4
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	VECTOR SPACES	Semigroup, group, ring, field (Definitions and examples)-vector space, subspace, linear independence and dependence-basis and dimension	12
II	LINEAR TRANSFORMATION	Linear transformation-range space and null space-rank and nullity-dimension theorem	12
III	EIGEN VALUES AND EIGEN VECTORS	Matrix representation of linear transformation-eigenvalues and eigenvectors of the linear transformation	12
IV	INNER PRODUCT SPACES	Inner product and norms-properties-orthogonal, orthonormal vectors - Gram Schmidt orthonormalization process	12
V	MATRIX DECOMPOSITION	QR decomposition - Singular value decomposition -Least square approximations	12
		Total Lecture hours:	**60**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Friedberg A.H., Insel A.J. and Spence L.	Linear Algebra	Prentice Hall of India, New Delhi	-	2004

Course Outcome	
CO	**Course Outcome**

CO1	Find the basis and dimension of vector space.
CO2	Obtain the nullity and rank of a linear transformation.
CO3	Find the eigenvalues and eigenvectors of linear transformations.
CO4	Find an orthonormal basis of inner product space.
CO5	Apply matrix decomposition in engineering and find least square approximations to the system of equations.

Course Code	Course Title		Credits
PH1001T	Engineering Physics		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	ACOUSTICS	Classification - Music and Noise - Characteristics of Sound: Pitch/Frequency, Loudness/Intensity - decibel scale - Weber-Fechner law - Loudness Curves - Quality/Timbre.	4
II	ULTRASONICS	Production - Magnetostriction and Piezoelectric methods - Detection - Piezoelectric, Acoustic grating - Non Destructive Testing - pulse echo system - reflection and transmission modes - Modes of data presentation - A, B and C scan displays - Sonogram.	5
III	QUANTUM PHYSICS	Planck's theory (derivation) - Deduction of Wien's displacement law and Rayleigh-Jeans law from Planck's theory - Properties of Matter waves - wave particle duality - Schrodinger's wave equation - Time independent and time dependent equations - Physical significance of wave function - Particle in a one dimensional box and extension to three dimensional box - Degeneracy of electron energy states - Quantum free electron theory - Density of states - Fermi-Dirac statistics - Free electron concentration in metals.	9
IV	SEMICONDUCTORS	Classification of semiconductors based on doping and band gap - Intrinsic semiconductor - Concept of hole - carrier concentration derivation - Fermi level and its variation with temperature - electrical conductivity - band gap determination - Extrinsic semiconductors - Carrier concentration derivation in n-type and p-type semiconductors - Variation of Fermi level with temperature and impurity concentration.	9
V	LASERS	Interaction of Radiation with Matter - Spontaneous and stimulated emissions - Einstein's A and B coefficients - Conditions for Laser action - Population inversion - Active medium - pumping schemes - Optical resonant cavity - Light Amplification - Types of lasers - Nd:YAG, CO2 and Semiconductor lasers - homo junction and hetero junction laser.	9
VI	FIBRE OPTICS	Principle and propagation of light in optical fibres - Numerical aperture and Acceptance angle - Classification of optical fibres (material, mode and refractive index) - Losses in fibres - attenuation, dispersion - Fibre optical communication system (block diagram) - Active and passive sensors - pressure, strain and displacement.	9
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	M. N. Avadhanulu and P. G. Kshirsagar	A Text Book of Engineering Physics	S. Chand & Co. Ltd.	Revised Edition	2014
Reference Books					
1	Kasap, S.O.	Principles of Electronic Materials and Devices	McGraw-Hill Education	3rd Edition	2017
2	Kittel, Charles	Introduction to Solid State Physics	Wiley	-	2004
3	Gaur R.K. and Gupta S.L.	Engineering Physics	Dhanpat Rai Publishers	-	2012
4	Halliday, D., Resnick, R. and Walker, J.	Principles of Physics	Wiley	-	2015
5	James Beauchamp (Editor)	Analysis, Synthesis, and Perception of Musical Sounds - The Sound of Music	Springer	2007th Edition	2006
6	Serway, R.A. and Jewett, J.W.	Physics for Scientists and Engineers	Cengage Learning	-	2010
7	Tipler, P.A. and Mosca, G.	Physics for Scientists and Engineers with Modern Physics	W.H. Freeman	-	2007

Course Outcome	
CO	**Course Outcome**
CO1	Analyse the characteristics of sound and understand production of ultrasonic waves and their applications.
CO2	Explain the basic quantum mechanical concepts and their applications.
CO3	Analyse the physics of semiconductors.
CO4	Elucidate the principle and working of different type of lasers.
CO5	Explicate the principle of light propagation, causes for losses and dispersion in fibre optic communication and working of fiberoptic displacement, pressure and strain sensors.

Course Code	**Course Title**		**Credits**
CS1001	Programming in C		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	C PROGRAMMING BASICS	Introduction to C programming: fundamentals - structure of a C program - compilation and linking processes - Constants, Variables, Data Types - Expressions using operators in C - Managing Input and Output operations - Decision Making and Branching - looping statements - solving simple scientific and statistical problems.	12

II	ARRAYS AND STRINGS	Arrays - Initialization - Declaration - One dimensional and Two dimensional arrays - Strings: String operations - String Arrays - Simple programs: sorting, searching and matrix operations.	10
III	FUNCTIONS AND POINTERS	Function: Definition of function - Declaration of function - Pass by value - Pass by reference - Recursion - Pointers: Definition - Initialization - Pointers arithmetic - Pointers and arrays.	8
IV	STRUCTURES AND UNION	Introduction - need for Structure data type - Structure definition - Structure declaration - Structure within a structure - Union - Programs using Structures and Unions - Storage classes - Preprocessor directives - Simple programs: singly linked list and doubly linked list.	8
V	FILE HANDLING AND ADDITIONAL FEATURES IN C	Console input output functions - disk input output functions - data files - Additional Features in C: command line arguments, bit wise operators, enumerated data types and type-casting.	7
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Kernighan, B.W. and Ritchie, D.M.	The C Programming Language	Pearson Education	2nd Edition	2006

Course Outcome	
CO	**Course Outcome**
CO1	Develop simple applications in C using basic constructs.
CO2	Design and implement applications using arrays and strings.
CO3	Develop and implement applications in C using functions and pointers.
CO4	Develop applications in C using structures.

Course Code	**Course Title**		**Credits**
CS1703	Digital Design + Lab		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	DIGITAL FUNDAMENTALS	Number Systems - Decimal, Binary, Octal, Hexadecimal, 1's and 2's complements, Codes - Binary, BCD, Excess 3, Gray, Alphanumeric codes, Boolean theorems, Logic gates, Universal gates, Sum of products and product of sums, Minterms and Maxterms, Karnaugh map Minimization.	9
II	COMBINATIONAL LOGIC	Design of Half and Full Adders, Half and Full Subtractors, Binary Parallel Adder - Carry look ahead Adder, BCD Adder, Multiplexer, Demultiplexer, Magnitude Comparator, Decoder, Encoder, Priority Encoder.	9
III	SEQUENTIAL LOGIC	Flip flops - SR, JK, T, D, Master/Slave FF - operation and excitation tables, Triggering of FF, Analysis and design of clocked sequential and asynchronous circuits - Design - Moore/Mealy models, state minimization, state assignment,	9

		circuit implementation - Design of Counters- Ripple Counters, Ring Counters, Shift registers, Universal Shift Register.	
IV	TIMING ANALYSIS & ARITHMATIC BLOCK DESIGN	Timing analysis - Combinational circuits - Critical path - Sequential Circuits - Setup Time/Hold Time; Data Paths - Adders, Multipliers - Array, Add and shift method, ALUs, Area and speed tradeoffs. Case Study: ALU Design.	9
V	MEMORY DEVICES	Basic memory structure - Address bus - RAM - Static and its transfer characteristics, dynamic RAM - Programmable Logic Devices - Programmable Logic Array (PLA) - Programmable Array Logic (PAL).	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	M. Morris Mano and Michael D. Ciletti	Digital Design	Pearson	5th Edition	2014
2	Thomas L. Floyd	Digital Fundamentals	Pearson Education Inc.	10th Edition	2011
3	Charles H. Roth	Fundamentals of Logic Design	Thomson Learning	6th Edition	2013
Reference Books					
1	John F. Wakerly	Digital Design Principles and Practices	Pearson Education	4th Edition	2007
E-References					
1	IIT Kharagpur / NPTEL	NOC: Digital Electronic Circuits	https://nptel.ac.in/courses/108105132	-	-

Course Outcome

CO	Course Outcome
CO1	Use Boolean algebra and simplification procedures and signed representation.
CO2	Design various combinational digital circuits.
CO3	Design and analyze synchronous and asynchronous sequential circuits.
CO4	Design arithmetic building blocks.
CO5	Study memory architecture.

SEMESTER II

Course Code	Course Title		Credits
EN1002	English for Engineers		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION	Listening: Listening to product descriptions and scientific/technical talks and completing information-gap exercises. Speaking: Describing a product; asking for and giving directions. Reading: Reading descriptions and short technical texts from journals and newspapers. Writing: Purpose statements, extended definitions, instructions, checklists, recommendations, note-making and note-taking. Vocabulary Development: Technical vocabulary, avoiding jargon. Language Development: Subject-verb agreement and compound words.	9
II	READING AND WRITING TECHNICAL TEXTS	Listening: Listening to longer technical talks and completing exercises based on them. Speaking: Describing a process and making enquiries. Reading: Reading longer technical texts and identifying transitions and paragraphing. Writing: Interpreting charts and graphs; writing formal letters/e-mails including complaints. Vocabulary Development: Vocabulary used in formal letters/e-mails and reports. Language Development: Impersonal passive voice and numerical adjectives.	9
III	BECOMING INDEPENDENT USERS OF LANGUAGE FOR TECHNICAL CONTEXTS	Listening: Listening to classroom lectures/talks on engineering/technology. Speaking: Introduction to technical presentations. Reading: Longer texts both general and technical, practice in speed reading. Writing: Describing a process, use of sequence words, compare and contrast paragraphs. Vocabulary Development: Sequence words and misspelled words. Language Development: Embedded sentences.	9
IV	LANGUAGE FOR JOB-PREPAREDNESS	Listening: Listening to documentaries and making notes. Speaking: Mechanics of presentations. Reading: Reading for detailed comprehension. Writing: Email etiquette, job application, cover letter, resume preparation, analytical essays and issue-based essays. Vocabulary Development: Finding suitable synonyms and paraphrasing. Language Development: Clauses and if-conditionals.	9
V	ADVANCED READING AND WRITING	Listening: TED/Ink talks. Speaking: Participating in a group discussion. Reading: Reading and understanding technical articles. Writing: Reports, minutes of a meeting, accident and survey reports. Vocabulary Development: Verbal analogies. Language Development: Reported speech.	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	N.P. Sudarshana and C. Savitha	English for Engineers	Cambridge University Press	-	2018

Course Outcome	
CO	**Course Outcome**
CO1	Read technical texts and write area- specific texts effortlessly.
CO2	Listen and comprehend lectures and talks in their area of specialization successfully.
CO3	Speak appropriately and effectively in varied formal and informal contexts.
CO4	Write reports and winning job applications.

Course Code	Course Title		Credits
MA1004	Statistical Foundations of Data Science		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	PROBABILITY THEORY	Probability - axioms - laws of probability - total probability - Bayes' Theorem - random variables - distribution functions - mass and density functions	9
II	STATISTICAL AVERAGES	Mathematical expectation of a random variable - properties of expectation - median - mode - variance - Kurtosis - skewness - moments - moment generating function	9
III	PROBABILITY DISTRIBUTIONS	Bernoulli - Binomial - Poisson - Multinomial - Uniform - Exponential and Gaussian distributions - Central Limit Theorem (for independent and identically distributed random variables)	9
IV	TWO-DIMENSIONAL RANDOM VARIABLES	Joint distribution - marginal distribution - conditional distribution - joint density function - marginal density function - conditional density function - covariance - correlation and regression lines	9
V	RANDOM PROCESSES	Definition - Classification - Stationary Process - Markov Processes and Markov chain.	9
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Gupta, S.C. and Kapoor, V.K.	Fundamentals of Mathematical Statistics	Sultan Chand and Sons	11th Edn. (Reprint)	2007

Course Outcome	
CO	**Course Outcome**
CO1	Understand the fundamental concepts of probability and random variables.
CO2	Apply the various statistical methods needed to analyse the given data.
CO3	Have knowledge of standard distributions which can describe the real-life phenomenon.
CO4	Understand the basic concepts of two-dimensional random variables and apply them in engineering applications.
CO5	Apply the concept of random processes in data analysis.

Course Code	Course Title		Credits
CS1002	Programming in Python		2
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	DATA, EXPRESSIONS, STATEMENTS, CONDITIONALS	Data and types: int, float, boolean, string, list - variables - expressions - statements - simultaneous assignment - precedence of operators - comments - in-built modules and functions - Conditional: boolean values and operators, conditional (if), alternative (if-else), case analysis (if-elif-else)	8
II	ITERATION, FUNCTIONS, STRINGS	Iteration: while, for, break, continue, pass - Functions: function definition, function call, flow of execution, parameters and arguments, return values, local and global scope, recursion - Strings: string slices, immutability, string functions and methods, string module	8
III	CONTAINERS	Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters, nested lists, list comprehension - Dictionaries: operations and methods, looping and dictionaries, reverse lookup, dictionaries and lists, dictionary comprehension - Tuples: tuple assignment, tuple as return value, tuple operations	8
IV	FILES AND EXCEPTION HANDLING	Files: Text files, reading and writing files, format operator, file names and paths - command line arguments - Exceptions: try-catch, types of exception handling	6
		Total Lecture hours:	**30**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Allen B. Downey	Think Python: How to Think Like a Computer Scientist	Shroff/O'Reilly	2nd Edition	2016

Course Outcome

CO	Course Outcome
CO1	Think logically to solve programming problems using Python.
CO2	Understand and develop simple Python programs using conditionals and loops.
CO3	Decompose a program into functions.
CO4	Represent compound data using Python lists, tuples, dictionaries.
CO5	Perform input/output with files.

Course Code	Course Title		Credits
CS1006T	Data Structures		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**

I	INTRODUCTION TO DATA STRUCTURES	Types of computational problems - Search: linear and binary; Sorting: bubble, selection, and counting sort; Abstract Data Types - Data Structures: types and operations - Time and space complexity analysis: Big-Oh notations - Growth rates - Time-space trade-off - Time complexity analysis of example computational problems.	10
II	LINEAR DATA STRUCTURES	List ADT - array implementation of list - operations on lists: insertion, deletion, merging - Linked list implementation: singly linked list, doubly linked list, circular linked list - Operations on linked lists - Polynomial ADT - Applications: merge two sorted linked lists, insertion sort. Stack ADT - array and linked list implementation - push and pop - Applications: balancing symbols, postfix expression evaluation, infix to postfix conversion. Queue ADT - array and linked list implementation - enqueue and dequeue - Circular queue ADT - Deque ADT - Applications: round robin scheduling, Josephus problem.	16
III	NON-LINEAR DATA STRUCTURES	Tree ADT - implementation of trees - tree traversals - Binary Tree ADT - Expression trees - Binary Search Trees: operations on BSTs - AVL Tree operations: insertion - B-Tree operations: insertion - Priority Queue ADT - Heap types and heap sort. Hash ADT - hash tables - insert, delete, search - hash functions - load factor - collision - separate chaining, linear probing, quadratic probing, rehashing, extendible hashing. Graph ADT - directed, undirected and weighted graphs - adjacency list and matrix - BFS, DFS - minimum spanning tree - Prim, Kruskal and Dijkstra algorithms.	19
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Mark Allen Weiss	Data Structures and Algorithm Analysis in C++	Pearson Education India	Fourth Edition	2013
2	Cormen TH, Leiserson CE, Rivest RL and Stein C	Introduction to Algorithms	MIT Press	Fourth Edition	2022

Course Outcome

CO	Course Outcome
CO1	Apply the basics of complexity analysis, abstraction, and identify computational problems in real-world scenarios.
CO2	Apply various linear data structure operations to store and retrieve data.
CO3	Apply various non-linear data structure operations to store and retrieve data.
CO4	Analyze searching, sorting, and graph algorithms for real-world problems.

Course Code	Course Title	Credits
CS1004	Computer Organization and Architecture	3

Module #	Module Title	Module Content	Lecture Hours
I	PROCESSOR FUNDAMENTALS	Computer Components - Performance Metrics - Instruction set architecture - Various addressing modes - Instruction execution in ALU - Simple data path	9
II	COMPUTER ARITHMETIC	Representing unsigned and signed integer numbers - Floating point system - Integer addition and subtraction - Adders: Ripple carry adder, Carry Look Ahead adders - Integer multiplication and division - High-Radix Multipliers and High-Radix Dividers - Redundant number systems - Residue number systems	12
III	MEMORY SYSTEMS	Memory hierarchy - Cache Memory: Organization, Design - Virtual Memory concepts	9
IV	INTERCONNECTIONS AND PERIPHERALS	Interconnection structures, Bus - PCI, Mesh, Hyper cube, Ring, Star - I/O Interface Systems: Keyboard, Monitor, Mouse, Bluetooth, USB, Flash	6
V	ILP ARCHITECTURES	Pipelining - Hazards in pipelining - Super pipelining - Super scalar - VLIW - Combining super scalar and VLIW with pipelining	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Carl Hamacher, Zvonko Vranesic and Safwat Zaky	Computer Organization	McGraw Hill Education	Fifth Edition	2011

Course Outcome

CO	Course Outcome
CO1	Explain processor fundamentals.
CO2	Design arithmetic and logic unit.
CO3	Evaluate performance of memory systems.
CO4	Extend the learning to parallel processing architectures.
CO5	Explain interconnection structures.

Course Code	Course Title	Credits
CS1704	Foundations of Data Science + Lab	4

Module #	Module Title	Module Content	Lecture Hours
I	INTRODUCTION TO DATA SCIENCE	Introduction: Need for data science - Benefits and uses - Facets of data - Big data ecosystem - The data science process: retrieving data, cleansing, integrating and transforming data, data analysis, building models, presenting findings and building applications.	9

II	TOOLBOXES FOR DATA SCIENTISTS	Introduction to Python - Fundamental Python Libraries for Data Scientists: NumPy, SciPy, Scikit-Learn, Pandas, Matplotlib - IDE - Data Manipulation with Python.	10
III	DESCRIPTIVE STATISTICS	Introduction - Data Preparation - Exploratory Data Analysis: data summarization, data distribution, outlier treatment, measuring asymmetry, continuous distribution; Estimation: mean, variance, sampling, covariance, correlation.	8
IV	STATISTICAL INFERENCE	Introduction - Frequentist Approach - Measuring the Variability in Estimates: point estimates, confidence intervals; Hypothesis Testing: using confidence intervals, using p-values.	8
V	MACHINE LEARNING	Supervised Learning: introduction, kNN classifier; Regression analysis: linear regression, logistic regression; Unsupervised Learning: introduction, clustering, evaluation metrics.	10
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Cathy O'Neil and Rachel Schutt	Doing Data Science: Straight Talk from the Frontline	O'Reilly Media	First Edition	2013
2	Joel Grus	Data Science from Scratch: First Principles with Python	O'Reilly Media	Second Edition	2019
3	Jake VanderPlas	Python Data Science Handbook: Essential Tools for Working with Data	O'Reilly Media	Second Edition	2022

Course Outcome

CO	Course Outcome
CO1	Explain the need, benefits, applications, facets of data, big data ecosystem, and the complete data science process.
CO2	Apply Python and common data science libraries such as NumPy, SciPy, Scikit-Learn, Pandas, and Matplotlib for data manipulation and analysis.
CO3	Perform descriptive statistical analysis using data preparation, exploratory data analysis, summarization, distribution analysis, outlier treatment, and measures such as mean, variance, covariance, and correlation.
CO4	Apply statistical inference techniques including point estimation, confidence intervals, hypothesis testing, and p-value based decision making.
CO5	Implement basic supervised and unsupervised machine learning techniques such as kNN, linear regression, logistic regression, clustering, and evaluate model performance using suitable metrics.

SEMESTER III

Course Code	Course Title	Credits
MA2003	Discrete Mathematics	4

Module #	Module Title	Module Content	Lecture Hours
I	LOGIC AND PROOFS	Propositional Logic - Propositional equivalences - Principal Normal forms - Rules of inference - Proof Techniques - Proof methods and strategy.	12
II	COMBINATORICS	Mathematical induction - The Pigeonhole principle - Principal of Inclusion and Exclusion - Recurrence relations - Solution of linear recurrence relations - Generating functions.	12
III	LATTICES AND BOOLEAN ALGEBRA	Partial ordering - Posets - Lattices as Posets - Properties of lattices - Lattices as algebraic systems - Sub lattices - Some special lattices - Boolean algebra - Stone's representation Theorem.	12
IV	GRAPHS	Graph terminology - special types of graphs - Subgraphs - Operations on graphs - Connectivity - Cut points - Bridges - Blocks - Eulerian and Hamilton graphs.	12
V	GRAPH ALGORITHMS	Matrix representation of graphs - graph isomorphism - Trees - Spanning trees - Dijkstra's algorithm for shortest path - Kruskal's and Prims's algorithm for minimum spanning tree.	12
		Total Lecture hours:	**60**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Kenneth H. Rosen	Discrete Mathematics and its Applications	Tata McGraw Hill, New Delhi	7th Edition, Special Indian Edition	2017
2	Tremblay J.P. and Manohar R.	Discrete Mathematical Structures with Applications to Computer Science	Tata McGraw Hill, New Delhi	30th Reprint	2011
Reference Books					
1	Frank Harary	Graph Theory	CRC Press	-	2019
2	Ralph P. Grimaldi	Discrete and Combinatorial Mathematics: An Applied Introduction	Pearson Education Asia	4th Edition	2007
3	T. Veerarajan	Discrete Mathematics with Graph Theory and Combinatorics	Tata McGraw Hill	-	2007

Course Outcome

CO	Course Outcome
CO1	Write simple proofs using Propositional and First-Order Logic.
CO2	Solve problems using different counting techniques.
CO3	Understand the concepts and significance of lattices and Boolean algebra.

CO4	Understand the basic concepts of graph theory.
CO5	Find the shortest path and spanning tree of a given graph.

Course Code	Course Title		Credits
CS2003	Object Oriented Programming		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION TO OOP AND JAVA FUNDAMENTALS	Object Oriented Programming - Abstraction - objects and classes - Encapsulation - Inheritance - Polymorphism - OOP in Java - Characteristics of Java - The Java Environment - Java Source File Structure - Compilation. Fundamental programming structures in Java - Defining classes in Java - constructors.	9
II	INHERITANCE AND INTERFACES	Inheritance - super classes and sub classes - protected members - constructors in sub classes - the Object class - abstract classes and methods - final methods and classes - Interfaces: defining an interface, implementing interface, differences between classes and interfaces and extending interfaces.	9
III	EXCEPTION HANDLING AND I/O	Exceptions - exception hierarchy - throwing and catching exceptions - built-in exceptions, creating own exceptions, Stack Trace Elements. Input/Output basics - Streams - Byte streams and Character streams - Reading and writing console - Reading and writing files.	9
IV	MULTITHREADING AND GENERIC PROGRAMMING	Differences between multi-threading and multitasking - thread life cycle - creating threads - synchronizing threads - inter-thread communication - daemon threads - thread groups. Generic programming - generic classes - generic methods - bounded types - restrictions and limitations.	9
V	EVENT DRIVEN PROGRAMMING	Graphics programming - Frame - Components - working with 2D shapes - using colour, fonts and images - Basics of event handling - event handlers - adapter classes - actions - mouse events - AWT event hierarchy - Introduction to Swing - layout management - Swing components.	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Cay S. Horstmann	Core Java, Volume I: Fundamentals	Pearson	13th Edition	2024

Course Outcome

CO	Course Outcome
CO1	Explain the principles of object-oriented programming and apply Java fundamentals such as classes, objects, constructors, abstraction, encapsulation, inheritance, and polymorphism.
CO2	Implement inheritance, abstract classes, final classes, interfaces, and interface extension mechanisms for object-oriented application development.

CO3	Apply exception handling and input/output mechanisms in Java for console-based and file-based applications.
CO4	Develop multithreaded and generic Java programs using thread life cycle, synchronization, inter-thread communication, generic classes, generic methods, and bounded types.
CO5	Design event-driven Java applications using AWT/Swing components, graphics programming, layout management, and event-handling mechanisms.

Course Code	Course Title		Credits
CS2701	Operating Systems + Lab		4
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION TO OPERATING SYSTEMS	Introduction: Computer system organization - Computer system architecture - Operating system operations, Operating system structures, Operating system services, System calls, System programs, Operating system structure, Operating system generation, System boot.	7
II	PROCESSES AND THREADS	Processes:Process concept, process scheduling, Operations on processes, Interprocess communication, Threads:Multicore programming, Multi threading models, Threading issues CPU, Scheduling: Basic concepts, Scheduling criteria, Scheduling algorithms, Thread scheduling, Multiple processor scheduling, Real-time CPU scheduling.	12
III	CONCURRENCY	Process Synchronization: Background, Critical section problem, Peterson's solution, Synchronization hardware, Mutex locks, Semaphores, Classic problems of synchronization, Monitors Deadlocks: System model, Deadlock characterization, Methods for handling deadlocks: Deadlock prevention, Deadlock avoidance, Deadlock detection, Recovery from deadlock.	10
IV	MEMORY MANAGEMENT	Main Memory: Background Swapping, Contiguous memory allocation, Segmentation Paging, Structure of the page table, Virtual Memory: Background, Demand paging, Copy-on-write, Page replacement, Allocation of frames, Thrashing, Memory-mapped files, Allocating kernel memory.	9
V	STORAGE MANAGEMENT	Mass-Storage Structure: Disk structure, Disk scheduling, Disk management, Swap-space management, I/O Systems: I/O hardware, Application I/O interface, Kernel I/O subsystem	7
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Silberschatz, A., Galvin, P.B. and Gagne, G.	Operating System Concepts	Wiley	10th ed.	2023
2	Kay A. Robbins and Steve Robbins	Unix Systems Programming: Communication, Concurrency, and Threads	Pearson Education	-	-

Course Outcome	
CO	**Course Outcome**
CO1	Understand the basic concepts, structure, and functions of operating systems.
CO2	Analyze process management concepts including processes, threads, and CPU scheduling algorithms.
CO3	Apply synchronization techniques and evaluate solutions to concurrency problems and deadlocks.
CO4	Understand and analyze memory management techniques such as paging, segmentation, and virtual memory.
CO5	Explain storage management concepts including disk scheduling, file systems, and I/O systems.

Course Code	**Course Title**		**Credits**
CS2007	Artificial Intelligence		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION	Introduction to Artificial Intelligence (AI): What is AI, foundations and history of AI, applications of AI. Intelligent Agents: agents and environments, concept of rationality, nature of environments and structure of agents.	9
II	PROBLEM SOLVING	Problem solving by classical searching: problem solving agents, uninformed search strategies, informed search strategies and heuristics in search. Beyond classical search: local search algorithms and optimization problems, searching with non-deterministic actions, searching with partial observations, adversarial search with alpha-beta pruning and constraint satisfaction problems.	9
III	KNOWLEDGE	Knowledge based logical agents: The Wumpus World, propositional logic, propositional theorem proving, agents based on propositional logic. First Order Logic: syntax and semantics, using first order logic, knowledge engineering in first order logic, unification and lifting, forward chaining and backward chaining.	9
IV	PLANNING AND REASONING	Planning: classical planning, components of a planning system, algorithms for planning as state-space search, hierarchical planning, multiagent planning and reactive systems. Reasoning: acting under uncertainty, representing knowledge in uncertain domains, semantics of Bayesian networks and rule-based methods.	9
V	EXPERT SYSTEMS	Expert Systems: representing and using domain knowledge, expert system shells, explanation, knowledge acquisition. Natural Language Processing: introduction, syntactic processing, semantic analysis, discourse and pragmatic processing, statistical NLP and spell checking.	9
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					

1	Stuart Russell and Peter Norvig	Artificial Intelligence - A Modern Approach	Pearson Education	Third Edition	2015
2	Elaine Rich and Kevin Knight	Artificial Intelligence	McGraw-Hill	Third Edition	2010
Reference Books					
1	G. Luger	Artificial Intelligence: Structures and Strategies for Complex Problem Solving	Pearson Education	Fourth Edition	2002
2	E. Charniak and D. McDermott	Introduction to Artificial Intelligence	Pearson Education	-	2008
3	Dan W. Patterson	Artificial Intelligence and Expert Systems	Prentice Hall	-	-

Course Outcome	
CO	**Course Outcome**
CO1	Identify and choose the appropriate representation for an AI problem or domain model.
CO2	Apply the most appropriate algorithm for search and reasoning within an AI problem domain.
CO3	Have a good knowledge of various learning techniques to solve AI problems.
CO4	Design, analyse and demonstrate AI applications or systems that apply to real life problems.

Course Code	**Course Title**		**Credits**
CS2009	Exploratory Data Analysis and Data Visualization		2
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	TOOLBOXES FOR DATA SCIENTISTS	Introduction to Python; Fundamental Python Libraries for Data Scientists: NumPy - SciPy - ScikitLearn - Pandas - Matplotlib; IDE; Data Manipulation with Python - Introduction to Single variable: Distribution Variables - Numerical Summaries of Level and Spread - Scaling and Standardizing	6
II	BASICS OF DATA VISUALIZATION	The Seven Stages of Visualizing Data - Different types of charts - Intro to tableau - Connections and Correlations - Scatterplot Maps - Trees, Hierarchies- Acquiring Data - Parsing Data - Calculated fields in tableau.	6
III	ADVANCE DATA VISUALIZATION	Visualizing Geographic Data - Creating dashboards, Story boards and Animations - Level of Detail (LoD) calculations - Dual Axis charts in tableau - time series visualization.	6
IV	MACHINE LEARNING	Supervised Learning: Introduction - kNN classifier; Regression analysis: Linear regression - Logistic regression; Unsupervised Learning : Introduction - Clustering; Evaluation metrics.	6
V	TIME SERIES, TEXT AND IMAGE EXPLORATION	Introduction to Time series -Algorithms for handling time series- Introduction to text processing - Regular Expressions - Basic text processing - Introduction to Image data exploration.	6
		Total Lecture hours:	**30**
Recommended Books			

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Reference Books					
1	McKinney, Wes. Python for data analysis: Data wrangling with Pandas, NumPy, and IPython	O'Reilly Media, Inc.	-	-	2012
2	Lorna Brown, Tableau Desktop Cookbook: Quick & Simple Recipes to Help You Navigate Tableau Desktop	O'Reilly Media, Inc.	-	-	2021
3	Müller, Andreas C., and Sarah Guido. Introduction to machine learning with Python: a guide for data scientists	O'Reilly Media, Inc.	-	-	2016
4	Nielsen	Aileen. Practical time series analysis: Prediction with statistics and machine learning. O'Reilly Media	-	-	2019

Course Outcome	
CO	**Course Outcome**
CO1	Apply Python and fundamental data science libraries such as NumPy, SciPy, Scikit-Learn, Pandas, and Matplotlib for data manipulation, scaling, standardization, and numerical summarization.
CO2	Explain the stages of data visualiization and create basic charts, scatterplots, maps, trees, hierarchies, and calculated fields using visualization tools such as Tableau.
CO3	Design advanced data visualizations using geographic data, dashboards, storyboards, animations, level-of-detail calculations, dual-axis charts, and time-series visualizations.
CO4	Implement basic supervised and unsupervised machine learning techniques such as kNN, linear regression, logistic regression, clustering, and evaluate models using suitable metrics.
CO5	Analyze time-series, text, and image data using basic algorithms, regular expressions, text-processing methods, and exploratory image-data techniques.

Course Code	Course Title		Credits
HS2001	Cognitive Psychology		2
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION	Introduction to Cognitive Psychology, History & Methods.	6
II	COGNITIVE METHODS	Cognitive Neuroscience & Methods: Vision, senses, attention, cognitive control.	6

III	MEMORY	Memory: Sensory Memory and STM, Working Memory, Encoding and Retrieval, Declarative Memory, Non-declarative Memory, Knowledge, Everyday Memory Errors.	6
IV	DECISION MAKING AND REASONING	Visual Imagery, Language, Decision making, Reasoning, Problem Solving & Creativity.	6
V	AGEING AND CONSCIOUSNESS	Development and Aging, Emotion and Motivation, Memories and holograms, Emotions in the brain, Theories of Consciousness.	6
		Total Lecture hours:	**30**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Goldstein, B.	Cognitive Psychology: Connecting Mind, Research and Everyday Experience	Wadsworth Cengage Learning	5th Edition	2018
Reference Books					
1	V. S. Ramachandran	Phantoms in the Brain	-	-	-
2	Joseph LeDoux	Emotional Brain	-	-	-
3	NPTEL	Demystifying the Brain	NPTEL	e-book	-

Course Outcome	
CO	**Course Outcome**
CO1	Understand the cognitive methods of human brain.
CO2	Different abstractions of memory.
CO3	Define the art of decision making.
CO4	Appreciate the theory of consciousness.

SEMESTER IV

Course Code	Course Title		Credits
CS2004	Design and Analysis of Algorithms		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION TO ANALYSIS OF ALGORITHMS	Review of Asymptotic Notation (O, Omega, Theta) - Growth rates, Computational Problems - Trivial upper and lower bounds of the problem - Analysis of non-recursive algorithms - Analysis of recursive algorithms - Solution to recurrence equations - Recursion tree method, repeated substitution method, substitution method, master method - Finding lower bound of problems - Sorting and searching.	9
II	ALGORITHM DESIGN PARADIGMS	Designing brute force algorithms for a problem - Basic algorithm design techniques - Incremental algorithm design, decrease and conquer, divide and conquer technique - Merge sort, Karatsuba multiplication, closest pair of points - Greedy algorithm design - 0/1 knapsack problem, Huffman codes, proof of correctness, interval scheduling problem - Dynamic programming design technique - Optimal substructure, 0/1 knapsack problem, longest common subsequence, matrix chain multiplication.	12
III	GRAPH ALGORITHMS	Analysis of graph algorithms - Graph problems - Shortest path - Dijkstra algorithm, Bellman-Ford algorithm, all-pairs shortest path - Floyd and Warshall algorithm - Network flow - Ford-Fulkerson method - Minimum spanning trees - Prim algorithm, Kruskal algorithm.	7
IV	SEARCH AND OPTIMIZATION TECHNIQUES	Exhaustive search algorithms - Backtracking: N-Queens, Sudoku, Constraint Satisfaction Problem - Branch and Bound: Job Assignment problem, TSP, 0/1 knapsack - Iterative refinement - Simplex for Linear Programming Problem.	9
V	DEALING WITH INTRACTABLE PROBLEMS	Introduction to Turing Machines - Decidability of problems - P and NP classes - NP-Complete problems - Reductions - Approximation algorithms (2-approximate algorithm) - Vertex Cover, Travelling Salesperson Problem - Randomized algorithms - Quicksort.	8
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Reference Books					
1	Kleinberg, J. and Tardos, E.	Algorithm Design	Pearson Education	-	2005
2	Dijkstra, E. W.	A note on two problems in connexion with graphs	Numerische Mathematik	Vol. 1	1959
3	Bellman, R.	Dynamic Programming	Princeton University Press	-	1957
4	Dantzig, G. B.	Linear Programming and Extensions	Princeton University Press	-	1963

Course Outcome	
CO	**Course Outcome**
CO1	Analyze the time and space complexity of algorithms using asymptotic notation.
CO2	To design and implement algorithms using basic algorithm design techniques for solving relevant computational problems.
CO3	Understand the basic principles and applications of state space search techniques.
CO4	Implement and analyze graph algorithms.
CO5	Understand the intractability and solve intractable problems using randomised and approximation algorithms.

Course Code	**Course Title**		**Credits**
CS2001T	Database Management Systems		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	CONCEPTUAL DATA MODELING	Database environment - Database system development lifecycle - Requirements collection - Database design - Entity-Relationship model - Enhanced-ER model - UML class diagrams.	8
II	RELATIONAL MODEL AND SQL	Relational model concepts - Integrity constraints - SQL Data manipulation - SQL Data definition - Views - SQL programming.	10
III	RELATIONAL DATABASE DESIGN AND NORMALIZATION	ER and EER-to-Relational mapping - Update anomalies - Functional dependencies - Inference rules - Minimal cover - Properties of relational decomposition - Normalization up to BCNF.	10
IV	TRANSACTIONS	Transaction Concepts - ACID Properties - Schedules - Serializability - Concurrency Control - Need for Concurrency - Locking Protocols - Two Phase Locking - Deadlock - Transaction Recovery - Save Points - Isolation Levels - SQL Facilities for Concurrency and Recovery.	9
V	NO-SQL DATABASES	No-SQL: CAP theorem - Document-based MongoDB data model and CRUD operations - Column-based Hbase data model and CRUD operations.	8
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Abraham Silberschatz, Henry F. Korth and S. Sudharshan	Database System Concepts	Tata McGraw Hill	Sixth Edition	2011
Reference Books					

1	Ramez Elmasri and Shamkant B. Navathe	Fundamentals of Database Systems	Pearson	Sixth Edition	2011
2	C. J. Date, A. Kannan and S. Swamynathan	An Introduction to Database Systems	Pearson Education	Eighth Edition	2006
3	Raghu Ramakrishnan	Database Management Systems	McGraw-Hill College Publications	Fourth Edition	2015
4	G. K. Gupta	Database Management Systems	Tata McGraw Hill	-	2011

Course Outcome	
CO	**Course Outcome**
CO1	Classify the modern and futuristic database applications based on size and complexity.
CO2	Map ER model to relational model to perform database design effectively.
CO3	Write queries using normalization criteria and optimize queries.
CO4	Compare and contrast various indexing strategies in different database systems.
CO5	Appraise how advanced databases differ from traditional databases.

Course Code	Course Title		Credits
MA2002	Statistical Inference		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	THEORY OF ESTIMATION	Characteristics of Estimates - Unbiased Estimators - Method of Maximum likelihood Estimation - Method of Moments - Method of Least Squares.	9
II	LARGE SAMPLE THEORY	Sampling distributions - Estimation of parameters - interval estimation - Statistical hypothesis - Large sample tests based on Normal distribution for proportion, mean.	9
III	SMALL SAMPLE THEORY	Tests based on t-distribution, confidence interval - Chi-square and F-distributions for mean, variance - Contingency table (test for independent) - Goodness of fit - Implementation in Excel.	9
IV	DESIGN OF EXPERIMENTS	One way and Two-way classifications - Completely randomized design - Randomized block design - Latin square design	9
V	NON-PARAMETRIC METHODS	Introduction - The sign test for paired data - The Mann-Whitney U test - Kruskal-Wallis test - The one-sample runs test - Rank correlation - Advantage of rank correlation - The Kolmogorov-Smirnov test.	9
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					

1	Gupta, S.C. and Kapoor, V.K.	Fundamentals of Mathematical Statistics	Sultan Chand and Sons	11th Edn. (Reprint)	2007
Suggested Readings					
1	Anderson, Sweeney and Williams	Statistics for Students of Economics and Business	Cengage Learning	-	-
2	Levin, Richard, David S. Rubin, Sanjay Rastogi and H. M. Siddiqui	Statistics for Management	Pearson Education	-	-
3	Murray R. Spiegel, Larry J. Stephens and Narinder Kumar	Statistics (Schaum's Outline Series)	McGraw Hill Education	-	-
4	Gupta, S.C.	Fundamentals of Statistics	Himalaya Publishing House	-	-

Course Outcome	
CO	**Course Outcome**
CO1	Apply appropriate estimation methods, including maximum likelihood, moments, and least squares, to estimate population parameters.
CO2	Perform interval estimation and large-sample hypothesis tests for population means and proportions using the normal distribution.
CO3	Analyse small-sample data using *t*, chi-square, and *F* distributions, and implement statistical tests using spreadsheet tools such as Excel.
CO4	Design and analyse experiments using one-way and two-way classifications, completely randomized design, randomized block design, and Latin square design.
CO5	Apply suitable non-parametric tests and rank-based methods to analyse data when parametric assumptions are not satisfied.

Course Code	**Course Title**		**Credits**
CS2012	Machine Learning Techniques		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	TYPES OF LEARNING	Types of learning: Supervised learning vs Unsupervised learning, Capacity - Overfitting and Underfitting - Hyperparameters and Validation Sets - Bias and Variance. Dimension reduction - PCA, Naive Bayes, Decision tree. Linear Regression.	9
II	GAUSSIAN MODELS AND DISCRIMINANT FUNCTIONS	Gaussian Models - Continuous inputs - Maximum Likelihood Estimation - Gaussian Mixture models - Expectation-maximisation for Gaussian mixtures, applications of GMM. Discriminant Functions - Two classes - Multiple classes - Least squares for classification - Fisher linear discriminant - Fisher discriminant for multiple classes.	9

III	DISCRIMINATIVE MODELS	Sparse Kernel Machines: Maximum Margin Classifiers - Support Vector Machine, Overlapping class distributions - Soft margin SVM, Multiclass SVM, Support vector regression.	9
IV	NEURAL NETWORKS	The perceptron algorithm. Neural Networks: Feed-forward Network Functions - Network Training - Parameter optimization - Use of gradient information - Gradient descent optimization - Error Backpropagation - A simple example.	9
V	OPTIMIZATION AND REGULARIZATION	Stochastic Gradient Descent optimization, Challenges in Optimization, SGD with Momentum, Parameter Initializations, Adaptive Learning rates. Regularization: Parameter norm penalty, dataset augmentation, noise robustness, semi-supervised learning, multi-task learning, early stopping, parameter tying and parameter sharing, sparse representations, bagging and other ensemble methods, dropout.	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Christopher M. Bishop	*Pattern Recognition and Machine Learning*	Springer	First Edition	2006
2	Ian Goodfellow, Yoshua Bengio and Aaron Courville	*Deep Learning*	MIT Press	First Edition	2016

Course Outcome

CO	Course Outcome
CO1	Explain different machine-learning paradigms and analyse model performance in terms of capacity, overfitting, underfitting, bias and variance.
CO2	Apply regression, dimensionality-reduction and classification techniques to solve machine-learning problems.
CO3	Develop probabilistic learning models using Gaussian distributions, maximum-likelihood estimation, Gaussian mixture models and discriminant functions.
CO4	Apply support vector machines and kernel-based methods to classification and regression problems.
CO5	Design and train neural-network models using backpropagation, optimization and regularization techniques.

Course Code	Course Title		Credits
CS2010	Data Mining		1
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION TO DATA MINING	Data Mining: Definition and Need-Knowledge Discovery in Databases (KDD)-Types of Data and Attributes-Data Mining Applications-Data Mining Tools Overview.	7

II	DATA PREPROCESSING AND CORE DATA MINING TECHNIQUES	Data Cleaning-Handling Missing Values-Data Transformation-Data Reduction-Data Normalization- Classification: Decision Trees-Naïve Bayes (Concepts) Clustering:k-Means Clustering-Association Rule Mining: Apriori Algorithm	8
		Total Lecture hours:	**15**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Jiawei Han and Micheline Kamber	Data Mining Concepts and Techniques	Elsevier	Third Edition	2012
Reference Books					
1	Alex Berson and Stephen J. Smith	Data Warehousing, Data Mining & OLAP	Tata McGraw-Hill	35th Reprint	2016
2	K. P. Soman, Shyam Diwakar and V. Ajay	Insight into Data Mining Theory and Practice	Prentice Hall of India	Eastern Economy Edition	2006
3	Ian H. Witten and Eibe Frank	Data Mining: Practical Machine Learning Tools and Techniques	Elsevier	Second Edition	-

Course Outcome	
CO	**Course Outcome**
CO1	Explain basic concepts of data mining algorithms.
CO2	Preprocess datasets for analysis.

SEMESTER V

Course Code	Course Title		Credits
MA3001	Optimization Techniques		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	MODULE I LINEAR PROGRAMMING PROBLEMS	General Mathematical Formulation of LPP - Graphical Methods to Solve LPP - Some Exceptional Cases - Simplex Method - The Simplex Algorithm - Big M Method - Variants of Simplex Method.	14
II	MODULE II TRANSPORTATION & ASSIGNMENT PROBLEM	Transportation Problems - Initial Solution by Northwest Corner Rule, Least Cost Method, Vogel's Approximation Method, Modified Distribution Method - Assignment Problems.	10
III	MODULE III NETWORK SCHEDULING	Project Network - Diagram Representation - Floats - Critical Path Method (CPM) - PERT.	10
IV	MODULE IV QUEUEING MODELS	Introduction, Queuing Theory, Operating characteristics of a Queuing system, Constituents of a Queuing system - Markovian queues - Little's formula - Single and multiple server queueing models - Queues with finite waiting rooms.	11
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Hamdy A Taha	Introduction to Operations Research	Prentice Hall India, 9th Edition, Third Indian Reprint	-	2010
Reference Books					
1	Kanti Swarup	P.K. Gupta	Man Mohan, Operations Research, Sultan Chand Sons, New Delhi, . J. K. Sharma, Operations Research Theory and applications, Macmillan, 5th Edition, . Hiller F.S, Liberman G.J, Introduction to Operations Research, 9th Edition Mc Graw Hill Inc., . Jit. S. Chandran, Mahendran P. Kawatra, Ki Ho Kim, Essentials of Linear	-	2004

			Programming, Vikas Publishing House Pvt. Ltd. New Delhi, . Philip D.T. and Ravindran A., Operations Research, John Wiley		

Course Outcome	
CO	**Course Outcome**
CO1	Formulate real-world decision-making problems as linear programming models and solve them using graphical methods.
CO2	Apply the simplex method, Big M method, and suitable simplex variants to solve linear programming problems, including exceptional cases.
CO3	Solve transportation and assignment problems using appropriate initial-solution and optimality-testing methods.
CO4	Construct project networks and apply CPM and PERT techniques to determine critical paths, floats, and project completion times.
CO5	Analyse single-server, multi-server, and finite-capacity queueing systems using Markovian models, operating characteristics, and Little's formula.

Course Code	**Course Title**		**Credits**
CS3005	Web Technologies		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	WEB SITE BASICS	Web Essentials: Introduction to HTML, CSS, JavaScript - Data types, Arrays, Functions, Other built-in objects. DOM - Document tree traversal and manipulations, Event handling. Introduction to AJAX - Request, Response.	
II	CLIENT-SIDE PROGRAMMING	Frontend Development: React JS/ React Overview, Model-View-Controller (MVC) Architecture, Introduction to ECMAScript6 (ES6), Virtual DOM, Javascript with XML (JSX), Components - Functional Component, Exporting and Importing Components, States, Props, Hooks - useState, useEffect, React Routing, React Bootstrap.	
III	SERVER-SIDE SCRIPTING	Backend Development: Introduction Node.js (LTS) - Modules, HTTP Module, File System, Node Package Manager (NPM), URL, Structured Data: MySQL, and Unstructured Data: MongoDB - Connecting, Creating, and Manipulating Databases, Express.	
IV	WEB SERVICES, API AND FSD	Introduction- SOAP, REST, SOAP Architecture, REST: Architecture, Requests and Responses, RESTful APIs, OData, Micro services Full Stack Development (FSD): MERN Stack.	
V	VERSION CONTROL AND DEPLOYMENT	Introduction to Version Control (GIT/GITHUB), APIs Security - Designing, Creating, Testing and Validating RESTful APIs, Introduction to Postman for API testing, Public Hosting, Project Deployment and Maintenance.	
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Paul J. Deitel, Harvey M. Deitel and Abbey Deitel	Internet & World Wide Web: How to Program	Pearson	Fifth Edition	2012
2	Brad Dayley, Brendan Dayley and Caleb Dayley	Node.js, MongoDB and Angular Web Development: The definitive guide to using the MEAN stack to build web applications	Pearson Education	Second Edition	2017
Reference Books					
1	Mark Pilgrim	HTML5: Up and Running	O'Reilly	-	2010
2	Brad Dayley, Brendan Dayley and Caleb Dayley	Learning Angular: A Hands-On Guide to Angular 2 and Angular 4	Addison-Wesley Professional	Second Edition	2018
3	Evan Hahn	Express in Action: Node applications with Express and its companion tools	Manning Publications	First Edition	2015
4	Kristina Chodorow	MongoDB: The Definitive Guide - Powerful and Scalable Data Storage	O'Reilly	Second Edition	2013
5	Subbu Allamaraju	RESTful Web Services Cookbook	O'Reilly	First Edition	2010

Course Outcome	
CO	**Course Outcome**
CO1	Course Statement Analyze and Build Dynamic Websites with HTML, CSS,.
CO2	Javascript, AJAX. Analyze and Build Single Page Applications using React for.
CO3	Front-End Application Development.
CO4	Analyze and Build Node.js and Express for Back-End.
CO5	Unstructured Data. Analyze and Build MERN Stack for Full Stack Applications with.
CO6	Apply Version Control using Git along with Project.
CO7	Deployment and Maintenance.

Course Code	**Course Title**		**Credits**
CS2702	Computer Networks + Lab		4
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION AND PHYSICAL LAYER	Networks - Network Types - Protocol Layering - TCP/IP Protocol suite - OSI Model - Physical Layer: Performance - Transmission media - Switching - Circuit-switched Networks - Packet Switching.	9

II	DATA-LINK LAYER & MEDIA ACCESS	Introduction - Link-Layer Addressing - DLC Services - Data-Link Layer Protocols - HDLC - PPP - Media Access Control - Wired LANs: Ethernet - Wireless LANs - Introduction - IEEE 802.11, Bluetooth - Connecting Devices.	9
III	NETWORK LAYER	Network Layer Services - Packet switching - Performance - IPV4 Addresses - Forwarding of IP Packets - Network Layer Protocols: IP, ICMP v4 - Unicast Routing Algorithms - Protocols - Multicasting Basics - IPV6 Addressing - IPV6 Protocol.	9
IV	TRANSPORT LAYER	Introduction - Transport Layer Protocols - Services - Port Numbers - User Datagram Protocol - Transmission Control Protocol - SCTP.	9
V	APPLICATION LAYER	WWW and HTTP - FTP - Email - Telnet - SSH - DNS - SNMP.	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Behrouz A. Forouzan	Data Communications and Networking	TMH	Fifth Edition	2013
2	Larry L. Peterson and Bruce S. Davie	Computer Networks: A Systems Approach	Morgan Kaufmann Publishers Inc.	Fifth Edition	2012
Reference Books					
1	James F. Kurose and Keith W. Ross	Computer Networking: A Top-Down Approach	Pearson Education	Seventh Edition	2017
2	William Stallings	Data and Computer Communications	Pearson Education	Tenth Edition	2013
3	Nader F. Mir	Computer and Communication Networks	Prentice Hall	Second Edition	2014
4	Ying-Dar Lin, Ren-Hung Hwang and Fred Baker	Computer Networks: An Open Source Approach	McGraw Hill Publisher	-	2011

Course Outcome

CO	Course Outcome
CO1	Comprehend the basic layers and its functions in computer networks.
CO2	Evaluate the performance of a network.
CO3	Understand the basics of how data flows from one node to another.
CO4	Analyze and design routing algorithms.
CO5	Design protocols for various functions in the network.
CO6	Understand the working of various application layer protocols.

Course Code	Course Title	Credits
CS3007	Deep Learning	3

Module #	Module Title	Module Content	Lecture Hours
I	REVISITING NEURAL NETWORKS	Revisiting Neural Networks: Basic Architecture - Training a neural network - Practical issues. Backpropagation - Algorithm, example for weight update. Optimization in deep models: challenges in optimization, vanishing and exploding gradients, gradient descent, stochastic gradient descent strategies, momentum, parameter initialization, adaptive learning rates, regularization for deep models.	10
II	CONVOLUTIONAL NEURAL NETWORKS	Convolutional Neural Networks: convolution operation, understanding hyperparameters, pooling, feature maps and parameters, variants of convolution operations: dilated convolution and transpose convolution, applications, case studies of ConvNets: LeNet, AlexNet, VGGNet, GoogleNet and ResNet.	10
III	RECURRENT NEURAL NETWORKS	Recurrent Neural Networks: Architecture, variants, back propagation through time, challenges, Long Short-term memory, Gated Recurrent Units, applications: video understanding using CNN and RNN, sequence to sequence learning.	8
IV	ATTENTION MODELS	Attention Models: Embedding, Attention for temporal data and spatial data, hard and soft attention, image captioning with attention, Transformers, self attention, multi-head attention, positional encoding, overall transformer architecture, applications in object detection and image recognition.	7
V	AUTOENCODERS AND GENERATIVE ADVERSARIAL NETWORKS	Autoencoders: Introduction, exploring autoencoders, convolutional autoencoders, denoising, variational autoencoders, exploring VAE. Generative Adversarial Networks: forging with neural networks, training and optimization, GANs in action, applications and evaluation metrics.	10
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Reference Books					
1	Ian Goodfellow, Yoshua Bengio and Aaron Courville	Deep Learning	The MIT Press	-	2016
2	Charu C. Aggarwal	Neural Networks and Deep Learning: A Textbook	Springer	-	2018
3	Aston Zhang, Zachary C. Lipton, Mu Li and Alexander J. Smola	Dive into Deep Learning	-	Release 1.0.3	2023

4	Andrew Glassner	Deep Learning: A Visual Approach	No Starch Press	-	2021
5	Amit Kumar Das, Saptarsi Goswami, Pabitra Mitra and Amlan Chakrabarti	Deep Learning	Pearson	-	2021
Online Materials					
1	NPTEL	Deep Learning - Course 106106184	https://nptel.ac.in/courses/106/106/106106184/	-	-
2	NPTEL	Deep Learning - Course 106105215	https://nptel.ac.in/courses/106/105/106105215/	-	-

Course Outcome	
CO	**Course Outcome**
CO1	Articulate the basic terminologies related to deep learning and deep models.
CO2	Appreciate the advantages of CNN over DNN and apply to other computer vision tasks.
CO3	Design a variant of CNN for a given computer vision task.
CO4	Illustrate the use of RNN, LSTM and GRU for sequential modelling tasks.
CO5	Do dimensionality reduction using autoencoders.
CO6	Generate new samples using adversarial networks.

Course Code	**Course Title**		**Credits**
BM3003	Principles of Management		2
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION TO MANAGEMENT AND ORGANIZATIONS	Definition of Management - Science or Art - Manager Vs Entrepreneur- types of managers - managerial roles and skills - Evolution of Management -Scientific, human relations, system and contingency approaches- Types of Business organization- Sole proprietorship, partnership, company-public and private sector enterprises- Organization culture and Environment - Current trends and issues in Management.	9
II	PLANNING	Nature and purpose of planning - Planning process - Types of planning - Objectives - Setting objectives - Policies - Planning premises - Strategic Management - Planning Tools and Techniques - Decision making steps and process.	9
III	ORGANISING	Nature and purpose - Formal and informal organization - Organization chart - Organization structure - Types - Line and staff authority - Departmentalization - delegation of authority - Centralization and decentralization - Job Design - Human Resource Management - HR Planning, Recruitment, selection, Training and Development, Performance Management, Career planning and management.	9

IV	DIRECTING	Foundations of individual and group behaviour - Motivation theories - Motivational techniques - Job satisfaction - Job enrichment - Leadership - types and theories of leadership - Communication - Process of communication - Barrier in communication - Effective communication - Communication and IT.	9
V	CONTROLLING	System and process of controlling - Budgetary and non - Budgetary control techniques - Use of computers and IT in Management control - Productivity problems and management - Control and performance - Direct and preventive control - Reporting.	9
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Harold Koontz and Heinz Weihrich	Essentials of Management	Tata McGraw Hill	-	1998
2	Stephen P. Robbins and Mary Coulter	Management	Prentice Hall (India) Pvt. Ltd.	10th Edition	2009
Reference Books					
1	Robert Kreitner and Mamata Mohapatra	Management	Biztantra	-	2008
2	Stephen A. Robbins, David A. Decenzo and Mary Coulter	Fundamentals of Management	Pearson Education	7th Edition	2011
3	Tripathy P. C. and Reddy P. N.	Principles of Management	Tata McGraw Hill	-	1999

Course Outcome	
CO	**Course Outcome**
CO1	Upon completion of the course, students will be able to have clear understanding of managerial functions like planning, organizing, staffing, leading & controlling.
CO2	Have same basic knowledge on international aspect of management.
CO3	Ability to understand management concept of organizing.
CO4	Ability to understand management concept of directing.
CO5	Ability to understand management concept of controlling.

Course Code	**Course Title**		**Credits**
CS3011	Introduction to Robotics		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**

I	ROBOTIC PRELIMINARIES & HOMOGENEOUS TRANFORMATION	Robot classifications - Robot anatomy - DoF, Arm Configurations - Workspace, volume - Manipulation & Control. Mathematical representation: Coordinate frames - Position and orientation - Mapping between frames - Homogeneous transformation. Fundamental rotation matrices - Fixed axis, Euler angle, Equivalent angle axis. - Robotic Toolbox Implementation - frame rotation, translation, Euler and RPY angles	9
II	FORWARD & INVERSE KINEMATICS	Description of Various joints and Links, Kinematic Modelling - Representation using the Denavit Hattenberg parameters - Direct kinematics- manipulator transformation matrices of 2-DoF, 3-DoF with both revolute and prismatic joints. Inverse Kinematics - SCARA robots- Solvability - Solution Methods - Trigonometric and algebraic methods. - Robotic Toolbox Manipulators with prismatic and revolute Joints - Forward and Inverse Kinematics - RRP, RPR, RPP	9
III	VELOCITY KINEMATICS & STATICS	Linear and angular velocities-Manipulator Jacobian- Velocity propagation along links, Jacobian Matrix for Prismatic and rotary joints- Inverse -Wrist and arm singularity - Static analysis - Force and toque computation. - Robotic Toolbox - Modelling of velocity components of a Manipulator.	9
IV	TRAJECTORY PLANNING	Definition- Path & Trajectory, Joint space technique - Polynomial Approximations with and without via points - Cubic - Quintic - Interpolation Methods - Linear Functions with Parabolic Blends - Position, Velocity and Acceleration profiles, Cartesian space technique - Parametric descriptions - Straight line and circular paths - Position and orientation planning. - Robotic Toolbox - Function approximations in parabolic and trapezoidal trajectory planning.	9
V	ROBOTICS VISION & MANIPULATOR CONTROL	Various kinds of sensor- Robotic Vision and Industrial Applications - Image representation & Resolution - Image Processing - Segmentation methods - thresholding, region based, edge based; Dynamic model & Manipulator control problem-Linear control schemes-PID control scheme and force control. - Implementation of algorithms on Image Segmentation & Basic control mechanism. Total(45L) =45 Periods	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	R. K. Mittal and I. J. Nagrath	Robotics and Control	Tata McGraw Hill, New Delhi	4th Reprint	2005
2	John J. Craig	Introduction to Robotics Mechanics and Control	Pearson Education	Third Edition	2009
3	P. I. Corke	Robotics, Vision and Control	Springer	-	2017
Reference Books					

1	Kevin M. Lynch and Frank C. Park	Modern Robotics: Mechanics, Planning, and Control	Cambridge University Press	-	2017
2	Robert J. Schilling	Fundamentals of Robotics	Prentice Hall India	-	2009
3	NPTEL	Introduction to Robotics	https://onlinecourses.nptel.ac.in/noc22_de11/preview	-	-

Course Outcome	
CO	**Course Outcome**
CO1	Upon completion of this course, the students will be able to:.
CO2	Bloom's Taxonomy Understand basic concepts and homogeneous transformation.
CO3	Analyse forward and inverse kinematics of manipulators.
CO4	Analyse the differential motion of manipulator and effect of static forces.
CO5	Understand the various trajectory planning techniques.
CO6	Analyse algorithms in robotic vision and manipulator control methods.

Course Code	Course Title		Credits
CS3009	Introduction to Digital Signal Processing		1
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION TO SIGNALS AND SYSTEMS	Classification of signals - Concept of frequency in continuous-time and discrete-time signals - Sampling theorem - Discrete-time signals and systems - Response of LTI systems to arbitrary inputs (convolution sum) - Correlation: cross-correlation and autocorrelation sequences, correlation of periodic sequences.	8
II	THE DISCRETE FOURIER TRANSFORM	Introduction of Z-Transform - Introduction to frequency analysis of discrete-time signals - Discrete Fourier Transform - DFT as a linear transformation - properties of DFT - DFT in linear filtering - Time and frequency resolution - Radix-2 FFT algorithms - decimation-in-time FFT.	7
		Total Lecture hours:	**15**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	John G. Proakis and Dimitris G. Manolakis	Digital Signal Processing - Principles, Algorithms, and Applications	Pearson	Fourth Edition	-
Reference Books					
1	Alan V. Oppenheim and Ronald W. Schafer	Discrete-time Signal Processing	Pearson	Third Edition	-

2	Sanjit K. Mitra	Digital Signal Processing - A Computer-based Approach	Tata McGraw-Hill	Third Edition	-
3	Lawrence R. Rabiner and Ronald W. Schafer	Digital Processing of Speech Signals	Pearson	-	-
4	Richard G. Lyons	Understanding Digital Signal Processing	Pearson Education	Second Edition	2005

Course Outcome	
CO	**Course Outcome**
CO1	Define various types of discrete-time signals and systems, and perform the basic operations on a given digital signal.
CO2	Estimate the frequency content of a given signal using discrete Fourier transform and appreciate time versus frequency resolution issues.

SEMESTER VI

Course Code	Course Title		Credits
CS3008	Image and Video Processing		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	INTRODUCTION	Image Processing, Computer Vision, low-level, mid-level and high-level vision; fundamentals of image formation and transformations: orthogonal, Euclidean, affine, projective, Fourier transform; convolution and filtering; image enhancement, restoration and histogram processing.	9
II	FEATURE EXTRACTION AND FEATURE SEGMENTATION	Feature extraction - edges: Canny, LOG, DOG; line detectors (Hough Transform), corners: Harris and Hessian Affine, orientation histogram, SIFT, SURF, HOG, GLOH, scale-space analysis, image pyramids and Gaussian derivative filters, Gabor filters and DWT. Image segmentation - region growing, edge based and other methods.	9
III	IMAGES, HISTOGRAMS, BINARY VISION	Simple pinhole camera model - Sampling - Quantisation - Colour images - Noise - Smoothing - 1D and 3D histograms - Histogram/Image equalisation - Histogram comparison - Back-projection - k-means clustering - Thresholding and threshold detection methods - Mathematical morphology.	9
IV	3D VISION AND MOTION	Methods for 3D vision - projection schemes - shape from shading - photometric stereo - shape from texture - shape from focus - active range finding - surface representations - point-based representation - volumetric representations - 3D object recognition - 3D reconstruction - introduction to motion.	9
V	APPLICATIONS	Overview of diverse computer vision applications: document image analysis, biometrics, object recognition, tracking, medical image analysis, content-based image retrieval, video data processing, virtual reality and augmented reality.	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	D. A. Forsyth and J. Ponce	Computer Vision: A Modern Approach	Pearson Education	-	2003
2	Richard Szeliski	Computer Vision: Algorithms and Applications	Springer Verlag London Limited	-	2011
Reference Books					
1	B. K. P. Horn	Robot Vision	McGraw-Hill	-	-
2	Simon J. D. Prince	Computer Vision: Models, Learning, and Inference	Cambridge University Press	-	2012
3	Mark Nixon and Alberto S. Aquado	Feature Extraction & Image Processing for Computer Vision	Academic Press	Third Edition	2012

4	E. R. Davies	Computer & Machine Vision	Academic Press	Fourth Edition	2012
5	Reinhard Klette	Concise Computer Vision: An Introduction into Theory and Algorithms	-	-	2014

Course Outcome	
CO	**Course Outcome**
CO1	Explain low level processing of image and transformation techniques applied to images.
CO2	Explain the feature extraction, segmentation and object recognition methods.
CO3	Apply Histogram transform for detection of geometric shapes like line, ellipse and objects.
CO4	Illustrate 3D vision process and motion estimation techniques.
CO5	Apply vision techniques to real time applications.

Course Code	**Course Title**		**Credits**
CS3012	Natural Language Processing		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	OVERVIEW AND LANGUAGE MODELING	Origins and challenges of NLP - Knowledge in language processing - NLP tasks - NLP applications - Regular expressions, text normalization, edit distance - tokenization - stemmer - Language Modeling: language and grammar, grammar-based language models, statistical language models, N-gram models and smoothing.	9
II	SEMANTIC EMBEDDINGS	Semantic Analysis: meaning structure of language, slot-filler representation, lexical semantics - Vector semantics - words and vectors - similarity measures - TF-IDF and PMI - word2vec - visualizing embeddings - analysis of embeddings.	9
III	SEQUENCE LABELLING AND WORD SENSES	Word classes - PoS tagging - named entities - named entity tagging - HMM-based PoS tagging - conditional random fields - evaluation of NER - word senses - WordNet - word sense disambiguation - improved embeddings - word sense induction.	9
IV	PARSING TECHNIQUES	Constituency grammars - context-free grammars - treebanks - normal forms - lexicalized grammars - constituency parsing - ambiguity - CKY parsing - span-based neural constituency parsing - evaluating parsers - CCG parsing - dependency parsing and dependency relations.	9
V	LOGICAL REPRESENTATIONS AND SEMANTIC ROLE LABELLING	Computational desiderata for representations - model-theoretic semantics - first-order logic - event and state representations - description logics - semantic roles - diathesis alternations - thematic roles - proposition bank - FrameNet - SRL task - selectional restrictions.	9
		Total Lecture hours:	**45**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					

1	Daniel Jurafsky and James H. Martin	Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition	-	Third Edition	2022
Reference Books					
1	Christopher D. Manning and Hinrich Schutze	Foundations of Statistical Natural Language Processing	MIT Press	-	1999
2	Nitin Indurkhya and Fred J. Damerau	Handbook of Natural Language Processing	CRC Press	Second Edition	2010
3	Tanveer Siddiqui and Tiwary U. S.	Natural Language Processing and Information Retrieval	Oxford University Press	-	2008
4	NLTK	Natural Language Tool Kit	http://www.nltk.org/	-	-
5	Steven Bird, Ewan Klein and Edward Loper	Natural Language Processing with Python	-	-	-
6	Dipanjan Sarkar	Text Analytics with Python: A Practical Real-World Approach to Gaining Actionable Insights from Your Data	APress	-	-

Course Outcome	
CO	**Course Outcome**
CO1	Build and apply language models for NLP tasks.
CO2	Build and apply word embeddings for NLP tasks.
CO3	Implement basic NLP tasks such as PoS tagging, named entity recognition, and word sense disambiguation.
CO4	Implement and use different parsing techniques for natural languages.
CO5	Perform semantic role labelling.

Course Code	**Course Title**		**Credits**
CS3010	Introduction to Speech Signal Processing		1
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	TIME-DOMAIN MODELS FOR SPEECH PROCESSING	Time-dependent processing of speech, Short-Time Energy and Average Magnitude, Short- Time Average Zero Crossing Rate, Speech vs. Silence Discrimination using Energy and Zero-Crossings. Short-Time Autocorrelation Function, Pitch Period Estimation using autocorrelation function.	5
II	SHORT-TERM FOURIER ANALYSIS OF SPEECH	Fourier transform Interpretation, Linear Filtering Interpretation, Spectrographic Displays, Harmonic Product Spectrum-based Pitch Estimation technique.	5

III	SPECTRAL FEATURES	Cepstrum: Definition - Computation of cepstrum - Formant and pitch estimation - Computation of mel-frequency cepstral coefficients, Linear predictive analysis: Basic principle - Pitch estimation using linear prediction error signal - Computation of LPCC.	5
		Total Lecture hours:	**15**

Recommended Books					
Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Text Books					
1	Lawrence R. Rabiner and Ronald W. Schafer	Digital Processing of Speech Signals	Prentice Hall	-	1978
2	Thomas F. Quatieri	Discrete-time Speech Signal Processing: Principles and Practice	Pearson Education India	-	2006
3	John G. Proakis and Dimitris G. Manolakis	Digital Signal Processing: Principles, Algorithms, and Applications	Pearson Education India	4th Edition	2007

Course Outcome	
CO	**Course Outcome**
CO1	Explain the usefulness of digital signal processing fundamentals in building speech- based systems.
CO2	Compare the time and frequency-domain parameters, and know how to compute / estimate those parameters.
CO3	Outline the relevant features that can be extracted from a given speech signal, and in what way the features are relevant to build speech-based systems.

SEMESTER VII

Course Code	Course Title	Credits
CS4007	Big Data Analytics	3

Module #	Module Title	Module Content	Lecture Hours
I	INTRODUCTION TO BIG DATA	Definition and characteristics of Big Data (Volume, Velocity, Variety, Veracity, Value) - Big Data challenges and opportunities - Overview of big data applications in various industries- Hadoop Ecosystem - Introduction to Hadoop and HDFS - Hadoop architecture and components - Installation and configuration of Hadoop	9
II	INTRODUCTION TO CLOUD COMPUTING WITH AWS	Introduction to Cloud: Classical On-prem Physical Data Center - Development on Virtualization - Classical On-prem Virtual Data Center - Cloud Computing Data Center - Amazon Web Services (AWS) - AWS Global Infrastructure - AWS Regions & Availability Zones - Amazon Elastic Compute Cloud (EC2) - Amazon Machine Image (AMI) - VPC Components - NAT Devices, NAT Gateway and NAT instance - Elastic Load Balancer (ELB) - Route 53 - Simple Storage Service - Relational Database Services	9
III	HADOOP DISTRIBUTED FILE SYSTEM (HDFS)	HDFS architecture and components - HDFS commands and operations - Data replication and fault tolerance - Setting up HDFS and basic operations - MapReduce Programming - Understanding MapReduce - Writing MapReduce programs - anatomy of MapReduce job run - classic Map-reduce - YARN - failures in classic Map-reduce and YARN	9
IV	INTRODUCTION TO APACHE SPARK	Overview of Spark and its ecosystem - Spark vs. Hadoop MapReduce - Setting up Spark environment - RDDs (Resilient Distributed Datasets) and DataFrames - Spark Core and Spark SQL - Spark Core concepts - Transformations and actions in Spark - Introduction to Spark SQL - Advanced Spark Programming - Spark streaming - Machine learning with Spark MLlib	9
V	ADVANCED BIG DATA TOOLS	Introduction to Apache Hive - Overview of Hive - Hive architecture and components - HiveQL (Hive Query Language) - Hive optimization techniques - Partitioning and bucketing in Hive - Streaming analytics - Apache Kafka -Distributed data processing platforms: Docker (orchestration).	9
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	Author(s)	Title	Publisher	Edition	Year
Text Books					
1	Viktor Mayer-Schonberger and Kenneth Cukier	Big Data: A Revolution That Will Transform How We Live, Work, and Think	Houghton Mifflin Harcourt	-	2013

Course Outcome

CO	Course Outcome

CO1	Explain the characteristics, challenges, applications, and ecosystem of Big Data, and configure a basic Hadoop environment.
CO2	Apply AWS cloud services, including EC2, S3, VPC, ELB, Route 53, and RDS, to design scalable cloud-based data solutions.
CO3	Perform distributed data storage and processing using HDFS, MapReduce, and YARN, considering replication, fault tolerance, and job execution.
CO4	Develop large-scale data-processing applications using Apache Spark, RDDs, DataFrames, Spark SQL, Streaming, and MLlib.
CO5	Implement advanced big-data solutions using Apache Hive, Kafka, and Docker for distributed querying, streaming analytics, and application deployment.

Course Code	**Course Title**		**Credits**
CS4009	Speech Technology		3
Module #	**Module Title**	**Module Content**	**Lecture Hours**
I	AUTOMATIC SPEECH RECOGNITION	Introduction. Hidden Markov models (HMM): Discrete-time Markov process - Extensions to HMM - Three basic problems of HMM -Types of HMM, Large vocabulary speech recognition: Context-dependent subword units - Language models. Deep neural network (DNN) acoustic modelling. HMM-DNN systems.	9
II	SPEAKER RECOGNITION	Verification vs Recognition - Recognition techniques - Distinguishing features - System design, Language and Accent identification, Speaker recognition by humans, GMM-based speaker identification system - a case study. TEXT-TO-SPEECH SYNTHESIS 9 Text to Speech (TTS): Overview. Text normalization. Letter-to-sound. Prosody. Data collection. Evaluation. Concatenative and parametric approaches. End-to-end speech synthesis.	9
III	LABORATORY	Speech data collection and preparation Feature extraction Build a small vocabulary speech recognition system Build a speaker identification/verification system Build a language identification system Build a text-to-speech synthesizer (concatenative, HMM-based, Neural-based)	18
		Total Lecture hours:	**45**

Recommended Books

Sl. No.	**Author(s)**	**Title**	**Publisher**	**Edition**	**Year**
Reference Books					
1	Thomas F. Quatieri	Discrete-Time Speech Signal Processing - Principles and Practice	Pearson Education	-	2006
2	John Makhoul	Linear Prediction: A Tutorial Review	Proceedings of the IEEE	Vol. 63, Issue 4	1975
3	Heiga Zen, Keiichi Tokuda and Alan W. Black	Statistical Parametric Speech Synthesis	Speech Communication	Vol. 51, Issue 11	2009

4	Lawrence R. Rabiner, Biing-Hwang Juang and B. Yegnanarayana	Fundamentals of Speech Recognition	Pearson	-	2008
5	Hinton et al.	Deep neural networks for acoustic modeling in speech recognition	IEEE Signal Processing Magazine	-	2012
6	Graves, A. and Jaitly, N.	Towards end-to-end speech recognition with recurrent neural networks	ICML	-	2014
7	Wang et al.	Tacotron: Towards end-to-end speech synthesis	arXiv	-	2017

Course Outcome	
CO	**Course Outcome**
CO1	Appreciate the usefulness of different parameters that can be estimated from the speech signal.
CO2	Build a simple connected digit speech recognition system.
CO3	Understand the working principle of any classifier.
CO4	Build a simple waveform concatenation-based synthesizer, and to understand the power of statistical parametric (HMM-based) synthesizer.