Department of
Artificial Intelligence and Data Science (AI &DS)

Bachelor of Technology
in
Computer Science and Engineering (Data Science)

Schema & Syllabus

[Effective from 2024 Onwards (Admitted Batch: 2024 and Admitted Batch: 2023 from 3rd semester)]

Total Credit: 21+21+27+26+28+26+18+13=42+138=180

SMIT SIKKIM MANIPAL UNIVERSITY

SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

SMU SIKKIM MANIPAL UNIVERSITY
Established under Govt.of Sikkim, Act 9 of 1995, recognised under 2(f) of the UGC Act, 1956

Vision, Mission and Objective of University

VISION

Global Leadership in Human Development, Excellence in Education and Healthcare.

MISSION

Develop professionals of excellent technical calibre in the field of Health Sciences, Engineering, Management and Social Sciences with a humane approach capable of shouldering the responsibility of building the nation and be globally competent.

OBJECTIVES

- To support, promote and undertake the advancement of academics
- To promote the use of ICT and modern education technologies
- To encourage research, creation and dissemination of knowledge.
- To facilitate extension and community service.
- To empower people of Sikkim and contribute to human development in Northeast.
- To create environmental and social responsibilities among students and employees.
- To ensure steady growth of the University.

SMIT SIKKIM MANIPAL UNIVERSITY
SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

Vision, Mission and Objective of Institute

VISION

To achieve eminence in the field of quality technological education and research.

MISSION

To develop SMIT into an Institution of Excellence capable of producing competent techno managers who can contribute effectively to the advancement of the society.

OBJECTIVES

- To provide wholesome education to meet the intellectual aspirations of the students.
- To equip students with techno-managerial skills to enable them to take their assigned role in the industry.
- To inculcate essential ethics and values to meet the spiritual needs to the students.
- To provide a sound institutional environment nurturing emotional strength, healthy mind, body and resilience amongst the students.

Vision, Mission and PEO of the Department

VISION

To achieve excellence in quality technological education and research for making frontline innovators, researchers and entrepreneurs in the domain of Artificial Intelligence & Data Science.

MISSION

- Developing the department as a center of excellence for Artificial Intelligence and Data Science dedicated to revolutionizing industries and society through Artificial Intelligence.
- Provide a learning experience conducive to independent thinking and growth through innovation.
- Inculcate among all stakeholders the spirit of innovation and enterprise.
- Provide an environment catalysing intellectual growth and lifelong learning practices.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

- To empower students with skills and employability to solve real life problems.
- To inculcate professional ethics in students and prepare them to become professionals.
- To enhance technical skills and enthusiasm among students to carry out higher studies and research.
- To motivate students for Cutting Edge education and research. ·
- To encourage students for becoming future entrepreneur and provide them an ecosystem for the same.

FIRST YEAR B. TECH CURRICULUM 2024 Onwards (Common to all branches)

(Applicable to students admitted during 2024 and later)

Semester	GROUP A (FIRST SEMESTER) PHYSICS GROUP						GROUP B (FIRST SEMESTER CHEMISTRY GROUP					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I	MA101A1	Engineering Mathematics–I	3	1	0	4	MA101A1	Engineering Mathematics–I	3	1	0	4
	CE101A1	Elements of Civil Engineering	3	0	0	3	ME102A1	Element of Mechanical Engineering	3	0	0	3
	PH101A1	Engineering Physics	3	1	0	4	CH101A1	Engineering Chemistry	3	1	0	4
	EC101A1	Basic Electronics	3	0	0	3	EE101A1	Element of Electrical engineering	3	0	0	3
	BA101A1	Communication Skills	2	0	0	2	CS101A1	Computer Programming in C	3	1	0	4
	ME101A1	Engineering Graphics	1	0	2	2	CH102A1	Environmental Science	1	0	0	1
	BP101A1	Constitution of India	1	0	0	1	CS101A4	Computer Programming Lab	0	0	2	1
	ME101A4	Workshop Practice	0	0	2	1	CH101A4	Engineering Chemistry Lab	0	0	2	1
	PH101A4	Engineering Physics Lab	0	0	2	1						
			16	2	6	**21**			16	3	4	**21**
	Total Contact Hours (L + T + P)		24				Total Contact Hours (L + T + P)		23			
II	GROUP A (SECOND SEMESTER)						GROUP B (SECOND SEMESTER)					
	MA102A1	Engineering Mathematics–II	3	1	0	4	MA102A1	Engineering Mathematics–II	3	1	0	4
	ME102A1	Element of Mechanical Engineering	3	0	0	3	CE101A1	Elements of Civil Engineering	3	0	0	3
	CH101A1	Engineering Chemistry	3	1	0	4	PH101A1	Engineering Physics	3	1	0	4
	EE101A1	Element of Electrical engineering	3	0	0	3	EC101A1	Basic Electronics	3	0	0	3
	CS101A1	Computer Programming in C	3	1	0	4	BA101A1	Communication Skills	2	0	0	2
	CH102A1	Environmental Science	1	0	0	1	ME101A1	Engineering Graphics	1	0	2	2
	CS101A4	Computer Programming Lab	0	0	2	1	BP101A1	Constitution of India	1	0	0	1
	CH101A4	Engineering Chemistry Lab	0	0	2	1	ME101A4	Workshop Practice	0	0	2	1
							PH101A4	Engineering Physics Lab	0	0	2	1
			16	3	4	**21**			16	2	6	**21**
	Total Contact Hours (L + T + P)		23				Total Contact Hours (L + T + P)		24			

Note: UHV–I has been introduced under Mandatory Induction Program.

SECOND YEAR B. TECH CSE (DATA SCIENCE) CURRICULUM

THIRD SEMESTER						FOURTH SEMESTER					
Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
MA205A1	Discrete Mathematics	3	1	0	4	MA206A1	Probability, Statistics and Stochastic Process	3	1	0	4
CD201A1	Digital Design and Computer Organization	3	1	0	4	CD204A1	Design and Analysis of Algorithms	3	1	0	4
CD202A1	Data Structures	3	1	0	4	CD205A1	Database Management Systems	3	1	0	4
CD203A1	Introduction to Data Science	3	1	0	4	CD2xxA3	Program Elective-II*	3	1	0	4
CD2xxA3	Program Elective-I*	3	1	0	4	CD2xxA2	Open Elective-II/Minor/NCC*	3	1	0	4
CD2xxA2	Open Elective-I/Minor/NCC*	3	1	0	4	GN201A1	Universal human values-II: understanding Harmony and ethical human conduct	2	1	0	3
CD201A4	Data Structures Laboratory	0	0	2	1	CD203A4	Object Oriented Programming using Java Laboratory	0	0	2	1
CD202A4	Data Science Laboratory	0	0	2	1	CD204A4	Database Management Systems Laboratory	0	0	2	1
CD201A5	Project Based Learning- I	0	0	2	1	CD202A5	Project Based Learning- II	0	0	2	1
		18	6	6	**27**			17	6	6	**26**
Total Contact Hours (L + T + P)		30				Total Contact Hours (L + T + P)		29			

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THIRD YEAR B. TECH CSE (DATA SCIENCE) CURRICULUM

FIFTH SEMESTER						SIXTH SEMESTER					
Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
CD301A1	Machine Learning	3	1	0	4	BA346A1	Industrial Management	2	0	0	2
CD302A1	Formal Languages and Automata Theory	3	1	0	4	CD305A1	Deep Learning	3	1	0	4
CD303A1	Data Warehousing and Big Data Analytics	3	1	0	4	CD306A1	Text Analytics and Natural Language Processing	3	1	0	4
CD304A1	Computer Networks	3	1	0	4	CD3xxA3	Program Elective-IV*	3	1	0	4
CD3xxA3	Program Elective-III*	3	0	0	3	CD3xxA3	Program Elective-V*	3	1	0	4
CD3xxA2	Open Elective-III/Minor/NCC*	3	1	0	4	CD3xxA2	Open Elective-IV/Minor*	3	1	0	4
CD301A4	Machine Learning using Python Laboratory	0	0	2	1	CD303A4	Deep Learning Laboratory	0	0	2	1
CD302A4	Computer Network Laboratory	0	0	2	1	CD304A4	Data Warehousing and Big Data Analytics Laboratory	0	0	2	1
CD301A5	Project Based Learning- III	0	0	2	1	CD302A5	Mini Project	0	0	2	1
CD301A9	Industrial Training-I	0	0	2	1	GN302A1	Quantitative Aptitude and Logical Reasoning-II	1	0	0	1
GN301A1	Quantitative Aptitude and Logical Reasoning-I	1	0	0	1						
		19	5	8	**28**	**** Optional Audit Course**		18	5	6	**26**
Total Contact Hours (L + T + P)		32				Total Contact Hours (L + T + P)		29			

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FOURTH YEAR B. TECH CSE (DATA SCIENCE) CURRICULUM

SEVENTH SEMESTER						EIGHTH SEMESTER					
Sub. Code	**Subject Name**	**L**	**T**	**P**	**C**	**Sub. Code**	**Subject Name**	**L**	**T**	**P**	**C**
CD4xxA2	Open Elective - V/Minor*	3	1	0	4	CD4xxA2	Open Elective - VI/Minor*	3	1	0	4
CD4xxA2	Choice Based Elective*	3	0	0	3	CD402A6	Major Project – Phase II	0	0	18	9
CD401A6	Major Project – Phase I	0	0	20	10						
CD401A9	Industrial Training-II	0	0	2	1						
		6	1	22	**18**			3	1	18	**13**
Total Contact Hours (L + T + P)		29				Total Contact Hours (L + T + P)		21			

Note:

1. A two days workshop to be conducted department wise in sixth semester on “Professional Communication and Technical Writing”.

2. * Upto maximum of 40% of the total credits in a particular semester through MOOCs Swayam NPTEL Platform. Under special circumstances, 20% of the core credits.

3. UHV-I has been introduced under Mandatory Induction Program.

Total Credit: 21+21+27+26+28+26+18+13=42+138=180

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List of Program Electives

Subject Code	Program Elective-I (3rd Semester)	CR	Subject Code	Program Elective-IV(6th Semester)	CR
CD201A3	Object Oriented Programming using Python	4	CD306A3	Machine Learning Operations (MLOps)	4
CD202A3	Digital Signal Processing	4	CD307A3	Compiler Design	4
CD203A3	Mathematical Foundation for Machine Learning	4	CD308A3	Cloud Computing	4
CD204A3	Fundamentals of Web Technologies	4	CD309A3	Remote Sensing & GIS	4
			CD310A3	Augmented and Virtual Reality	4
			CD311A3	High Performance Computing	4
			CD312A3	Cryptography and Network Security	4
			CD313A3	DevOps Engineering	4
	Program Elective-II (4th Semester)			**Program Elective-V (6th Semester)**	
CD205A3	Operating System	4	CD314A3	Generative AI and Prompt Engineering	4
CD206A3	Introduction to Artificial Intelligence	4	CD315A3	Social Network Analytics	4
CD207A3	Programming in Java	4	CD316A3	Blockchain Technologies	4
CD208A3	Speech Processing	4	CD317A3	Bio-Inspired Computing	4
CD209A3	Analog Electronic Circuits	4	CD318A3	Quantum Computing	4
	Program Elective-III (5th Semester)		CD319A3	Reinforcement Learning	4
CD301A3	Digital Image Processing	3	CD320A3	Cyber Security	4
CD302A3	Optimization Techniques	3	CD321A3	Wireless Sensor Network	4
CD303A3	Internet of Things (IoT)	3	CD322A3	MERN Stack Development	4
CD304A3	ARM controller	3	CD323A3	Software Engineering	4
CD305A3	Parallel and Distributed Algorithms	3	CD324A3	AI in Healthcare	4

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List of Minor Specializations/Open Electives

Minor Specialization	Semester	Subject Code (Open/Minor)	Open Electives	CR
Data Science[$]	III	CD201A2/CD201A8	Introduction to Python Programming	4
	IV	CD202A2/CD202A8	Fundamentals of Data Science	4
	V	CD301A2/CD301A8	Mathematical Foundations of Machine Learning	4
	VI	CD302A2/CD302A8	Machine Learning	4
	VII	CD401A2/CD401A8	Deep Learning for Computer Vision	4
	OR			
	VII	CD402A2/CD402A8	Prompt Engineering	4
	OR			
	VII	CD403A2/CD403A8	Backend Development with Java Spring Boot	4
	VIII	CD404A2/CD404A8	Business Analytics	4
	OR			
	VIII	CD405A2/CD405A8	Cyber Security Tools, Techniques and Counter Measures	4
Computer Vision and Speech Technology	III	CD203A2/CD203A8	Digital Signal Processing	4
	IV	CD204A2/CD204A8	Applied Time-Series Analysis	4
	V	CD303A2/CD303A8	Speech Processing	4
	VI	CD304A2/CD304A8	Computer Vision and Image Processing	4
	VII	CD406A2/CD406A8	Medical Image Analysis	4
	VIII	CD407A2/CD407A8	Automatic Speech Recognition	4
Biomedical Technology	III	CD203A2/CD203A8	Digital Signal Processing	4
	IV	CD206A2/CD206A8	Biomedical Signal Processing	4
	V	CD303A2/CD303A8	Speech Processing	4
	VI	CD305A2/CD305A8	Biomedical Instrumentation	4
	VII	CD406A2/CD406A8	Medical Image Analysis	4
	VIII	CD408A2/CD408A8	Bioinformatics	4

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$- Data Science specialization not to be offered to CSE(DS) students. The Open Elective/Minor Specialization course in VII and VIII semesters to be decided by the DAC for a particular batch depending upon the availability of courses offered by NPTEL.

List of Choice based Electives

Subject Code	Choice based Electives (Seventh Semester)
CD401A3	Introduction to Japanese Language and Culture
CD402A3	Mandarin (Chinese) for beginners
CD403A3	Spoken Sanskrit: Basic and Intermediate Levels
CD404A3	Essence of Indian Traditional Knowledge
CD405A3	Indian Knowledge System(IKS): Concepts and Applications in Engineering
CD406A3	Introduction to Language and Linguistics
CD407A3	Understanding Incubation and Entrepreneurship
CD408A3	Principles of Economics
CD409A3	Science, Technology and Society

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**** Industrial Trainings will be conducted during the summer vacations after IV and VI Semester and evaluated in V and VII Semester respectively**

Industrial Training:

1. Students have to undergo an internship (Industrial Training I, CD301A9) of minimum 2 weeks from an industry of repute during the summer break between 4th semester and 5th semester.
2. Students have to undergo an internship (Industrial Training II, CD401A9) of minimum 4 weeks from an industry of repute during the summer break between 6th semester and 7th semester
3. Students have to submit a completion certificate and present PPT related to training imparted at the industry.
4. For industrial training/ viva-voce/ seminar it will be evaluated out of 100 at the end of the semester.

Mini Project/Project Based Learning:

Sl. No.	Subject Code	Subject Name	Internal Marks	External Marks	Credits
1	CD201A5	PBL-I	50	50	1
2	CD202A5	PBL-II	50	50	1
3	CD301A5	PBL-III	50	50	1
3	CD302A5	Mini Project	50	50	1

Research based Project/ Industrial Project -Phase-I &II:

Sl. No.	Subject Code	Internal Marks	External Marks	Duration of Project	Credits
1	CD401A6	50	50	20 hours/ weeks	10
2	CD402A6	50	50	18 hours/weeks	9

** Project Evaluation:

1. One interim evaluation to be followed [Candidate has to present PPT/demonstration].
2. Final Evaluation with PPT presentation/demonstration to be followed at the end of session

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PROGRAM OUTCOMES (PO)

Engineering Graduates will be able to:

PO 1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO 6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO 9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO 1	The ability to understand, analyses, design and demonstrate the knowledge of human cognition, Artificial Intelligence, Machine Learning and data engineering, electronics and communication engineering in terms of real-world problems to meet the challenges of the future in multidisciplinary domain.
PSO 2	To provide a concrete foundation and enrich their abilities to qualify for Employment, Higher studies and research works in Artificial Intelligence and Data science with ethical values

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Core Courses: Semester III

****

Sub Code: MA205A1 **Credit: 4 (L-3, T-1, P-0)**

Discrete Mathematics

Questions to be set: 05 (One from each Module) Questions to be answered: ALL

Course Objectives: The objective of this course is to familiarize on numerous counting techniques and abstract structures which appear frequently in many areas such as Algorithm analysis, data structures, database management system. Discrete mathematics plays a crucial role in enabling students of computer science to tackle these problems. Graph theory has tremendous application in Computer Networks, Optimization. Group theory has applications coding theory, cryptography

Pre-requisites: Set theory, Permutations and Combinations, Relations, Functions, Differential & Integral calculus.

Course Outcomes (CO'S): On successful completion of this course, students will be able to:

CO 1: Solve problems using Counting Principles, Relations, Functions lattices.

CO 2: Apply concepts of Group theory to model the real-world problems.

CO 3: Analyze the use of graphs in engineering applications.

CO 4: Critically think and arrive at solution for Permutation and Combination, Ordering, Recursion and generating functions.

CO 5: Determine and solve problems related to predicate calculus that occur frequently in areas of computer science.

Module I: Set theory: Principle of inclusion and exclusion, Relations, and functions, Techniques of Proofs, Pigeonhole Principle; Partial ordering, lattice and algebraic systems, principle of duality, basic properties of algebraic systems defined by lattices, distributive and complemented lattices. [8HR]

Module II : Group Theory: Groups, subgroups, permutation group with simple examples. Cosets, normal subgroup, Burnside's theorem (statement only) and its simple applications, codes and group codes. Burnside's theorem (statement only) and its simple applications, codes and group codes. [8HR]

Module III: Graph Theory: Graphs, Digraphs, Walk, Path, Cycles, Connectedness, Tree, Computer representation of relation, relation digraph, and graphs, transitive closer and Warshall's Algorithm. [8HR]

Module IV: Configuration, Ordering: Elementary configurations: Permutations and Combinations, Generating functions, Partitions and Compositions, Lexicographical and Fike's orderings of permutations. Algorithms for Lexicographical, Reverse Lexicographical and Fike's ordering of permutation. [8 HR]

Module V: Predicate calculus: Connectives, Well-formed formula (WFF), Quantification, examples and properties of WFF into Causal form. Resolution and refutation, answer extraction and simple examples. [8 HR]

Text Books

1. Jean-Paul Tremblay and Manohar, R: Discrete Mathematical Structures with application to Computer Science, McGraw Hill.
2. C.L. Liu: Elements of discrete mathematics, McGraw Hill. 3. Narasingh Deo: Graph theory with applications to Computer Science, PHI.

Reference Books:

1. B. Kolman, R.C. Busby & S. Ross.: Discrete Mathematical Structures, Pearson.
2. Principles of Artificial Intelligence; N. J. Nielson. 3. E. S. Page & L.B. Wilson: An introduction to Computational Combinatorics, Cambridge University

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Sub Code: CD201A1 **Credit: 4 (L-3, T-1, P-0)**

Digital Design and Computer Architecture

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide basic knowledge in digital electronics and internal architecture of a computer.

Pre-requisites: Knowledge of Number system and logic gates

Course Outcomes(CO):

Upon successful completion of the course, students should be able to

CO 1: Identify various combinational logic circuits and their applications.

CO 2: Identify various sequential logic circuits and their applications.

CO 3: Design basic digital circuits using HDL.

CO 4: Analyze the competence of a computer system architecture.

CO 5: Design alternative computer systems for improved performance.

Module	Topics	Hrs	CO
Module 1: Basic Logic Gates and Combinational Circuits	Boolean Algebra: De-Morgan's Theorem, Simplification of Logic Circuits, Combinational Circuits: Introduction to K-map, Half and Full Adder Circuit, Parallel Adder, Multiplexer, De multiplexer, Decoder, Encoders, Comparators, 7-Segment Decoder, and current trends in digital electronics (Reversible logic)	9	1
Module 2: Sequential Circuits	Latches and Flip-Flops, State Diagram and State Tables, Analysis of Asynchronous Sequential Circuits, Analysis of Synchronous Sequential Circuits, Design of Sequential Logic Circuit, Asynchronous and Synchronous Counter and Shift Register.	8	2
Module 3: Hardware Descriptive Language (HDL)	Motivation and Introduction to HDL (VHDL/Verilog), Modules, Language origins, simulation and synthesis, Behavioral modeling, Structural modeling	8	3
Module 4:	Computer Architecture: von Neuman Architecture, Fetch Decode Execution Cycle, Machine instructions and addressing modes, ALU, data-path and control unit	10	4

Computer Architecture, Memory and IO	Memory System: Caches, Virtual memory, I/O Introduction, DMA, Interrupts PC I/O systems		
Module 5: Microarchitecture and Pipelining	Microarchitecture: Flynn's Classification**,** Introduction, Single and multicycle processor, pipelined processor, Performance Analysis,	8	5

Text Books:

1. David Money Harris & Sarah L. Harris (2012). *Digital Design and Computer Architecture*, Morgan Kaufmann; 2nd edition
2. Douglas L. Perry (2017). *VHDL: Programming by Example*, McGraw Hill Education; 4th edition
3. Douglas Comer. (2019), *Essentials of Computer Architecture*, (2nd ed.), CRC Press
4. M. Morris Mano, (2017), *Computer System Architecture*, (3rd ed), Pearson.
5. William J. Fletcher, (1997), *An Engineering approach to Digital Design*, (1st ed), PHI.

Reference Books:

1. Joseph D. Dumas II,(2016), "Computer Architecture: Fundamentals and Principles of Computer Design", (2nd ed), CRC Publication.

2. C. H. Roth, (1998), "Digital System Design using VHDL", (4th ed), PWS publication.

Sub Code: CD202A1 **Credit:4 (L-3, T-1, P-0)**

DATA STRUCTURES

Questions to be set: 05 (All Compulsory)

Course Objectives: This course emphasizes on the organization of information, the implementation of linear data structures such as linked lists, stacks, queues, and non-linear data structures such as trees, and graphs. This course also explores recursion principles, the close relationship between data structures and algorithms and the analysis of algorithm complexity.

Pre-requisites: Programming concepts

Course Outcomes (CO): On successful completion of this course, students should be able to:

1. Describe the working of data structures like array, stack, queue, linked list, tree and graph
2. Explain common applications for array, stack, queue, linked list, tree and graph
3. Solve a given problem using appropriate data structures and algorithm
4. Discuss about the working of the principal algorithms for sorting, searching, and hashing
5. Correlate the performance of a program with respect to the choice of data structure & algorithm

**** not more than 20% of total topics to be allotted for assignment**

Module	Mode	Topics	Hrs	CO
Module 1: <Introduction>	in class	Definition, Algorithmic analysis: 'Oh' notation, Contiguous data structures: Representation of multidimensional arrays, highly structured sparse matrices using dimensioned arrays,	8	1
	****Assignment Topics**	String representation and manipulation.		
Module 2: <Stacks & Queues>	in class	Definition, Operations on stacks, Implementation using array. Application of Stacks: Evaluation of arithmetic expressions. Recursion: Use of recursive techniques in enumeration problems and back tracking algorithms, Recursion removal using stacks. Definition, Operations on queue, Implementation of queues, Circular queues. Applications	8	1, 2
	****Assignment Topics**			

Module 3: <Non-contiguous Data Structures>	in class	Linear linked list: Insertion, Traversal and deletion operations on singly linked list. Various types of linked list: Doubly linked list, Circular lists, Use of header node in circular lists, Generalized (recursive) list, Application of linear list.	7	2,3
	**Assignment Topics	Representation and manipulation of sets, Strings and graphs.		
Module 4: <Trees & Graphs>	in class	Definition of a tree and various terminologies used in tree, Binary tree, Recursive and non-recursive	10	2,3
		tree traversal algorithms, Representation of n-ary trees using binary trees, Application of trees, Expression trees. Search trees: Definition, Insertion, Deletion and reversal, Height balanced search trees (using AVL trees illustrative example) and weight balanced search trees. Terminology and representations: Introduction, Definition and terminology, Graph representations, Traversals, connected components and spanning trees, Shortest path problem, Dijkstra's algorithm.		
	**Assignment Topics			
Module 5: <Sorting and searching >	in class	Sorting: Insertion, 2-way merge, Heap sort and quick sort, Comparison of different sorts. Hashing technique: Hash tables, Different hashing functions, Overflow handling, Methods for collision handling, Theoretical evaluation.	7	4,5
	**Assignment Topics	Radix sort. Searching: Linear, Binary search, Comparison of different methods. H		

Text Books:

1. Ellis Horowitz and Sartaj Sahni, "Fundamentals of Data Structures", Galgotia.
2. Samanta, D., "Classic Data Structures", PHI.

Reference Books:

1. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, "Data Structures and Algorithms", Pearson
2. E.M. Reingold and W.J. Hansen, "Data Structures", CBS.
3. A. S. Tanenbaum, Y. Langsam, M.J. Augenstein, "Data Structures using C", Pearson.
4. M. A. Weiss, "Data Structure and Algorithm Analysis in C", Pearson

Sub Code: CD203A1 **Credit: 4 (L-3, T-1, P-0)**

Introduction to Data Science

Questions to be set: 05 (All Compulsory)

Course Objectives: The course objective is to provide fundamental knowledge of statistics for Data Science, Visualization Techniques and Tools, and Python programming for implementation.

Pre-requisites: Basic statistical knowledge.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Apply appropriate data analysis techniques.

CO 2 Implement data science problem using python programming.

CO 3 Explain the concept of Estimation and Hypothesis.

CO 4: Apply SciKit Learn tool for machine learning tasks.

CO 5: Analyze data using visualization techniques and tools.

Module	Topics	Hrs	CO
Module 1: Introduction to Data Science	**Introduction:** Data Science, Applications, Relation between Data Science and other fields, **Data:** Introduction, Data types, Data collections, Data Pre-processing **Techniques**: Introduction, Data Analysis and Data Analytics, Descriptive Analysis: Variables, Frequency Distribution, Measures of Central Tendency, Measure of Dispersion Diagnostic Analytics: Correlations Predictive Analytics, Prescriptive Analytics, Exploratory Analysis, Mechanistic Analysis (Regression)	8	1

Module 2: Toolboxes for Data Scientist	Introduction to Python, Advantages and Disadvantages *Data Science Ecosystem Installation*, *Integrated Development Environments (IDE) for python*: Jupyter notebook, Pycharm, Spyder First Slithers with Python: Basic Types, Numbers, Strings, Complex Numbers, Lists, Tuples, Dictionaries Control Flow: if…..elif…else, while, for, try..except, Functions, Scripts and Modules Computation and Data Manipulation: Matrix Manipulations and Linear Algebra, NumPy arrays and Matrices, Indexing and Slicing, Pandas, Plotting and visualizing: Matplotlib *Get Started with Python for Data Scientists:* Reading, Selecting Data, Filtering Data, Filtering Missing Values, Manipulating Data, Sorting, Grouping Data, Rearranging Data, Ranking Data, Plotting. *Information on Fundamental Python Libraries for Data Scientists:* Math: Numpy, SciPy; Data Mining: BeautifulSoup, Scrapy; Data Exploration and Visualization: Pandas, Matplotlib, Plotly, Seaborn; Machine Learning: Scikit Learn, PyCaret, TensorFlow, Keras, PyTorch ,	10	2
Module 3: Statistical Inference	**Distribution:** Normal Distribution, Standard Normal Distribution, Central Limit Theorem, Standard Error, Estimators and Estimates. **Confidence Intervals**: Population Variance Known-Z-score, Student's T Distribution, Population Variance Unknown-T-score; Two Means-Dependent samples, Independent samples **Hypothesis Testing:** Null and Alternative Hypothesis, Rejection Region and Significance Level, Type I Error and Type II Error, Test for the Mean-Population Variance Known, p-value, Test for the Mean-Population Variance Unknown, Test for the Mean. Dependent Samples, Independent samples	10	3

Module 4: Model Fit & Performance Evaluation	**Regression Models**- Linear and Logistic Model, **Classification Models** – Decision Tree, Naïve Bayes, SVM and Random Forest, **Clustering Models** – K Means and Hierarchical clustering **Performance Evaluation:** Loss Function and Error: Mean Squared Error, Root Mean Squared Error – Model Selection and Evaluation criteria: Accuracy, Precision, F1 score, Recall Score – Binary Predictive Classification – Sensitivity – Specificity	8	3
Module 5: Data Visualization Techniques and Tools	**Data Visualization Techniques**: Line Plot, Pie Chart, Bar Chart, Histogram, Gantt Chart, Heat Map, Box and Whisker Plot, Violin plots, Waterfall Chart, Area Chart, Scatter Plot, Pictogram Chart, Timeline, Highlight Table, Bullet Graph, Choropleth Map, Word Cloud, Network Diagram, Correlation Matrices **Data Visualization Tools :** Microsoft Excel (and Power BI), Google Charts, Tableau, Zoho Analytics, Datawrapper, Infogram, etc.	8	5

Text Books:

1. Shah, C. (2020). A Hands-On Introduction to Data Science. Cambridge: Cambridge University Press.
2. Jesús Rogel-Salazar ,(2014). *Data Science and Analytics with Python* (1st ed). CRC Press.

Reference Books:

1. João Moreira, Andre Carvalho, Tomás Horvath (2018). *A General Introduction to Data Analytics* (3rd ed). Wiley.
2. Rao, R. Nageswara , (2018). *Core python programming* (1st ed). Dreamtech press publication.
3. Grus, Joel (2019). *Data science from scratch: first principles with python* (1st ed). O'Reilly
4. David Dietrich, Barry Heller, and Beibei Yang (2015). *Doing Data Science* (1st ed). O'Reilly.
5. Laura Igual and Santi Seguí (2017). *Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications*, Springer
6. David Dietrich, et.al.(2015). *Data Science & Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data*. John Wiley & Sons.

E-Resource

1. **https://github.com/cmaroblesg/Data_Visualization_with_Tableau/tree/master**
2. https://www.udemy.com/course/the-data-science-course-complete-data-science-bootcamp/

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Sub Code: CD201A4 **Credit: 1(L-0,T-0,P-2)**

Data Structures Laboratory

Minimum Experiment to be done: 12

Course Objectives: The course objective is to provide practical knowledge on data structure using **Python** or C programming.

Pre-requisites: Basic knowledge of data structure and programming Concept.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Write programs to implement basic search algorithms (such as linear search and binary search) and sorting algorithms (such as bubble sort, insertion sort, Merge sort and quicksort).

CO 2: Write programs to create and manipulate stack and queue data structures.

CO 3: Write programs to create, insert, delete, and traverse linked lists. They will explore singly linked lists, doubly linked lists, and circular linked lists.

CO 4: Write programs to construct and manipulate tree data structures.

CO 5: Write programs for graph data structures and algorithms. They will explore different representations of graphs (such as adjacency matrix and adjacency list) and implement graph traversal algorithms (such as depth-first search and breadth-first search).

List of Experiments:

Module	Name of Experiments	Hours	CO
Module: 1 Search and Sort Algorithms	Experiment 1: Write a program for Linear Search and Binary search	2	1
	Assignment1: Insertion and Deletion on specific array positions		
	Experiment 2: Write a program to implement Selection sort and Bubble Sort Sort.	2	1
	Assignment2: Insertion Sort.		
	Experiment 3: Write a program to implement Merge sort	2	1
	Assignment 3: Quick sort		
Module:2 Matrix, Stack and Queue	Experiment 4: Write a program to create dense and sparse matrix.	2	2
	Experiment 5: Write a program to implement Stacks and Queues.	2	2
	Assignment 4: Implementation of stack as a queue and vice versa		

Module:3 Link List	Experiment 6: Write a program to implement Singly Linked List.	2	3
	Experiment 7: Write a program to implement Doubly Linked list.	2	3
	Experiment 8: Write a program to implement Singly-Circular Linked list.	2	3
	Assignment 5: Doubly-Circular Linked list		
Module:4 Tree	Experiment 9: Write a program to implement Binary Search Tree	2	4
	Experiment 10: Write a program to implement Tree traversal algorithms (In-order, Pre-order, post-order).	2	4
	Assignment 6: AVL Tree. Assignment 7: Write a program to implement Heaps using Priority Queues.		
Module:5 Graph	Experiment 11: Write a program to implement Graph representation.	2	5
	Experiment 12: Write a program to implement BFS (Breadth First Search).	2	5
	Assignment 8: DFS (Depth First Search)		

Text Books:

1. Ellis Horowitz and Sartaj Sahni, "Fundamentals of Data Structures", Galgotia.
2. Dr Shriram K. Vasudevan (Author), Mr Abhishek S. Nagarajan (Author), Prof Karthick Nanmaran (2021). Data Sructures using Python, Oxford University Press, India; First Edition
3. M. A. Weiss, "Data Structure and Algorithm Analysis in C", Pearson.
4. Samanta, D., "Classic Data Structures", PHI.

Reference Books:

5. Steven S. Skiena ,(2008), "The Algorithm Design Manual" (2nd ed) Springer.
6. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, "Data Structures and Algorithms", Pearson
7. E.M. Reingold and W.J. Hansen, "Data Structures", CBS.
8. A. S. Tanenbaum, Y. Langsam, M.J. Augenstein, "Data Structures using C", Pearson.
9. Reema Thareja, (2017), "Python Programming" (3rd ed) Oxford university press.

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Sub Code: CD202A4 **Credit: 1(L-0, T-0, P-2)**

Data Science Laboratory

Minimum Experiment to be done: 12

Course Objectives: To provide hands-on exposure to python programming for Data Science.

Pre-requisites: Basics knowledge of statics and programming.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Execute basic python programming for Array, Data frame, Matrix, vector, list and factors.

CO 2: Use statistical methods to analyze the data with python.

CO 3: Evaluate distribution and correlation of using python.

CO 4: Develop models for the regression and decision trees and evaluate them by using python.

CO 5: Write the program for different classifiers & Clustering algorithms and evaluate its performance using python.

List of Experiments:

Module	Name of Experiments	Hours	CO
Module: 1	Experiment 1.1: Numpy Array, Matrix	6	1
	Experiment 1.2: Write a python program for computing statistical parameters such as Mean, Median, Mode, standard deviation, and Percentiles.		1
	Experiment 1.3: Write a python program to find and visualize the data distributions (Normal, Binomial, Multinomial, Poisson, uniform, Exponential, Rayleigh)		1
Module:2	File Handling and Pandas	4	2
	Experiment 2.1: Reading several types of data sets (e.g. .txt, .csv, xlsx) from the web and disk and writing in a file in a specific disk location.		2
	Experiment 2.2: Data Cleaning		2
Model: 3	Experiment 3.1: Use Matplotlib library to visualize line, histogram, bar chart, pie chart, scatter plot, box/Whisker plot.	2	3
	Experiment 3.2: Write a python program for analyzing univariate data (using histogram, and boxplot), bivariate data (using scatter plot, pair plot, correlation), for the iris dataset.	4	2
	Experiment 3.3: Perform Analysis of covariance: variance (ANOVA), if data have categorical variables on iris data		

Model:4	Experiment 4.1: Write a python program for linear and polynomial regression for a specific data set.	2	4
	Experiment 4.2: Write a python programming for k-mean clustering algorithm and visualize the result through a plot.	2	4
Model:5	Experiment 5.1: Write a python program for classical ML classifiers (Logistic Regression and K-NN) and list the performances for a specific dataset.	2	5
	Experiment 5.2: Experiment 5.2: Write a python program for prediction based on SVM (Support Vector Machine) classifier model.	2	5

Textbooks:

2. João Moreira, Andre Carvalho, Tomás Horvath, (2019). *A General Introduction to Data Analytics (*1st ed), John Wiley & Sons Inc
3. Reema Thareja (2017). *Python Programming* (3rd ed). Oxford University Press.
4. Jesús Rogel-Salazar (2014).*Data Science and Analytics with Python* (1st ed). CRC Press.
5. David Dietrich, et.al.(2015). *Data Science & Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data,* John Wiley & Sons.
6. João Moreira, Andre Carvalho, Tomás Horvath, (2018). *A General Introduction to Data Analytics* (3rd ed), Wiley.
7. Rao, R. Nageswara, (2018). *Core python programming (*1st ed). Dream tech Press publication.

Reference Books:

1. Grus, Joel (2019). *Data science from scratch: first principles with python* (1st ed), O'Reilly
2. Vincent Granville (2014). *Developing Analytic Talent: Becoming a Data Scientist*(1st ed). Wiley publishers.
3. Jojo Moolayil, (2016). *Smarter Decisions: The Intersection of IoT and Data Science* (3rd ed). PACKT,
4. David Dietrich, Barry Heller, Beibei Yang, (2015). *Doing Data Science* (1st ed). O'Reilly

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Core Courses: Semester – IV

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Sub Code: MA206A1 **Credit: 4 (L-3, T-1, P-0)**

PROBABILITY, STATISTICS AND STOCHASTIC PROCESSES

Questions to be set: 05 (All Compulsory)
Course Objectives: The objective of this course is to enhance the capability of students to analyze the problems related to random phenomena. Concepts on probability theory will be of immense help to the students in analyze random experiments. Statistical Analysis plays a big role in areas like data mining and information retrieval. Stochastic models have tremendous applications in queuing theory, finance, Insurance. Students will find adequate tools in these modules which will be effective enough to solve related problems.
Pre-requisites: Differential and Integral Calculus, Matrix Algebra, Permutation and Combination.
Course Outcomes (CO): After completing the course, the students will be able to
CO1: demonstrate basic principles of probability and understand a random variable that describe randomness or an uncertainty in certain realistic situation.
CO2: comprehend concepts of discrete, continuous probability distributions and able to solve problems of probability using various distributions.
CO3: analyse the statistical data for inference and apply various tests for testing the Hypothesis,
CO4: understand the various classifications of Random Processes that arise frequently and model them.
CO5: apply different Queuing models that appear in Computer Science

**** not more than 20% of total topics to be allotted for assignment**

Module	Topics	Hrs	CO
Module 1: **Probability Theory, Random Variables, and distribution**	Introduction, Classical definition of probability, Axiomatic definition of probability, Conditional probability, Baye's theorem. Random variables, Mean, Variance, Chebyshev's inequality, Central limit theorem.	10	1

Module 2: **Conditional Probability and known distribution:**	Correlation coefficient, conditional distributions, conditional expectations, and regression curves, Standard probability distributions (Binomial, Poisson, Uniform, Normal, exponential, chi-square.), Reliability and MTTF.	10	2
Module 3: **Introduction to Statistics**	Random sample, Sampling distribution, Statistic, Least square curve fitting Parameter estimation: Unbiased estimate, Consistent estimate, Maximum likelihood estimate, interval estimate. Testing of Hypothesis for mean with known variance for normal population	6	3
Module 4: **Stochastic Processes**	: Introduction to Stochastic Process, Poisson Process, Discrete parameter Markov Chains	8	4
Module 5: **Queuing Models**	Concept of a queues: Basic idea of continuous parameter Markov chain, Birth and death processes, M / M /1/∞, M / M /1/N, queuing systems.	6	5

Textbook:

1. Kishor. S. Trivedi (2013). Probability & Statistics with Reliability, Queuing and Computer Science Applications (2nd ed.). Wiley.
2. Johnson, R.A., Miller, I and Freund J.Miller and Freund's (2015). Probability and Statistics for Engineers (8th ed.). Pearson Education, Asia.
3. P.L. Meyer : Introductory Probability theory and statistical Applications, Second Ed. Oxford & IBM Publishers.

Reference Books:

1. William Feller(2008). Introduction to Probability Theory and its Applications, Wiley.
2. Geza Schay (2007). Introduction to Probability with Statistical Applications, Brikhaus
3. Papoulis, A. and Unnikrishnapillai, S. (2010). Probability, Random Variables, and Stochastic Processes (4th ed.). McGraw Hill Education, India
4. Arnold O.. Allen (2014). *Probability, Statistics & Queuing Theory with Computer Science Applications.*Academic Press.

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Sub Code: CD204A1 **Credit: 4 (L-3, T-1, P-0)**

Design & Analysis of Algorithms

Questions to be set: 05 (All Compulsory)

Course Objectives: This course builds upon preliminary knowledge delivered in Data Structures. The main objectives of the course are to provide thorough knowledge and understanding of different algorithm analysis techniques, design strategies and their applications. Special purpose machines, some critical problems and innovative techniques are used in solving them.

Pre-requisites: Data Structures and Programming concepts.

Course Outcomes(CO): On successful completion of this course, students should be able to:

1. Define asymptotic notations and solve problems related to it
2. Calculate time and space complexities for recursive/non-recursive algorithms.
3. Explain the basic Greedy algorithms.
4. Describe Dynamic programming & Back Tracking.
5. Explain Branch and Bound Method and describe the classes P, NP, and NP-Complete.

**** not more than 20% of total topics to be allotted for assignment**

Module	Topics to be covered	Topics	Hrs	CO
Module 1: <Algorithms & Mathematical >	In Class	Definition, aim of the subject, designing algorithms and Analyzing algorithms: An introduction, Performance of a program: Space and Time complexity. Asymptotic notations and common Functions	9	1
	****Assignment Topics**	Example Asymptotic notation: Insertion sort		
Module 2: < Recurrences and divide and conquer >	In Class	The basics of divide & conquer method, Merge sort , Quick sort, Solving recurrences: Substitution method, Recursion tree method, Finding maximum and minimum, Strassen's matrix multiplication, Binary search.	7	2
	****Assignment Topics**	Master method: Proof of master method		

Module 3: < Greedy method >	in class	Basics of greedy method, Applications- 0/1 Knapsack Problem – Topological sorting-Heapsort, Huffman codes, Activity selection, Minimum spanning tree-Kruskal's algorithm, Prim's algorithm, Single source shortest path: Dijkstra's algorithm	7	3
	****Assignment Topics**	Topological sorting – Bipartite Cover		
Module 4: < Dynamic programming & Back Tracking >	in class	Basics of dynamic programming, Applications- Matrix chain multiplication, longest common subsequence, Traveling salesperson problem, all pair shortest Path-Floyd and Wars hall's algorithm.	9	4
		Backtracking Method, Applications-Container Loading, 0/1 Knapsack Problem, Max Clique, Travelling Salesperson, Board Permutation		
	**Assignment Topics	Non-Crossing Subsets of Nets		
Module 5: < Branch And Bound & NP completeness >	in class	Branch and Bound Method, Applications-Container Loading, 0/1 Knapsack Problem, Max Clique, Travelling Salesperson. Basic Concepts, P NP, NP Complete, NP Hard problems, Travelling Salesman Problem.	8	5
	****Assignment Topics**	Board Permutations.		

Text Books:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, "Introduction to Algorithms", PHI.
2. Subrata Saha, Techno India HooglySaha, S. (2023). Data Structures and Algorithms Using Python. Cambridge University Press.
3. Ellis Horowitz and Sartaj Sahni,(2007), "Computer Algorithms/C++", (2nd ed), University Press.

Reference Books:

1. Anany Levitin,(2011) " Introduction to the Design and Analysis of Algorithms", (3rd ed), Pearson Education
2. S. Basse, A. Van Gelder, "Computer Algorithms-Introduction to Design and Analysis", Pearson.
3. Alfred V. Aho, John E. Hop croft, Jeffrey D. Ullman, "Data Structures and Algorithms", Addison Wesley.
4. M. A. Weiss, "Data Structure and Algorithm Analysis in C", Pearson Education.

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Sub Code: CD205A1 **Credit: 4 (L-3, T-1, P-0)**

Database Management Systems

Questions to be set: 05 (All Compulsory)

Course Objectives: This course provides the basic information about relational Database Management System and their development. The major objectives of the course are to provide an introduction of DBMS and their use, be familiar with the basic DBMS architecture, components, and interfaces, have experience using at least one modern Database Management System, understand and use database models in database and application design

Pre-requisites: Programming Concepts

Course Outcomes (CO): On successful completion of this course, students should be able to:

1. Describe fundamental elements of a relational database management system.
2. Design entity-relationship diagrams to represent simple database application scenarios
3. Explain the basic concepts of relational data model, Entity-relationship model, Relational database design, relational algebra and database language SQL
4. Apply and relate the concept of transaction, concurrency control and recovery in database
5. Analyze various Normalization techniques and improve the database design by normalization

**** not more than 20% of total topics to be allotted for assignment**

Module	Mode	Topics	Hrs	CO
Module 1: <Introduction & Data modelling >	In Class	DBMS: Characteristics, Advantages, Architecture. Database concept and architecture, Data models, Instances and schema, Database languages, Database manager, Database administrator, Database users, Concept of centralized database management system and distributed database system. Entity sets, attributes types and keys, Entity Relationship (ER) diagram, Type role and structural constraints, Enhanced entity-relationship (EER), Object modelling, Specialization and generalization, Modelling of union types, Relational-algebra operations.	8	1,2
	****Assignment Topics**	Data models: Definition, Purpose and Types, Hierarchical models, Network model, Relational model.		
Module 2:	In	Database design process, Relational database design,	8	3

<Database design >	Class	Relation schema, Functional dependencies, Membership and minimal covers, Normal forms, Multivalued dependencies, Join dependencies, Converting EER diagrams to relations.		
	****Assignment Topics**	Effect of de-normalization on database performance.		
Module 3: < Data Storage and	In Class	File organizations, primary, secondary index structures, various index structures - hash-based, dynamic hashing techniques, multi-level indexes, B+	9	3,4
Indexes & Database query languages >		trees. Query-by-example (QBE), Introduction to SQL, Use of some special data types, Overview of SQL 92, Basic queries in SQL, Advanced queries in SQL, Functions in SQL, Basic data retrieval, Aggregation, Categorization, Updates in SQL, Embedded SQL and 4GLs, Procedural extension to SQL: PL/SQL.		
	****Assignment Topics**			
Module 4: < Transaction processing, Concurrency control and backup & recovery mechanisms >	in class	Desirable properties of transactions, Implementation of atomicity and durability, Reconsistent model, Read only and write only model, Concurrent executions, Schedules and recoverability, Serializability of schedules, Concurrency control, Precedence graph. Overview of concurrency control, Locking techniques, Lock based protocols, Time stamp based protocols, Commit protocols, Optimistic technique, Granularity of data items, Time stamp ordering multi version concurrency control, Deadlock handling, Recovery mechanisms, Database recovery techniques based on immediate and deferred update.	9	4
	****Assignment**	Concepts of database security mechanisms, Case study		

	Topics	of Distributed Database Systems		
Module 5: <Graph Database & NoSQL >	in class	Overview of graph database, Structure and advantages of graph database. An overview of NoSQL, Characteristics of NoSQL, Advantages and challenges of NoSQL, NoSQL storage types, Case study of MongoDB.	6	5
	****Assignment Topics**	high level view of graph space, Property graph model.		

Text Books:

1. Abraham Silberschatz, Henry Korth, S. Sudarshan (2010). *Database System Concepts* (6th ed.). McGraw Hill.
2. Ramez Elmasri and Shamkant Navathe (2010). *Fundamentals of Database System* (6th ed.). Addison Wesley Publications Co.
3. R. Ramakrishnan and J. Gehrke (2014). *Database Management System* (3rd ed). McGraw Hill Publisher.

Reference Books:

1. Thomas Connolly, Carolyn Begg, "Database Systems – A Practical Approach to Design, Implementation and Management", Pearson Education.
2. Jefrey D. Ullman, Jenifer Widom, "A First Course in Database Systems", Pearson Education.
3. Bipin C Desai, "An Introduction to Database Systems", Galgotia.
4. Atul Kahate, "Introduction to Database Management Systems", Pearson.
5. Ian Robinson, Jim Webber, Emil Eifrem,"Graph Databases",O'Reilly Media.
6. Gaurav Vaish, "Getting started with NoSQL", Packt.
7. Shashank Tiwari, (2011). *Professional NoSQL*. Wiley.

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Sub Code: GN201A1 **Credit: 3 (L-2, T-1, P-0)**

UNIVERSAL HUMAN VALUES-II: UNDERSTANDING HARMONY and ETHICAL HUMAN CONDUCT

Course Objectives:

This introductory course input is intended:

1. To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2. To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
3. TohighlightplausibleimplicationsofsuchaHolisticunderstandingintermsofethicalhuman conduct, trustful and mutually fulfilling human behaviour and mutually enriching interaction with Nature.

Thus, this course is intended to provide a much needed orientational input in value education to the young enquiring minds.

Pre-requisites: None. However, it is desired that students may have gone through UHV-I: Universal Human Values-Introduction

Course Outcome (CO):

1. Students are expected to understand self-exploration and Basic Human Aspirations.
2. To understand harmony in themselves (Human being).
3. To become more aware of their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
4. They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hopedthattheywouldbeabletoapplywhattheyhavelearnttotheirownselfindifferentday-to-day settings in real life, at least a beginning would be made in thisdirection.

Therefore, the course and further follow up is expected to positively impact common graduate attributes like:

1) Holistic vision oflife
2) Socially responsiblebehaviour
3) Environmentally responsiblework

4) Ethical humanconduct
5) Having Competence and Capabilities for Maintaining Health andHygiene
6) Appreciation and aspiration for excellence (merit) and gratitude forall

Module 1 –Introduction to Value Education (9 Hrs)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)
Lecture 2: Understanding Value Education

Tutorial 1: PracticeSession *PS1 Sharing aboutOneself*

Lecture 3: Self-exploration as the Process for Value Education
Lecture 4: Continuous Happiness and Prosperity – the Basic Human Aspirations
Tutorial 2: Practice SessionPS*2 Exploring HumanConsciousness*

Lecture 5: Happiness and Prosperity – CurrentScenario

Lecture 6: Method to Fulfil the Basic HumanAspirations
Tutorial 3: PracticeSessionPS*3 Exploring Natural Acceptance*

Module 2 – Harmony in the Human Being (9 Hrs)

Lecture 7: Understanding Human being as the Co-existence of the Self and the Body
Lecture 8: Distinguishing between the Needs of the Self and the Body
Tutorial 4: Practice Session PS*4 Exploring the difference of Needs of Self and Body*
Lecture 9: The Body as an Instrument of the Self
Lecture 10: Understanding Harmony in the Self
Tutorial 5: Practice Session PS*5 Exploring Sources of Imagination in the Self*
Lecture 11: Harmony of the Self with the Body
Lecture 12: Programme to ensure self-regulation and Health

Tutorial 6: Practice Session PS*6 Exploring Harmony of Self with the Body*

Module 3 – Harmony in the Family and Society (9 Hrs)

Lecture 13: Harmony in the Family – the Basic Unit of Human Interaction
Lecture 14: 'Trust' – the Foundational Value in Relationship
Tutorial 7: Practice Session PS*7 Exploring the Feeling of Trust*
Lecture 15: 'Respect' – as the Right Evaluation
Tutorial 8: Practice Session PS*8 Exploring the Feeling of Respect*
Lecture 16: Other Feelings, Justice in Human-to-Human Relationship
Lecture 17: Understanding Harmony in the Society
Lecture 18: Vision for the Universal Human Order
Tutorial 9: Practice Session PS*9 Exploring Systems to fulfil Human Goal*

Module 4 – Harmony in the Nature/Existence (6 Hrs)

Lecture 19: Understanding Harmony in the Nature
Lecture 20: Interconnectedness, self-regulation, and Mutual Fulfilment among the Four Orders of Nature
Tutorial 10: Practice Session PS*10 Exploring the Four Orders of Nature*
Lecture 21: Realizing Existence as Co-existence at All Levels
Lecture 22: The Holistic Perception of Harmony in Existence
Tutorial 11: Practice Session PS*11 Exploring Co-existence in Existence*

Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics

(9 Hrs)

Lecture 23: Natural Acceptance of Human Values
Lecture 24: Definitiveness of (Ethical) Human Conduct
Tutorial 12: Practice Session PS*12 Exploring Ethical Human Conduct*
Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order
Lecture 26: Competence in Professional Ethics

Tutorial 13: Practice Session PS*13 Exploring Humanistic Models in Education*
Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical Case Studies
Lecture 28: Strategies for Transition towards Value-based Life and Profession
Tutorial 14: Practice Session PS*14 Exploring Steps of Transition towards Universal Human Order*

Content for Practice Sessions (Tutorials)

Inordertoconnectthecontentoftheproposalswithpractice(living),14practicesessionshavebeen designed. The full set of practice sessions is available in the Teacher's Manual as well as the website.

Practice Sessions for Module 1 – Introduction to Value Education
PS1 Sharing aboutOneself
PS2 Exploring Human Consciousness
PS3 Exploring NaturalAcceptance

Practice Sessions for Module 2 – Harmony in the Human Being

PS4 Exploring the difference of Needs of Self and Body

PS5 Exploring Sources of Imagination in theSelf

PS6 Exploring Harmony of Self with theBody

Practice Sessions for Module 3 – Harmony in the Family and Society
PS7 Exploring the Feeling of Trust PS8 Exploring the Feeling ofRespect
PS9 Exploring Systems to fulfil HumanGoal

Practice Sessions for Module 4 – Harmony in the Nature (Existence)
PS10 Exploring the Four Orders of Nature
PS11 Exploring Co-existence in Existence

Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics
PS12 Exploring Ethical Human Conduct
PS13 Exploring Humanistic Models in Education
PS14 Exploring Steps of Transition towards Universal Human Order

Text Book

A Foundation Course in Human Values and Professional Ethics, R R Gaur, R Asthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019. ISBN 978-93-87034- 47-1

The Teacher'sManual

Teachers' Manual for *A Foundation Course in Human Values and Professional Ethics*, RRGaur,RAsthana,GPBagaria,2ndRevisedEdition,ExcelBooks,NewDelhi,2019. ISBN978-93-87034-53-2

Reference Books

1. Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak,1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi,2004.
3. The Story of Stuff(Book).
4. The Story of My Experiments with Truth - by Mohandas KaramchandGandhi
5. Small is Beautiful - E. FSchumacher.
6. Slow is Beautiful - CecileAndrews
7. Economy of Permanence - J CKumarappa
8. Bharat Mein Angreji Raj – PanditSunderlal
9. Rediscovering India - byDharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K.Gandhi
11. India Wins Freedom - Maulana Abdul KalamAzad
12. Vivekananda - Romain Rolland(English)
13. Gandhi - Romain Rolland(English)

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Sub Code: CD203A4 **Credit:1 (L-0, T-0, P-2)**

Object Oriented Programming using Java Laboratory

Minimum Experiment to be done: 12

Course Objectives:

• To understand object-oriented programming concepts, and apply them in solving problems.
• To introduce the principles of inheritance and polymorphism; and demonstrate how they relate to the design of abstract classes
• To introduce the implementation of packages and interfaces
• To introduce the concepts of exception handling and multithreading.
• Able to solve problems using java collection framework, abstract classes and I/o classes.
• Able to develop GUI based applications and multithreaded applications with synchronization.

Pre-requisites: Basic knowledge of object-oriented programming concepts.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Able to use Java compiler, write and execute java program.
CO 2: Understand and Apply Object oriented features and Java concepts.
CO 3: Able to apply the concept of multithreading and implement exception handling
CO 4: Able to access data from a Database, Console I/O and File I/O with java program.
CO 5: Develop GUI applications.

List of Experiments:

Module	Name of Experiments	Hours	CO
Module 1: Introduction programming	**Experiment 1:** Write a simple java application, to print the message , "Welcome to java"	2	1
	Experiment 2: Write a program to print the following triangle of numbers 1 1 2 1 2 3 1 2 3 4 1 2 3 4 5	2	1

	Experiment 3: Write a program to display the month of a year. Months of the year should be held in an array.	2	1
	Assignment 1: Write a program to assign two integer values to X and Y. Using the 'if' statement the output of the program should display a message whether X is greater than Y.	2	1
	Assignment 2: Write a program to find the area of rectangle.	2	1
	Assignment 3: Write a program to list the factorial of the numbers 1 to 10. To calculate the factorial value, use while loop. (Hint Fact of 4 = 4*3*2*1)	2	1
Module2: Object oriented features and Java concepts	**Experiment 4:** Write a java program to add two integers and two float numbers. When no arguments are supplied, give a default value to calculate the sum. Use function overloading.	2	2
	Experiment 5: Write a program to perform mathematical operations. Create a class called AddSub with methods to add and subtract. Create another class called MulDiv that extends from AddSub class to use the member data of the super class. MulDiv should have methods to multiply and divide A main function should access the methods and perform the mathematical operations.	2	2
	Experiment 6: Write a program with class variable that is available for all instances of a class .Use static variable declaration. Observe the changes that occur in the object's member variable values.	2	2
	Assignment 4: Write a java program to create a Student class with following attributes Enrollment No:, Name, Mark of sub1, Mark of sub2, mark of sub3, Total Marks. Total of the three marks must be calculated only when the student passes in all three subjects. The pass mark for each subject is 50. If a candidate fails in any one of the subjects his total mark must be declared as zero. Using this condition write a constructor for this class. Write separate functions for accepting and displaying student details. In the main method create an array of three student objects and display the details.	2	2
Module3: Multithreading	**Experiment 7:** Write a Java program to define a class called employee with the name and date of appointment. Create ten employee objects as an array and sort them as per their date of appointment. ie, print them as per their seniority.	2	3

and Exception Handling	**Experiment 8:** Write a small program to catch Negative Array Size Exception. This exception is caused when the array is initialized to negative values.	2	3
	Assignment 5: Write a program to handle Null Pointer Exception and use the "finally" method to display a message to the user.	2	3
	Assignment 6: Write a program to explain the multithreading with the use of multiplication table. Three threads must be defined. Each one must create one multiplication table.	2	3
	Assignment 7: Write a program to illustrate thread priority.	2	3
Module4: Database, Console I/O and File I/O	**Experiment 9:** Write a java program that connects to a database using JDBC and does add, deletes, modify and retrieve operations.	2	4
	Experiments 10: Write a Java program to illustrate Input-output in Java programming.	2	4
	Assignment 8: Write a program to illustrate IO InputStream and OutputStreams.	2	4
Module5: GUI Applications	**Experiment 11:** Write a Java program that handles all mouse events 40-42 and shows the event name at the center of the window when a mouse event is fired. (Use adapter classes).	2	5
	Experiment 12: Create a GUI program in java with the following components. A frame with flow layout. Add the following components on to the frame. i. Two Text Field ii. A button with the label display Allow the user to enter data into the textfield When the button is clicked paint the frame by displaying the data entered in the textfield Allow the user to properly close the frame	2	5
	Assignment 9: Write a Java program which creates a frame with two buttons father and mother. When we click the father button the name of the father, his age and designation must appear. When we click mother similar details of mother also appear.	2	5

Text Books:

1. Java The complete reference, 9th edition, Herbert Schildt, McGraw Hill Education (India) Pvt. Ltd.
2. Understanding Object-Oriented Programming with Java, updated edition, T. Budd, Pearson Education.

Sub Code: CD204A4 **Credit:1 (L-0, T-0, P-2)**

Database Management System Laboratory

Questions to be set: 05 (All Compulsory)
Course Objectives: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer**.**
Pre-requisites: Corresponding theory paper Database Management Systems and associated prerequisites.
Course Outcomes(CO): On successful completion of this course, the student should be able to:

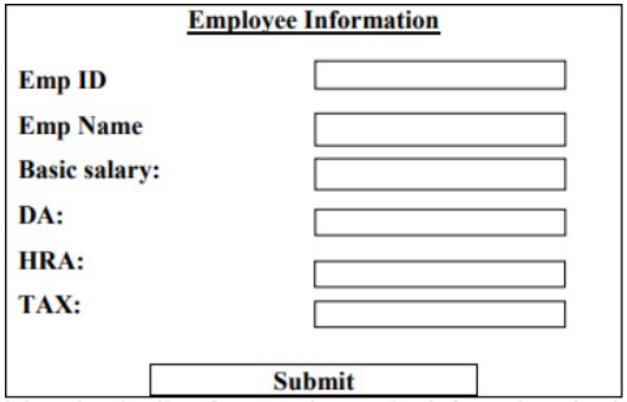
1. Select appropriate SQL/MongoDB commands and functions for a given query on the database.
2. Infer constraints and relationships between tables from conceptual/logical level schema and convert them into relationship and integrity constraints at the physical level schema.
3. Write Oracle PL/SQL Programs for data processing.
4. Design nested queries for efficient data processing on the database.
5. Test an SQL interface of a multi-user relational DBMS package to create, secure, populate, maintain, and query a database.

**** not more than 20% of total topics to be allotted for assignment**

Module	Topics to be covered	Topics	Hrs	C O
Module 1: **Implementation of DDL and DML commands, functions and operators of SQL**	In Class	Implementation of DDL and DML commands of SQL with suitable examples	0.5	1
	****Assignment Topics**	**Write SQL queries for following question**: **Customer** (Cust id : integer, cust_name: string) **Item** (item_id: integer, item_name: string, price: integer) **For the above schema, perform the following**— a) Create the tables and insert five records in each table	2.5	1
		b) Display the schema of each table		
		c) Change the data type of price from integer to number. d) Change the name of column/field item name to I_name. e) Delete the record of customer having cust_id _6‘ f) Add a column age in table Customer g) Rename the attribute price in table Item to Costprice h) Add an attribute in table Item i) Update the price of Item id ‘4‘ from 1000 to 2000 j) Update the name of Customer having id _001‘ k) Delete the contents of the table Customer l) Display table Item in the following way: i.Selected rows all columns ii.All rows selected columns ii.All rows selected columns v.Selected rows selected columns m) Drop table Customer		
	in class	Implementation of different types of functions with suitable examples.	0.5	1

	****Assignment Topics**	**Create a table EMPLOYEE with following schema: (Emp_no, E_name, E_address, E_ph_no, Dept_no, Dept_name,Job_id, Designation , Salary, DOJ)** **Write SQL statements for the following query.** 1. List the E_no, E_name, and Salary of all employees working as MANAGER. 2. Display all the details of the employee whose salary is more than the Salary of any manager 3. List the employees in the ascending order of Designations of those joined after 1981. 4. Display the sum and average of salary of all employees 5. List the employees who are either _CLERK‘ or ANALYST‘. 6. List the employees who joined on 1-MAY-81, 3- DEC-81, 17-DEC-81,19-JAN-80 . 7. List the employees who are working for the Dept no 10 or 20. 8. List the Employee names those starting with ‘S‘. 9. Display the name as well as the first five characters of name(s) starting with ‘H‘ 10. List the Employee names ending with ‘a‘. 11. Display the maximum and minimum salary of employees 12. Display the count of employees in each designation	2.5	1
	in class	Implementation of different types of operators in SQL	0.5	1

	****Assignment Topics**	**Create a table Salesmen with following schema: (salesman_id, name , city , age, commission) Write SQL statements for the following query.** 1. Filter those salesmen with all information who comes from any of the cities Paris and Rome 2. Make a list of salesman_id, name, city and commission of each salesman who live in cities other than Paris and Rome 3. Write a SQL statement to find those salesmen with all information who gets the commission within a range of 100 and 500 4. Write a query to sort out those salesmen with all information whose ID value is within any of 3007, 3008 and 3009. 5. Write a SQL statement to find those salesmen with all other information and name started with any letter within 'A' and 'K' 6. Write a SQL statement to find that salesman with all information whose name begins with the letter 'B'. 7. Write a SQL statement to find all those salesmen with all information whose names are ending with the letter 'n' 8. Write a SQL statement to find those salesmen with all information whose name containing the 1st character is 'N' and the 4th character is 'l' and rests may be any character 9. Display the salesman details in ascending order of his age 10. Display names of salesman containing two a‘s in his name 11. Display the count of salesman within the age group 25 to 35 12. Display the total number of salesman staying in each city	2.5	1

	in class	Implementation of JAVA Database connectivity.	0.5	5
	****Assignment Topics**	1. Write a program to do the following: i. Develop the following JSP page:  **ii.** After giving the details of an employee, the information should be stored in the database. The message should be displayed as "Employee information are stored successfully". Create a table named as "Login" having two columns User Id and Password. Write a program to create a login page. Once the user performs the login, the authentication should be checked from the login table and "Valid Login" or "Invalid Login" should be displayed.	2.5	5
Module 3: **SQL Joins, Subqueries and Constraints**	in class	Implementation of different types of Joins	0.5	2

		1. Find all information of sailors who have reserved boat number 101. 2. Find the name of boat reserved by Bob. 3. Find the names of sailors who have reserved a red boat, and list in the order of age. 4. Find the names of sailors who have reserved at least one boat. 5. Find the ids and names of sailors who have reserved two different boats on the same day. 6. Find the ids of sailors who have reserved a red boat or a green boat. 7. Find the name and the age of the youngest sailor. 8. Count the number of different sailor names. 9. Find the average age of sailors for each rating level. 10. Find the average age of sailors for each rating level that has at least two sailors.		
	in class	Implementation of Subqueries and Views	0.5	4
	****Assignment Topics**	**Consider the following schema:** **Sailors (sid, sname, rating, age)** **Boats (bid, bname, color)** **Reserves (sid, bid, day(date))** Write subquery statement for the following queries. 2. Find all information of sailors who have reserved boat number 101. 3. Find the name of boat reserved by Bob. 4. Find the names of sailors who have reserved a red boat, and list in the order of age. 5. Find the names of sailors who have reserved at least one boat. 6. Find the ids and names of sailors who have reserved two different boats on the same day. 7. Find the ids of sailors who have reserved a red boat or a green boat. 8. Find the name and the age of the youngest sailor.	2.5	2

		9. Count the number of different sailor names. 10. Find the average age of sailors for each rating level. 10. Find the average age of sailors for each rating level that has at least two sailors.		
	in class	Implementation of different types of constraints	0.5	2
	****Assignment Topics**	Create a table called EMP with the following structure. **Name Type** **---------- ---------- EMPNO** **NUMBER (6)** **ENAME VARCHAR2 (20)** **JOB VARCHAR2 (10)** **DEPTNO NUMBER (3)** **SAL NUMBER (7,2)** 1. Allow NULL for all columns except ename and job. 2. Add constraints to check, while entering the empno value (i.e) empno > 100. 3. Define the field DEPTNO as unique. 4. Create a primary key constraint for the table (EMPNO). 5. Create another table and add foreign key in table emp	2.5	2
	in class	Implementation of Database Backup & Recovery Commands, Rollback, Commit, save point.	0.5	2
	****Assignment Topics**	1. Write a query to implement the save point. 2. Write a query to implement the rollback. 3. Write a query to implement the commit.	2.5	2

Module 4: **PL/SQL**	in class	Basics of PL/SQL	0.5	3
	****Assignment Topics**	1. Write a PL/SQL block to find the largest of two numbers. 2. Write a PL/SQL block to calculate the area of a circle. 3. Write a PL/SQL block to calculate simple interest and compound interest. 4. Write a PL/SQL block to find the sum of first 100 odd nos. and even nos. 5. Write a PL/SQL block to find the sum of first 100 natural nos.	2.5	3
	in class	PL/SQL Continued	0.5	3
	****Assignment Topics**	1. Write a PL/SQL block to find the sum of digits of a number. 2. Write a PL/SQL block to reverse the digits of a number. 3. Write a PL/SQL block to raise the salary by 20% of given employee on following table. **Emp_Salary (eno, ename, city, salary)** 4. Write a PL/SQL block to check whether a string is a palindrome or not. 5. Write a PL/SQL block to check whether a given number is a Armstrong number. 6. Write a PL/SQL block to find factorial of a number. 7. Write a PL/SQL block to check whether a number is prime or not. 8. Write a program to generate all prime numbers below 100.	2.5	3

Module 5: **MongoDB**	in class	Basics of MongoDB	0.5	1
	****Assignment Topics**	Write a MongoDB query for the following: The collection in the database should have the name 'Departments'. It should have the following fields: Departments (Dept_id, Dept_name, Manager_id, Location) Insert at-least SIX records. a) Find the names of all departments which are located at Kolkata. b) Sort the departments according to increasing order of their 'Dept_id'. c) Find the names of all departments which are located either in _Delhi' or 'Bombay'. d) Rename the department name where Manager_id is 100.	2.5	1
	in class	MongoDB continued	0.5	1
	****Assignment Topics**	Write a MongoDB query for the following: The collection in the database should have the name 'Project'. It should have the following fields: Project(Project_id, P_name, Department, no_of_member, P_cost) Insert at-least SIX records. a) Find the Project_id and P_name of all projects belongs to 'CSE' department. b) Sort the projects alphabetically with respect to project name. c) Find the names of all projects belong to both 'ECE' and 'EE' department. d) Change the P_cost for project_id=5 to 1,00,000.	2.5	1

Text Books:

1. Elmasri and Navathe: “Fundamentals of Database Systems”, Addison Wesley.
2. Silberschatz, Korth, Sudarshan, “Database System Concepts”, McGraw-Hill

Reference Books:

1. Thomas Connolly, Carolyn Begg, “Database Systems – A Practical Approach to Design, Implementation and Management”, Pearson Education.
2. Jefrey D. Ullman, Jenifer Widom, “A First Course in Database Systems”, Pearson Education.
3. Bipin C Desai, “An Introduction to Database Systems”, Galgotia.
4. Atul Kahate, “Introduction to Database Management Systems”, Pearson.
5. Ian Robinson, Jim Webber, Emil Eifrem,”Graph Databases”,O'Reilly Media.
6. Gaurav Vaish, ”Getting started with NoSQL”, Packt.

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Core Courses: Semester – V

Sub Code: CD301A1 **Credit: 4 (L-3, T-1, P-0)**

Machine Learning

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide knowledge regarding the fundamental concepts in machine learning algorithms such as supervised, unsupervised learning algorithms and their applications.

Pre-requisites: Basic knowledge of Probability, Statistics and basic concept of algorithm.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Apply the knowledge of linear regression and logistic regression for prediction and classification problems.

CO 2: Use supervised learning algorithms to solve classification problems.

CO 3: Explain the theoretical framework for analyzing the generalization error of a learning algorithm.

CO 4: Apply unsupervised learning algorithms for dimensionality reduction and clustering techniques to real world problems.

CO 5: Explain the basic concept of Artificial Neural Network and case study.

Module	Topics	Hrs	CO
Module 1: Basics of ML and Regression	Basic Definition, Types of Learning: Supervised Learning, Unsupervised Learning, Semi supervised Learning and Reinforcement Learning, Examples of Machine Learning Applications., hypothesis space and inductive bias, evaluation, cross-validation **Linear Regression:** Linear Regression with Single Variables- Model Representation and Cost Function; Parameter Learning: Gradient Descent, Gradient Descent Intuition, Gradient Descent for Linear Regression, Linear Regression with Multiple Variables- Multiple Features, Gradient Descent for Multiple Variables, Gradient Descent in Practice: Feature Scaling and Learning Rate; Features and Polynomial Regression; **Logistic Regression**: Classification and Representation- Classification, Hypothesis Representation and Decision Boundary, Logistic Regression Model - Cost Function, Simplified Cost Function and Gradient Descent Multiclass Classification- One-vs-all,	8	1

	Regularization: Overfitting problems, Regularized Linear Regression, Regularized Logistic Regression		
Module 2: Supervised Learning	Nearest neighbor (NN), Linear Discriminant Analysis, Support vector machines, Decision Trees, Generative classifiers like naive Bayes;	8	2
Module 3: Computational learning theory	PAC learning model, Sample complexity, VC Dimension, Ensemble learning: Bagging, Boosting, Stacking	8	3
Module 4: Unsupervised Learning	Principle component Analysis, Factor Analysis, Non-negative matrix factorization, Rate-Distortion Theory, K-means, hierarchical clustering, Gaussian mixture model, Expectation-Maximization Algorithm	8	4
Module 5: Neural Networks& case study	Overview of neural networks, perceptron's, Activation functions, Multilayer network, backpropagation Algorithm. Case study for business problem solving.	8	5

Text Books:

1. Ethem Alpaydın (2010). *Introduction to Machine Learning* (2nd edition), MIT Press.
2. Tom M. Mitchell (1997). *Machine Learning.* McGraw-Hill Science.
2. Trevor Hastie, Robert Tibshirani and Jerome Friedman (2009). *The Elements of Statistical Learning* (2nd edition). Springer.

Reference Books:

1. Christopher M. Bishop (2006). *Pattern Recognition and Machine Learning*. Springer.
2. Stephen Marsland (2015). *Machine Learning: An Algorithmic Perspective* (2nd edition). CRC Press.
3. R. O. Duda, P. E. Hart, and D. G. Stork (2012). *Pattern classification.* John Wiley & Sons.
4. Shai Shalev-Shwartz and Shai Ben-David (2017). *Understanding Machine Learning*.. Cambridge University Press.

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Sub Code: CD302A1 **Credit: 4 (L-3, T-1, P-0)**

Formal Languages and Automata Theory

Questions to be set: 05 (All Compulsory)

Course Objectives: This course builds upon preliminary knowledge delivered in discrete structure for computer science and computer programming concepts. The main objectives of the course are to provide learners with a detailed understanding of the mathematical models of the machines and their evolution through requirement generation and advancement in languages. Thorough the concepts and operations in Formal Language and Automata Theory, their use in Compiler Design and their application in Natural Language Processing.

Pre-requisites: Knowledge in discrete mathematics and in programming

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain different concepts in automata theory and formal languages.

CO 2: Produce various grammars and their acceptors.

CO 3: Analyze the various language acceptors.

CO 4: Acquire a fundamental understanding of computational models related to decidability and recursive enumerability.

CO 5: Illustrate various proofs using mathematical principles.

** not more than 20% of total topics to be allotted for assignment

Module	Topics	Hrs	CO
Module 1: Introduction And Finite automata	Definitions: Language, Grammar, Automata, Relation between language, Grammar and automata, Importance of automata theory. Informal introduction: Drawing examples from everyday life to bring out the essence of finite automata, Finiteness and its importance in automata theory. Deterministic finite automata: Definition, Processing strings, Transition functions, Language of a DFA, Nondeterministic finite automata: Non-determinism, Definition, Extended transition functions, Language of a NFA, Equivalence of DFA and NFA, Kleene's theorem, Epsilon transitions, Applications of Finite automata in text search.	10	1,2
	Assignments: Mathematical preliminaries: Sets, Logic, Functions, Relations, Languages		

Module 2: Regular expressions and regular languages	Memory required to recognize a language, Regular expressions, Regular expression to finite automata, Finite automata to regular expression, Algebraic laws for regular expressions, Applications of regular expressions, Criterion for regularity, Regular languages. Pigeonhole principle, Pumping lemma for regular languages, Closure properties, **Assignments:** Testing membership of regular languages, Equivalence of automata.	8	3,5
Module 3: Context Free Grammars and Languages	Definition, Leftmost and rightmost grammars, Parse trees, Ambiguity: Ambiguous grammar, Removing ambiguity. Normal forms, Applications of context free grammars: Parsers	8	2
Module 4: Pushdown automata, Context free languages, and Turing machines	Definition of pushdown automata, Representing pushdown automata, Acceptance by pushdown automata: By final state, By empty stack, Deterministic pushdown automata, Equivalence of pushdown automata and context free grammars, Testing membership of context free, Decision problems for context free languages. Definition, Language of a Turing machine, Programming turing machines, The church-turing thesis, A simple programming language, Extensions of the basic turing machine. **Assignments:** Pumping lemma for context free languages, Closure properties of context free languages	10	2,3
Module 5: Recursively enumerable languages, decidability, and Language learning	Definition, Enumeration, Chomsky hierarchy of Recursively enumerable languages, The halting problem, the post correspondence problem. Learning framework, Inductive inference **Assignments:** Time and space complexity of turing machines, Complexity classes. Grammar induction	7	2,4

Text Books:

1. John. E. Hopcroft, Rajeev Motwani, Jeffry. Ullman,(2006) "Introduction to Automata Theory, Languages and Computation", (3rd ed) Pearson Education.
2. John Martin ,(2011) "Introduction to Languages and the Theory of Computation",(4th ed) Tata McGraw Hill.
3. Peter Linz, "An Introduction to Formal Languages and Automata", Narosa.

Reference Books:

1. James. L. Hein, "Discrete Structures, Logic and Computability", Narosa.
2. Partha Niyogi, "The Computational Nature of Language Learning and Evolution", PHI.
3. Zvi Kohavi and Niraj K. Jha, "Switching and Finite Automata theory", Tata McGraw Hill

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CD303A1 **Credit: 4 (L-3, T-1, P-0)**

Data Warehousing and Big Data Analytics

Questions to be set: 05 (All Compulsory)

Course Objectives: This course is indent for understanding the techniques behind the recent development in data warehousing and Big data analytics.

Pre-requisites: Object Oriented Programing.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain basics of data warehouse and OLAP technology.

CO 2: Understand the basic concepts of data mining.

CO 3: Describe the findatamental concepts of Big Data.

- CO 4: Apply Spark and Hadoop Ecosystem for Big Data Applications.

CO 5: Apply Apache Spark for Machine Learning Algorithms.

Module	Topics	Hrs	CO
Module 1: Data Warehouse and OLAP Technology: An Overview	Introduction to Data Warehouse, Differences between operational database systems and data Warehouses, *A Multidimensional Data Model*: From Tables and Spreadsheets to Data Cubes; Stars, Snowflakes, and Fact Constellations: Schemas for Multidimensional Databases; Examples for Defining Star, Snowflake, and Fact Constellation Schemas; Measures: Their Categorization and Computation; Concept Hierarchies; OLAP Operations in the Multidimensional Data Model; A Starnet Query Model for Querying Multidimensional Database *Data Warehouse Architecture*: Steps for the Design and Construction of Data Warehouses, A Three-Tier Data Warehouse Architecture, Data Warehouse Back-End Tools and Utilities, Metadata Repository, Types of OLAP Servers: ROLAP versus MOLAP versus HOLAP *Data Warehouse Implementation:* Efficient Computation of Data Cubes, Indexing OLAP Data, Efficient Processing of OLAP Queries *From Data Warehousing to Data Mining*: Data Warehouse Usage, From On-Line Analytical Processing to On-Line Analytical Mining	**8**	**1**

Module 2: Data Mining	Motivation, Introduction to Data Mining, Data Mining—On What Kind of Data? Data Mining Functionalities—What Kinds of Patterns Can Be Mined? Classification of Data Mining Systems, Data Mining Task Primitives, Integration of a Data Mining System with a Database or Data Warehouse System, Major Issues in Data Mining *Data Preprocessing*: Need, Descriptive Data Summarization, Data Cleaning, Data Integration and Transformation, Data Reduction, Data Discretization and Concept Hierarchy Generation	**8**	**2**
Module 3: Introduction to Big Data	Big Data: why and where, Characteristics of Big Data and Dimensions of Scalability, Data Science: Getting Value out of Big Data; Foundations for Big Data Systems and Programming; Systems: Getting started with Hadoop	8	1
Module 4: Big Data with Spark and Hadoop	Introduction to Hadoop ecosystem, Apache Spark, Data frames and Spark SQL, Development and Runtime Environment Options, Monitoring and Tuning; Data processing using Spark	8	2
Module 5: Machine Learning with Apache Spark	Spark for Data Engineers, Regression using SparkML, Classification using SparkML, Clustering using SparkML, GraphFrames on Apache Spark; Data Engineering for Machine Learning using Apache Spark: Spark Structured Streaming, ETL Workloads, Spark SQL, Feature Extraction and Transformation, Machine Learning Pipelines using Spark, Model Persistence•5 minutes	8	5

Textbooks:

1. Data Mining-Concepts and Techniques- Jiawei Han, Micheline Kamber, Morgan Kaufmann Publishers, Elsevier
2. Vignesh Prajapathi, (2013), "Big Data Analytics with R and Hadoop", (1st ed), Packt Publishing.
3. Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia, (2015), "Learning Spark: Lightning-Fast Big Data Analysis", (1st ed), O'Reilly Media Inc.

Reference Books:

1. Michael Minnelli, Michele Chambers, (2013), "Big Data Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley India Pvt. Ltd.
2. Arvind Sathi, (2012), "Big Data Analytics", (1st ed), MC Press, LLC.
3. Data Ware Housing Fundamentals, Pualraj Ponnaiah, Wiley Student Edition
4. The Data Ware House Life Cycle Toolkit- Ralph Kimball, Wiley Student Edition

E-Resources:

1. https://www.coursera.org/learn/data-warehouse-bi-building
2. https://www.ibm.com/docs/en/db2/11.5?topic=instances-creating
3. https://www.projectpro.io/projects
4. https://www.coursera.org/learn/getting-started-with-data-warehousing-and-bi-analytics
5. https://www.coursera.org/specializations/big-data
6. https://www.coursera.org/professional-certificates/ibm-data-engineer#courses

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Sub Code: CD304A1 **Credit:4 (L-3, T-1, P-0)**

COMPUTER NETWORKS

Questions to be set: 05 (All Compulsory)

Course Objectives: This course emphasizes on several computer network concepts, applications and protocols in OSI as well as TCP/IP layered architecture. It also covers the various protocols of various layers, their operations and applications. Further it discusses the concept of network security, challenges and their counter measures.

Pre-requisites: NIL

Course Outcomes (CO): On successful completion of this course, students will be able to:

1. Understand and identify the engineering fundamentals concerning Data Communication and Computer Network.
2. Identify the complex engineering problem involved in Data communication and its architecture for a successful network based communication.
3. Ability to Practice and formulate a solution for an engineering problem concerning any layers in Data Communication model
4. Demonstrate an ability to formulate and interpret a model based on the fundamentals of Computer Networks
5. Compare and understand the IOS reference model and TCP-IP reference model for data communication

**** not more than 20% of total topics to be allotted for assignment**

Module	Mode	Topics	Hrs	CO
Module 1: <Overview & Data Link Layer >	in class	Introduction to data communications, Types of Network, Store and forward, Packet Switching, Circuit Switching, Layered architecture: OSI and TCP/IP, Performance Metric: Delay, Throughput, Jitter Data link layer design issue, Error detection and correction: Parity bit, Polynomial: CRC. Elementary data link protocol: Random Access: ALOHA, Slotted ALOHA, CSMA, CSMA/CD, Controlled Access: Reservation, Polling. Ethernet Frame Structure, L2 Addressing, ARP.	9	1,5
	****Assignment Topics**			
Module 2: < Network Layer & Routing>	in class	Network Topology and performance evaluation, Internet Protocol: IPv4 and IP addressing and sub-netting. Internet Control Message Protocol (ICMP), Mapping Physical to Logical Address: Reverse Address	9	1,2

		Resolution Protocol (RARP), Dynamic Host Configuration Protocol (DHCP). Structure of IP datagram, Network Address Translation (NAT). Distance Vector routing (DVR), Link state routing, and Interior gateway protocol: Routing Information Prortocol (RIP) and Open Shortest Path First (OSPF), Exterior gateway protocol: Border Gateway Protocol (BGP).		
	****Assignment Topics**			
Module 3: < Transport Layer>	in class	Functions of transport layer protocols: Reliable and unreliable service, Introduction to Transmission Control Protocol (TCP) and User Datagram Protocol (UDP), Header description of TCP and User Datagram Protocol (UDP), Congestion control mechanism of TCP.	9	1,3
	****Assignment Topics**			
Module 4: < Application Layer>	in class	Brief overview of protocols in Application Layer: Domain Name Systems, Hyper Text Transmission Protocol,), Multimedia Application: Audio and video streaming using UDP, VoIP.	9	1,4
	****Assignment Topics**			
Module 5: < Network Security & Other Network Technologies >	in class	Confidentiality, Authenticity, Integrity and Non-repudiation, Attacks, Introduction to Symmetric and asymmetric Cryptography. Wireless LAN: IEEE 802.11 specification, CSMA/CA. Introduction to Cellular Network, Ad Hoc Network and Software Defined Network	4	1,2
	****Assignment Topics**			

Text Books:

1. Behrouz A. Forouzan, “Data Communications and Networking”, Tata McGraw Hill.
2. William Stallings, “Data and Computer Communications”, PHI.

Reference Books:

1. Andrew S. Tanenbaum, “Computer Networks”, PHI.
2. A S Godbole, “Data Communication and Networking”, Tata McGraw Hill.
3. William C Y Lee, “Mobile Communication Engineering”, Tata McGraw Hill.
4. Larry L. Peterson, Bruce S. Davie, “Computer Networks: A Systems Approach”, Wiley

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Sub Code: CD301A4 **Credit: 1(L-0,T-0,P-2)**

Machine Learning using Python Laboratory

Minimum Experiment to be done: 12

Course Objectives: To provide knowledge regarding the hands-on exposure to ML tools and techniques to solve real-world problems. The knowledge of ML techniques leads to the advancement of research and technology.

Pre-requisites: Python programming, Linear Algebra, Probability and Statistics.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Implement Linear Regression to predict the output.

CO 2: Implement Supervised Learning models for classification tasks.

CO 3: Utilize scikit-learn to implement ML models.

CO 4: Understand the unsupervised learning.

CO 5: Implement simple neural network and learn ML model deployment tools

List of Experiments:

Module	Name of Experiments	Hours	CO
Module:1 Supervised Learning : Regression (Prediction)	Experiment 1: Linear regression: Model Representation, Cost Function, Gradient Descent Algorithm	4	1,3
	Experiment 2: Utilize scikit-learn to implement linear regression using Gradient Descent		
	Assignment1: Multiple linear regression: Feature Scaling using z-score normalization, Gradient Descent with Multiple Variables		
Module:2 Supervised Learning-I : Classification	Experiment 3: Logistic Regression: Problem Statement, Loading and visualizing the data, Sigmoid function (also known as the logistic function), Logistic Loss, Cost function, Gradient Descent, Learning Parameter, Decision boundary, Evaluating Logistic Regression	4	2,3
	Assignment2: Utilize scikit-learn to implement logistic regression using Gradient Descent Assignment3: Overfitting		
	Experiment 4: Regularization		

Module:3 Supervised Learning-II : Classification	Experiment 5: Implement a decision tree from scratch and apply it to the task of classifying whether a mushroom is edible or poisonous. Experiment 6: Utilize scikit-learn to implement Decision tree and K-NN. Assignment 4: Utilize scikit-learn to Naive Bayes , SVM and Random forest.	4	2, 3
Module:4 Unsupervised Learning	Experiment 7: K-Means clustering Assignment 4**:** Expectation Maximization algorithm and 2 component GMM	6	4
	Experiment 8: Principal Component Analysis (PCA)		
	Experiment 9: Anomaly Detection		
Module:5 Neural Network and ML Deployment	Experiment 10: Neural Networks for Binary Classification	4	5
	Experiment 11 & 12: Deploy a Machine Learning Model		

Textbooks:

1. Saikat Dutta, (2020), "Machine Learning", (5th ed), Pearson press.

2. Ethem Alpaydın,(2010) "Introduction to Machine Learning", (2nd ed), MIT Press.

3. Tom M. Mitchell, (1997), "Machine Learning", (1st ed), McGraw-Hill Science.

Reference Books:

1. Christopher M. Bishop, (2006), "Pattern Recognition and Machine Learning", (1st ed), Springer.

2. Stephen Marsland, (2015), "Machine Learning: An Algorithmic Perspective", (2nd ed), CRC Press.

E-Resources:

1. https://www.coursera.org/specializations/machine-learning-introduction
2. https://www.coursera.org/specializations/machine-learning
3. https://www.coursera.org/specializations/machine-learning-tensorflow-gcp

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Sub Code: CD302A4 **Credit: 1(L-0,T-0,P-2)**

Computer Networks Laboratory

Course Objectives: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Communication Technique and Data Communication

Course Outcomes (CO):

1. Identify and understand various functions used in socket programs
2. Develop and test of socket program for client server interaction for various purpose.
3. Implementing and Validate Sub network with static and various dynamic routing protocols.
4. Analyze the packet structure of various protocols used for communication
5. Understand the fundamentals of SDN

**** not more than 20% of total topics to be allotted for assignment**

Module	Topics to be covered	Topics	Hrs	CO
Module 1: TCP Socket Programs	in class	Introduction to client-server architecture, Introduction to working of TCP, functions related to TCP Socket Programming.	4	1,2
	****Assignment Topics**	Program to write a simple Message passing TCP socket program, TCP Socket program with specific aim, TCP socket program involving multiple clients.	3	1,2
Module 2: UDP Socket Programs	in class	Introduction to client-server architecture, Introduction to working of UDP, functions related to UDP Socket Programming.	4	1,2
	****Assignment Topics**	Program to write a simple Message passing UDP socket program, UDP Socket program with specific aim.	3	1,2
Module 3: Creating/Designing Sub-network with	In Class	Introduction to classless IP, Introduction to CIDR and VLSM, Introduction to Network Devices and Sub-netting, Basic Router	3	3

Static routing		configuration followed by Static route configuration		
	****Assignment Topics**	To configure the sub-network with given requirements and configure the static route in the topology for routing.	3	3
Module 4: Creating/Designing Sub-network with Dynamic routing	in class	Revision to CIDR and VLSM, revision to Basic Router configuration followed by Dynamic route configuration	3	3
	****Assignment Topics**	To configure the sub-network with given requirements and configure the Dynamic route in the topology for routing.	3	3
Module 5: Introduction to SDN and traffic Monitoring	in class	Introduction to Software Defined Network, Introduction to Installation of Mininet, Overview of Mininet environment, Introduction to tools like ipref and wire shark.	3	4,5
	****Assignment Topics**	To establish and configure the simple SDN network topology and use tools like ipref and wire shark for necessary analysis.		

Text Books:

1. Behrouz A. Forouzan, "Data Communications and Networking", Tata McGraw-Hill
2. Andrew S. Tanenbaum, "Computer Networks", PHI.

Reference Books:

1. William Stallings, "Data and Computer Communications", PHI.
2. Alberto Leon-Garcia, Indra Widjaja, "Communication Networks – Fundamental Concepts and Key Architectures", Tata McGraw-Hill

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Sub Code: **GN301A1** **Credit: 1 (L-1, T-0, P-0)**

QUANTITATIVE APTITUDE AND LOGICAL REASONING - I

Questions to be set: 05 (All Compulsory)

Course Objective: The main aim of introducing "Quantitative Aptitude & Logical Reasoning" to university students is to develop numerical skills among students and to prepare them for various examinations to enhance better job prospects. This initiative is being taken to include essential mathematical principles to build students' confidence. It is expected to expand students' knowledge and foster their logical reasoning and analytical thinking abilities.

Pre-requisites: NIL

Course Outcomes (CO): On successful completion of the course

CO	STATEMENT
CO1	Student will be able to solve variety of simple problems in the space of quantitative domain.
CO2	Students will be able to use data to determine or to deduce other facts from a set of given data of less complexity.
CO3	Students will be able to use shortcuts, tricks and techniques to solve the problems with moderate accuracy.
CO4	Students will be able to demonstrate essential skills pertaining to public speaking, resume writing and telephone etiquette.
CO5	Students will be able to demonstrate basic skills during the placement interviews

Module	Topics to be covered	Topics	Hrs.	CO	PO	PSO
Module 1: **Quantitative Aptitude**	In class	Problems on Trains, Time and Distance, Height and Distance, Time and Work, Simple Interest, Compound Interest, Profit and Loss, Partnership, Percentage, Problems on Ages, Calendar, Clocks, Average, Area, Volume and Surface Area	6	1		
Module 2: **Puzzles, Problem Solving and Analysis**	In class	Sudoku, Number Puzzles, Missing Letter Puzzles, Playing Card Puzzles, Clock Puzzles.	3	2		
Module 3:	In class	Number Series, Letter and Symbol series, Verbal Classification Essential Part, odd man out and visual	5	3		

Logical Reasoning		reasoning, Analogies, Artificial Language, Matching Definitions, Making Judgements.				
Module 4: **Professional Builder**	In class	Resume Writing, Public Speaking, Extempore, Telephone etiquette.	4	4		
Module 5: **Use Cases**	In Class	Mock Interview – Hard and Soft Skills Sector: FMCG, IT, Production, Manufacturing etc.	2	5		

Text books:

1. Aggarwal, R. S. (2008). *Quantitative Aptitude*. S. Chand., ISBN: 9788121924986, 8121924987
2. Devi, S. (2005). *Puzzles to puzzle you*. Orient Paperbacks., ISBN: 8122200141, 9788122200140

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Core Courses: SEMESTER – VI

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Sub Code: BA346A1 **Credit: 2 (L-2, T-0, P-0)**

Industrial Management

Questions to be set: 05 (All compulsory)

Course Objective: To provide basic knowledge of functions of management along with their practical implications

Pre-requisites: NIL

Course Outcomes (CO):

CO1: To provide basic knowledge and application of functions of management

CO2: To help students to understand and apply principles of management evolved by pioneers of management.

CO3: To enable students to apply basic quantitative techniques for making decisions related to operations management

CO4: To help students apply various techniques for optimal production management

CO5: To apply concepts of materials management for maintaining optimal inventory

Module	Topics	Hrs	CO
Introduction	Philosophy and Development of Management thought. Concept and definition of management, Functions and Roles of Management, Social Responsibilities of Management.	3	1
Pioneers in Management	Taylor's Scientific Management, Contribution of Henry Fayol, Maslow, McGregor, Gilbreth and Mayo.	3	2
Quantitative Techniques in Managerial Decisions	Concept of budget and budgetary control. Time-event network analysis; ABC Analysis, Break-even Analysis; Decision Tables; Concept of productivity, measuring productivity, Use information technology	5	3
Production Management	Types of production; Types of Planning, Manufacturing Planning; Production planning, Scheduling; Work study & Method Study; Systems of wage payments, bonus, Automation. Organization of production, planning and control department.	5	4
Materials Management	Practice of purchasing and materials management, quality, Inventory Management, EOQ model; Value Analysis and Value Engineering.	4	5

Text Books:

1. H. Koontz and H. Weihrich (1989). Management. McGraw Hill.

Reference Books:

1. Dobler W.D. (1984). Purchasing & Materials Management. TMHC, New Delhi.

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Sub Code: CD305A1 **Credit: 4 (L-3, T-1, P-0)**

Deep Learning

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of the course is to familiarize students with deep learning algorithms, regularization and optimization techniques for deep learning.

Pre-requisites: Familiarity with Probability theory and Linear Algebra, Basic Programming knowledge.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the basic concept of deep learning.

CO 2: Apply gradient based optimization and regularization techniques in solving problems.

CO 3: Apply the appropriate CNN architectures based on the applications.

CO 4: Explain the various architectures of sequence models.

CO 5: Understand the concept of state-of-the art Generative AI models.

Module	Topics	Hrs	CO
Module 1: Introduction	Biological Neuron, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm Multilayer Perceptrons (MLPs), Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Backpropagation	8	1
Module 2: Gradient-based optimization algorithms and Regularization	Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout	8	2
Module 3: Convolutional Neural Networks	Convolutional Neural Networks, LeNet5, AlexNet, VGGNet, GoogLeNet, ResNet , MobileNetv2, U-NET, Object Detection: Faster RCNN, YOLO, SSD, Transfer Learning Concept.	10	3
Module 4: Sequence Model	Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Gated Recurrent Units (GRUs), Long Short Term Memory	10	4

	(LSTM) Cells, Solving the vanishing gradient problem with LSTMs, Word embedding (Word2Vec), Encoder-Decoder Models, Attention Mechanism		
Module 5: Generative AI:	Generative Adversarial Networks, Variational autoencoder, Diffusion Model, Transformer. *Discussion on Research Article R2*	8	5

Text Books:

1. Aaron Courville, Ian Goodfellow, and Yoshua Bengio, (2015)"Deep Learning", (1st ed), MIT Press

2. Li Deng and Dong Yu , (2014), "Deep Learning: Methods and Applications"(1st ed) new publishers.

Reference Books:

1. "Deep Learning Tutorial" By LISA Lab, University of Montreal

2. Gozalo-Brizuela, R., & Garrido-Merchan, E. C. (2023). ChatGPT is not all you need. A State of the Art Review of large Generative AI models. *arXiv preprint arXiv:2301.04655*. [Online] https://arxiv.org/pdf/2301.04655

E-Resources:

1. http://cse.iitm.ac.in/~miteshk/CS7015_2018.html
2. http://cse.iitm.ac.in/~miteshk/CS6910.html
3. https://www.coursera.org/specializations/deep-learning

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Sub Code: CD306A1 **Credit: 4 (L-3, T-1, P-0)**

Text Analytics and Natural Language Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide knowledge regarding the technique that how the NLP attempts to interact with humans and human texts via language through a set of sequential process like problem definition, analysing and decision making. This course also provide the idea about the translating from one language to another with cooperative tasks.

Pre-requisites: Data Structures. Basic of text and natural language, some familiarity with probability would help.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the basic concepts of automata.

CO 2: Describe Morphology Parsing.

CO 3: Use words and sentence tokenization for natural language processing.

CO 4: Explain the process steps in NLP.

CO 5: Performnormalization and segmentation of text and other processes for Text analysis.

Module	Topics	Hrs	CO
Module 1: Basics of automata	Basics of Finite State Automata, Knowledge in Speech and Language Processing, Ambiguity, Models and Algorithm	7	1
Module 2: Survey of English Morphology	Survey of English Morphology, Finite-State Morphological Parsing, Building a Finite- State Lexicon, FSTs for Morphological Parsing, Lexicon-Free FSTs	7	2
Module 3: Words and sentence tokenization	Words and sentence tokenization, Detecting and Correcting Spelling Errors. English Word Classes :Tag-sets for English, Part-of-Speech Tagging, The Noisy Channel Model for Spelling	6	3
Module 4: Natural Language Processing	Introduction, Components of NLP , Difficulties in NLU , NLP Terminology , Process Steps in NLP , Deep Learning Based NLP, Implementation Aspects of Syntactic Analysis , Advantages and limitations of NLP, Application of NLP	6	4

Module 5: Case study	Normalizing Text, Segmentation. N-Grams, Unsmoothed N-Grams, Smoothing, Interpolation, and Backoff, Automatic Tagging. Constituency, Some Grammar Rules for English, The Penn Treebank project, Dependency Grammar. Parsing with Context Free Grammars, CKY algorithm, Statistical Parsing	10	5

Text Books:

1. Steven Bird, Ewan Klein and Edward Loper, (2009), "Natural Language Processing with Python" (1st ed), O'Reilly publishers .

2. Julia Silge and David Robinson, (2017), "Text Mining with R", (1st ed), O'Reilly publishers .

Reference Books:

1. Christopher Manning, and Hinrich Schütze, (1999), "Foundations of Statistical Natural Language Processing", (1st ed). MIT press.

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Sub Code: **CD303A4** **Credit: 1(L-0,T-0,P-2)**

Deep Learning Laboratory

Minimum Experiment to be done: 12

Course Objectives: Make student efficient to develop different models used in deep learning with the help of Python associated with tensor-flow.

Pre-requisites: Basic knowledge in deep learning, Python script and tensor flow.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Implement Activation functions and Shallow Neural Networks.

CO 2: Implement feedforward Deep Neural Network.

CO 3: Implement Gradient Descent based optimization algorithms and regularization techniques.

CO 4: Implement CNN and apply it in realizing various applications.

CO 5: Implement sequence models (RNN and LSTM), and apply it in realizing various applications.

List of Experiments:

Module	Name of Experiments	Hours	CO
Module:1 (Activation and Simple Neural Network)	**Experiment no 1**: Write a python program to implement activation functions and its derivatives.	2	1
	Experiment no 2.1 & 2.2: Build a logistic regression classifier with neural network mindset to recognize cats. [Hint: **Logistic Regression is actually a very simple Neural Network (Sigmoid Neuron)**] • Write a python program for forward pass for a sigmoid neuron. • Write a python program to implement the cost function and its gradient for the propagation. • Write a python program to implement gradient descent optimization algorithm to updates the parameters weight and bias. • Use w and b to predict the labels for a dataset X.	2+2	1
	Experiment no 3 : Write a python program for Planar Data Classification with One Hidden Layer.	2	1

Module:2 (Feedforward Deep Neural Network)	**Experiment no 4**: Write a python program to build feedforward Deep Neural Network: Step by Step.	2	2
	Experiment no 5.1: Write a python program to build feedforward Deep Neural Network(with 2 Layer i.e. (INPUT -> LINEAR -> RELU -> LINEAR -> SIGMOID -> OUTPUT) for Image Classification application.	2	
	Experiment no 5.2: Write a python program to build feedforward Deep Neural Network (with L Hidden Layer i.e. model can be summarized as: [LINEAR -> RELU] × (L-1) -> LINEAR -> SIGMOID) for Image Classification Application.	2	
Module:3 (Optimization and Regularization)	**Experiment no 6**: Write a python program to implement Gradient Descent based optimization algorithms.	2	3
	Experiment no 7: Write a python program to implement regularization techniques using inbuilt libraries.	2	
Module:4 (Convolutional Neural Network)	**Experiment no 8.1 & 8.2 :** Write a python program to implement Convolutional Neural Networks: Step by Step.	2+2	4
	Experiment no 9.1: Create a mood classifer using the TF Keras Sequential API.	2	
	Experiment no 9.2: ConvNet to identify sign language digits using the TF Keras Functional API.		
	Experiment no 10.1: Write a python program to Implement the Identity block-Skip connection "skips over" 2 layers, of ResNets in a deep neural network using Keras.	2+2	
	Experiment no 10.2: Write a python program to Implement the Convolutional block of ResNets in a deep neural network using Keras. **Experiment no 10.3** : Write a python program to implement ResNet-50 model for Image Classification.		
Module:5 (Sequence Models)	**Experiment no 11:** Write a python program to building Recurrent Neural Network (basic RNN and LSTM) - Step by Step.	2+2	5
	Experiment no 12: Write a python program to build a character-level text generation model using RNN and LSTM.	2+2	

Assignment 1: Implement Face Verification and Face Recognition System using Transfer Learning.

Assignment 2: Implement sentiment classifier using word embeddings.

Assignment 3: Implement an algorithm for trigger word detection (sometimes also called keyword detection, or wake word detection).

Assignment 4: Implement Transformer Network Application: Named-Entity Recognition.

Textbooks:

1. Yoshua Bengio , Aaron Courville (2016) Deep Learning by Ian Good fellow. The MIT Press.
2. Mark Lutz , (2013), "Learning Python", (5th ed), O'Reilly publishers
3. Hadley Wickham , Garrett Grolemund, (2017), "R for data science". (1st ed), O′Reilly publishers

Reference Books:

1. Li Deng ,Dong Yu, (2014), "Deep Learning: Methods and Applications". (1st ed) , now publishers Inc
2. Deep Learning Tutorial by LISA Lab, University of Montreal

E-Resources

1. https://www.coursera.org/specializations/deep-learning
2. https://github.com/cmaroblesg/Deep_Learning

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Sub Code: CD304A4 **Credit: 1(L-0,T-0,P-2)**

Data Warehousing and Big Data Analytics Laboratory

Minimum Experiment to be done: 12

Course Objectives:

1. Learn how to build a data warehouse and query it (using open source tools like Pentaho Data Integration Tool, Pentaho Business Analytics).
2. Learn to perform data mining tasks using a data mining toolkit (such as open source WEKA).
3. Learn Hadoop and Spark
4. Learn to implement ML models with Apache Spark
5. Learn Data Engineering with Apache Spark

Pre-requisites: Basic knowledge of big data and use of tools.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Build Data Warehouse.

CO 2: Apply Weka tool for data mining.

CO 3: Use Hadoop and Spark.

CO 4: Implement Machine Learning with Apache Spark

CO 5: Understand Data Engineering with Apache Spark.

List of Experiments:

Module	Name of Experiments	Hours	CO
Module:1 Build Data Warehouse	A. Build Data Warehouse/Daata Mart (using open source tools like Pentaho Data Integration Tool, Pentaho Business Analytics; or other data warehouse tools like Microsoft-SSIS, Informatica, Business Objects,etc.,) A.1 Identify source tables and populate sample data. A.2. Design multi-dimensional data models namely Star, Snowflake and Fact Constellation schemas for any one enterprise (ex. Banking, Insurance, Finance, Healthcare, manufacturing, Automobiles, sales etc).	6	1
	A.3. Write ETL scripts and implement using data warehouse tools.		
	A.4 Perform Various OLAP operations such slice, dice, roll up, drill up and pivot.		

	A.5 Explore visualization features of the tool for analysis like identifying trends etc		
Module 2 Explore WEKA Data Mining/Machine Learning Toolkit	Explore WEKA Data Mining/Machine Learning Toolkit for understanding features of Weka toolkit, perform data preprocessing tasks and demonstrate association rule mining on data sets, and demonstrate performing classification on data sets.	6	2
Module 3 Hadoop and Spark	Getting Started with Hive, Hadoop MapReduce, Hadoop Cluster (Optional) Getting Started with Spark using Python Introduction to DataFrames Introduction to SparkSQL Submit Apache Spark Applications Apache Spark on Kubernetes Monitoring and Performance Tuning Data Processing Using Spark Data Analysis using Spark ETL using Spark, Analyze a dataset using SparkSQL, Feature Extraction and Transformation Lab, PipeLine creation using SparkML, Model Persistence Hadoop Implementation of file management tasks, such as Adding files and directories, retrieving files and Deleting files Implement of Matrix Multiplication with Hadoop Map Reduce Experiments on Cloudera Distribution for Hadoop	6	3
Module:4 Machine Learning with Apache Spark	Connecting to Spark Cluster using SN Labs Regression using SparkML Classification using SparkML	4	4

	Clustering Customer Data using SparkML		
Module:5 Data Engineering with Apache Spark	ETL using Spark	4	5
	Analyze a dataset using SparkSQL		
	Feature Extraction and Transformation Lab		
	PipeLine creation using SparkML,		
	Model Persistence		

Textbooks:

1. Vignesh Prajapathi, (2013), "Big Data Analytics with R and Hadoop", open source, Packt Publishing.
2. Holden Karau, Andy Konwinski, Patrick Wendell, Matei Zaharia, (2015), "Learning Spark: Lightning-Fast Big Data Analysis", (1st ed), O'Reilly Media Inc.

Reference Books:

1. Michael Minnelli, Michele Chambers, (2013), "Big Data Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", (1st ed), Wiley India Pvt. Ltd.

E-Resources:

1. https://www.coursera.org/learn/data-warehouse-bi-building
2. https://www.coursera.org/professional-certificates/data-warehouse-engineering
3. https://www.coursera.org/learn/data-warehousing-capstone-project#modules
4. https://www.coursera.org/learn/introduction-to-big-data-with-spark-hadoop
5. https://www.coursera.org/learn/machine-learning-with-apache-spark

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Sub Code: **GN302A1** **Credit: 1 (L-1, T-0, P-0)**

QUANTITATIVE APTITUDE AND LOGICAL REASONING - II

Questions to be set: 05 (All Compulsory)

Course Objective:
The key objective of this course is to strengthen the numerical skills and logical abilities & skills of university students and prepare them for various competitive exams, thereby improving their employment opportunities. This initiative aims to incorporate fundamental mathematical principles to build students' confidence. Additionally, it seeks to broaden their knowledge and foster their logical reasoning and analytical thinking skills.
Pre-requisites: NIL

Course Outcomes (CO): On successful completion of the course

CO	STATEMENT
CO1	Student will be able to solve variety of problems simple to complex in the space of quantitative domain.
CO2	Students will be able to use data to determine or to deduce other facts from a set of given data which are simple to complex.
CO3	Students will be able to use shortcuts, tricks and techniques to solve the problems with high accuracy.
CO4	Students will be able to demonstrate essential skills pertaining to business communications.
CO5	Students will be able to demonstrate advanced skills required at the time of placement interviews.

Module	Topics to be covered	Topics	Hrs.	CO
Module 1: **Quantitative Aptitude**	In class	Problems on Permutations and Combinations, Probability, Numbers, Problems on Numbers, Problems on HCF and LCM, Decimal Fraction, Simplification, Square Root and Cube Root, Surds and Indices, Ratio and Proportion, Chain Rule, Pipes and Cistern, Boats and Streams, Allegation and Mixtures, Logarithm, Races and Games, Stocks and Shares, Probability, True Discount, Odd man out and Series.	8	1
Module 2: **Puzzles, Problem Solving and Analysis**	In class	Logical Connectives and Syllogisms, Data Interpretation, Cases, Venn Diagrams.	3	2
Module 3: **Logical Reasoning**	In class	Verbal Reasoning, Logical Problems, Logical Games, Data Arrangement and Blood Relations, Analyzing Arguments, Statement and Assumption, Course of action, Statement and Conclusion, Theme	4	3

		Detection, Cause and Effect, Statement and Argument, Logical Deduction.		
Module 4: **Professional Builder**	In class	CV Writing, Verbal & Non Verbal Communication, Group Discussion, Netiquettes,	2	4
Module 5: **Use Cases**	In Class	Mock Interview on Hard and Soft Skills Sector - IT, FMCG, Product, Financials, Manufacturing, Production, Construction etc.	3	5

Text books:

1. Aggarwal, R. S. (2008). *Quantitative Aptitude*. S. Chand., ISBN: 9788121924986, 8121924987
2. Devi, S. (2005). *Puzzles to puzzle you*. Orient Paperbacks., ISBN: 8122200141, 9788122200140

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PROGRAM ELECTIVES

List of Program Electives

Subject Code	Program Elective-I (3rd Semester)	CR	Subject Code	Program Elective-IV(6th Semester)	CR
CD201A3	Object Oriented Programming using Python	4	CD306A3	Machine Learning Operations (MLOps)	4
CD202A3	Digital Signal Processing	4	CD307A3	Compiler Design	4
CD203A3	Mathematical Foundation for Machine Learning	4	CD308A3	Cloud Computing	4
CD204A3	Fundamentals of Web Technologies	4	CD309A3	Remote Sensing & GIS	4
			CD310A3	Augmented and Virtual Reality	4
			CD311A3	High Performance Computing	4
			CD312A3	Cryptography and Network Security	4
			CD313A3	DevOps Engineering	4
	Program Elective-II (4th Semester)			**Program Elective-V (6th Semester)**	
CD205A3	Operating System	4	CD314A3	Generative AI and Prompt Engineering	4
CD206A3	Introduction to Artificial Intelligence	4	CD315A3	Social Network Analytics	4
CD207A3	Programming in Java	4	CD316A3	Blockchain Technologies	4
CD208A3	Speech Processing	4	CD317A3	Bio-Inspired Computing	4
CD209A3	Analog Electronic Circuits	4	CD318A3	Quantum Computing	4
	Program Elective-III (5th Semester)		CD319A3	Reinforcement Learning	4
CD301A3	Digital Image Processing	3	CD320A3	Cyber Security	4
CD302A3	Optimization Techniques	3	CD321A3	Wireless Sensor Network	4
CD303A3	Internet of Things (IoT)	3	CD322A3	MERN Stack Development	4
CD304A3	ARM controller	3			
CD305A3	Parallel and Distributed Algorithms	3			

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Program Elective-I (3rd Semester)

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Sub Code: **CD201A3** **Credit: 4 (L-3, T-1, P-0)**

Object Oriented Programming using Python

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide knowledge regarding the OOPs programming like basics of Python along with the technique for handling I/O, packaging and basic GUI.

Pre-requisites: Basic programming skills

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Acquire programming skills in core Python.

CO 2: Acquire Object-oriented programming skills in Python.

CO 3: Develop the skill of designing graphical-user interfaces (GUI) in Python.

CO 4: Develop the ability to write database applications in python

CO 5: Acquire Python programming skills to move into specific branches - Internet of Things (IoT), DataScience, Machine Learning (ML), Artificial Intelligence (AI) etc.

Module	Topics	Hrs	CO
Module 1: Introduction to python and object oriented concepts	Introduction to Python: Features of Python, Data types, Operators, Input and output, Control Statements. Introduction to Object Oriented Concepts: Features of Object-oriented programming system (OOPS) – Classes and Objects, Encapsulation, Abstraction, Inheritance, Polymorphism.	8	1
Module 2: Python classes and objects	Classes and Objects: Creating a class, The Self variable, Constructor, Types of Variable, Namespaces, Types of Methods, Inheritance and Polymorphism – Constructors in inheritance, the super () method, types of inheritance, polymorphism, abstract classes and interfaces.	8	2

Module 3: Strings and functions	Strings: Creating strings and basic operations on strings, string-testing methods. Functions: Defining a function, Calling a function, returning multiple values from a function, functions are first class objects, formal and actual arguments, positional arguments, recursive functions.	8	3
Module 4: Exception handling	Exception: Errors in a Python program, exceptions, exception handling, types of exceptions, the except block, the assert statement, user-defined exceptions.	8	4
Module 5: Graphical user interface	GUI in Python: The root window, fonts and colors, working with containers, Canvas, Frames, Widgets – Button widget, Label widget, message widget, text widget, radio button widget, entry widget.	8	5

Text Books:

1. R Nageswara Rao (2017). *Core Python Programming* (2nd edition), Dreamtech press.
2. Dusty Philips (2015), "Python Object Oriented Programming", (2nd ed) PACKT Publishing.

Reference Books:

1. Mark Lutz (2013) "Programming Python", (5th ed) O'Reilly
2. Michael Goldwasser, David Letscher, (2007) "Object Oriented Programming in Python", (1st ed) Prentice Hall.

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Sub Code: **CD202A3** **Credit: 4 (L-3, T-1, P-0)**

Digital Signal Processing

Questions to be set: 05 (All Compulsory)

Course Objectives:
(1) To Analyze signals and systems in time and frequency domain.
(2) To attain a good analytical ability in digital filter design.
(3) To investigate the applications of digital signal processing.
Pre-requisites: Calculus

Course Outcomes (CO):
Upon successful completion of the course, students should be able to
CO 1: Illustrate signals, systems and their significance.
CO 2: Analyze the signals using various digital transforms DTFT, DFT etc.
CO 3: Understand Z-transform, the discrete analogue of Laplace Transform.
CO 4: Explain the fundamentals of IIR and FIR filters.
CO 5: Understand the fundamental concepts of adaptive filters and real-world applications of signal processing.

Module	**Topics**	**Hrs**	**CO**
Module 1: Signals and Systems	Continuous-Time and Discrete-Time Signals, Nyquist Sampling Theorem, LTI Systems and its properties, Generation of Signals and basic operations using MATLAB/OCTAVE	**8**	**1**
Module 2: Frequency Analysis	Discrete Time Fourier Transform (DTFT), Properties of DTFT, Discrete Fourier Transform (DFT), Properties of DFT, Frequency analysis of signals and systems using MATLAB/OCTAVE	8	2
Module 3:	Z-Transform, ROC, Poles & Zeros, Properties of Z-Transform	8	3

Module 4: Fundamentals of IIR & FIR Filters	Introduction to Analog IIR Filters; Design of Butterworth IIR LPF Filters. Windowing, Design of FIR filter using Window, Filter structures	8	4
Module 5: Adaptive Filters and DSP Applications	Basics of Adaptive filters; Wiener Filters and LMS Filter, Real-world applications of digital signal processing	8	5

Text Books:

1. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab (1996).*Signals and Systems* (2nd ed.). PHI
2. John G Proakis, Dimitris Manolakis (2007). *Digital Signal Processing* (4th ed.). Pearson
3. S.K.Mitra (2013). *Digital Signal Processing: A Computer - Based Approach* (4th edition). McGraw Hill Education.

Reference Books:

1. K.S. Thyagarajan (2019). *Introduction to Digital Signal Processing Using MATLAB with Application to Digital Communication*s (1st Edition)Springer
2. *Vinay K. Ingle and John G. Proakis (2011). Digital Signal Processing Using MATLAB* (3rd Edition). CL Engineering.

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Sub Code: **CD 203A3** **Credit: 4 (L-3, T-1, P-0)**

Mathematical Foundations for Machine Learning

Questions to be set: 05 (All Compulsory)

Course Objective: The Mathematical Foundations for Machine Learning course aims to equip students with the essential mathematical tools necessary for understanding and excelling in the field of machine learning. Throughout the course, participants will delve into key topics that form the backbone of machine learning mathematics. These topics include: Linear Algebra and Analytic Geometry, Matrix Decompositions, Vector Calculus, Probability and Distributions and Optimization.

Pre-requisites: NIL.

Course Outcomes (CO): ***Upon successful completion of the course, students should be able to***

CO1: Understand the fundamentals of linear algebra, a crucial mathematical concept in machine learning.

CO2: Apply matrix decomposition techniques, such as Cholesky, Eigen, and singular value decomposition, to machine learning issues.

CO3: Use the vector calculus concepts such as partial derivatives, Jacobian, Hessian in Taylor series and relevant problems.

CO4: Apply probability and distribution principles to real-world issues.

CO5: Apply appropriate convex optimization techniques to a particular machine learning problem.

Module	Topics	Hrs.	CO
Module 1: Linear Algebra and Analytic Geometry	*Linear Algebra:* Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings, Affine Spaces *Analytic Geometry:* Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions, Orthogonal Projections, Rotations	10	1

Module 2: Matrix Decompositions	Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigendecomposition and Diagonalization, Singular Value Decomposition	8	2
Module 3: Vector Calculus	Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series	8	3
Module 4: Probability and Distributions	Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Gaussian Distribution, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform	9	4
Module 5: Continuous Optimization	Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers, Convex Optimization	8	5

Text Books:

1. S.Boyd and L. Vandenberghe. Introduction to Applied Linear Algebra - Vectors, Matrices, and Least Squares. Cambridge University Press, 2019
2. M. P. Deisenroth, A. A. Faisal and Cheng Soon Ong. Mathematics for Machine Learning. Cambridge University Press, 2019

Reference Books:

1. J. A. Gubner, Probability and Random Processes for Electrical and Computer Engineers, Cambridge University Press, 2006.
2. S. L. Miller and D. Childers, Probability and Random Processes: With Applications to Signal Processing and Communications.

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Sub Code: **CD 204A3** **Credit: 4 (L-3, T-1, P-0)**

Fundamentals of Web Technologies

Questions to be set: 05 (All Compulsory)

Course Objectives:

1. To equip learners with adequate skills to conceptualize, design and develop well-engineered web systems.
2. To enable learners to apply free and open source web technologies for developing powerful and scalable web applications.

Pre-requisites: Programming language concepts, Computer Networks, Database Systems.

Course Outcomes (CO): On successful completion of this course, students will be able to:

1. Identify the various terms and components of HTML, CSS, JavaScript, PHP and Drupal
2. Illustrate various components of web development languages
3. Connect different modules of open source technologies for website development
4. Select appropriate web technology for implementing solution to a given problem
5. Construct a web domain using appropriate tools and techniques

**** not more than 20% of total topics to be allotted for assignment**

Module	Topics to be covered	Topics	Hrs	CO
Module 1: < Introduction & HTML AND XHTML>	in class	History of internet and world wide web, World Wide Web consortium, Web architecture, Web 2.0, HTTP protocol, Personal, distributed and client-server computing. Introduction, editing XHTML, w3c XHTML validation service, headers, linking, images, special characters, unsorted lists, nested and ordered lists, XHTML tables, XHTML forms, internal linking.	8	1,2
	****Assignment Topics**	Web browser basics, Browser portability, meta elements.		

Module 2: < HTML5>	in class	HTML5 Basics, HTML5 Syntax, New HTML5 Elements, Times and Dates, Browser Support, Semantic Formatting, New Input Types and Attributes, New Form Elements and Attributes, Playing Audio, Playing Video.	7	2
	****Assignment Topics**	The Canvas, Other HTML5 Technologies.		
Module 3: <Style Sheets, JQuery and Ajax>	in class	Inline styles, embedded style sheets, conflicting styles, linking external style sheets, positioning elements, backgrounds, element dimensions, Box Model and text flow, Media Types, Building a CSS drop-down menu. JQuery: Introduction, What JQuery does, Functions, Selecting elements, Useful predefined Jquery functions, Add page elements, Adding events, Ajax: Introduction to Ajax: Overview of Ajax; The basics of Ajax.	9	1,3
	****Assign ment Topics**	User style sheets. Formatting elements		
Module 4: <Server Side Programming & Database Access through the Web >	in class	LAMP Technology, PHP: Origins and uses of PHP, Overview of PHP, General syntactic characteristic, Primitives, operations and expressions, Control statements, Looping, Arrays, Functions, Form handling, Files. Relational Databases, An introduction to SQL, The MySQL Database system, Database access with PHP and MySQL.	8	3,5

	**Assign ment Topics	Cookies, Session tracking. Architectures for Database access		
Module 5: <Case studies: Drupal as a Content Management System >	in class	Basics of CMS, Workflow management using CMS, Free and open source content management frameworks in PHP: Drupal. Drupal: Drupal technology Stack in LAMP Platform, Drupal modules: Core, contributed and custom modules, Drupal Theme Configuration, Site Building: Content Type, Entity, Nodes, Views, Blocks, Taxonmoy, User management.	8	
	**Assign ment Topics	Wordpress, Joomlaand, permission and roles.		

Text Books:

1. M. Deitel, P.J. Deitel, A. B. Goldberg, “Internet & World Wide Web How to program”, 3rd Edition, Pearson Education, 4 th edition, PHI, 2011.
2. Robert W. Sebesta, “Programming the World Wide Web”, 4th Edition, Pearson Education.

Reference Books:

1. Chris Bates, “Web Programming Building Internet Applications”, 3rd Edition, Wiley India.
2. Joyce Farrell, XueBai, Michael Ekedahl, “The Web Warrior Guide to Web Programming”, Thomson

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Program Elective-II (4th Semester)

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Sub Code: **CD205A3** **Credit: 4 (L-3, T-1, P-0)**

OPERATING SYSTEMS

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide knowledge regarding the operating system architecture, services, scheduling and related algorithms.

Pre-requisites: Basic computer architecture.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain basic idea of System Structure and Services.

CO 2: Describe the Process Management of an operating system.

CO 3: ConcludeProcess Management of an operating system.

CO 4: Explain basic idea of I/O management & Disk scheduling in an operating system.

CO 5: Correlate Inter Process Communication,Multi-Processor Virtualization Concepts.

Module	Topics	Hrs	CO
Module 1: Introduction	Introduction to operating system, Operating System Structure,Operations, Goals .Interaction of O. S.& hardware architecture, System calls, Batch, multiprogramming. Multitasking, time sharing, parallel, distributed operating system.Basics of Network Operating System, System and Real Time Operating System.	8	1
Module 2: Process Management	Process Concept, Process states, Process control, Threads, Uni-processor Scheduling: Types of scheduling: Preemptive, Non preemptive, Scheduling algorithms: FCFS, SJF, RR, Priority, Thread Scheduling, Real Time Scheduling. System calls like ps, fork, join, exec family, wait., Overview, Linux scheduling	8	2

Module 3: Memory Management	Memory Management requirements, Memory partitioning: Fixed and Variable Partitioning, Memory Allocation: Allocation Strategies (First Fit, Best Fit, and Worst Fit), Fragmentation, Swapping, and Paging. Segmentation, Demand paging Virtual Memory: Concepts, management of VM, Page Replacement Policies (FIFO, LRU, Optimal, Other Strategies), Thrashing.	8	3
Module 4: I/O management & Disk scheduling:	I/O Devices, Organization of I/O functions, Operating System Design issues, I/O Buffering, Disk Scheduling (FCFS, SCAN, C-SCAN, SSTF), RAID, Disk Cache. Thrashing, Disk Scheduling, Swap-Space Management, System Model, Deadlock: Deadlock prevention, Avoidance, Detection, Recovery, File Concept, Protection.	8	4
Module 5: Inter Process Communication,Multi-Processor Virtualization Concepts	Basic Concepts of Concurrency, Cooperating process, Advantage of Cooperating process, Bounded-Buffer Shared-Memory Solution, Inter-process Communication (IPC), Basic Concepts of Inter-process Communication and Synchronization, Virtual machines; supporting multiple operating systems simultaneously on a single hardware platform; running one 815operating system on top of another. Reducing the software engineering effort of developing operating systems for new hardware architectures. True or pure virtualization Para virtualization; optimizing performance of virtualization system; hypervisor call interface.	8	5

Text Books:

1. Avi Silberschatz, Peter Baer Galvin, Greg Gagne (2018)"Operating System Concepts"(10th ed) John Wiley & Sons
2. Charles Crowley, (1996), "Operating Systems: A Design-Oriented Approach" (1st ed) McGraw-Hill Science.
3. Andrew S. Tanenbaum, (2015), "Modern Operating Systems" (4th ed), Pearson.

Reference Books:

1. William Stallings (2018), "Operating systems internals and design principles" (9th ed) Pearson.

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Sub Code: **CD206A3** **Credit: 4 (L-3, T-1, P-0)**

Introduction to Artificial Intelligence

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide knowledge regarding the basic principles of Artificial Intelligence, learn and design intelligent agents. This course also focus on the basic areas of Artificial Intelligence including problem solving, knowledge representation, reasoning, decision making, planning, perception and action.

Pre-requisites: Basic knowledge in sensors, actuator and systems.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the basics of artificial intelligence.

CO 2: Describe different models for Agent & environment used in AI.

CO 3: Co-relate among the Knowledge and key words for Reasoning used in AI based model.

CO 4: Reframe Expert system implement in AI.

CO 5: Explain the Applications, Modern Trends, and future of Artificial intelligence

Module	Topics	Hrs	CO
Module 1: Introduction to artificial intelligence	Introduction, the History of AI, Objectives, Components, Contributes, different Programming Languages. task domain of AI. It also describes Applications and Research Area of AI	6	1
Module 2: Agent & environment	Introduction, what are Agent and Environment? , Agent Terminology, The Structure of Intelligent Agents -, Different Types of Agents, Simple Reflex Agents, Model Based Reflex Agents, Utility Based Agents, Learning agent, PAGE Descriptor of Intelligent agent, PEAS Descriptor of Intelligent agent, The Nature of Environments, Properties of Environment, Intelligent Agent applications, Game Theory.	9	2
Module 3: Knowledge ,Reasoning, representation	Introduction of knowledge, Different types of knowledge, knowledge representation , The knowledge cycle, Basic Knowledge base system, definition of reasoning, Different types of reasoning , The Wumpus World, What is Proportional logic , Syntax, Semantics , Advantages of Proportional Logic , Limitations of Proportional logic ,Applications , What is Predicate Logic? , How predicate logic used in AI, Advantages of Predicate	9	3

	Logic, Limitations of Predicate Logic, Applications of Predicate Logic , Difference between Proportional logic and Predicate Logic		
Module 4: Expert system	Introduction of Expert Systems, Characteristics of Expert Systems, Capabilities of Expert Systems , Components of Expert Systems , Knowledge Base , Inference Engine , User Interface, Requirements of Efficient ES User Interface, Expert System Technology , Development of Expert Systems: General Steps, Benefits of Expert Systems , Expert Systems Limitations ,Applications of Expert System	9	4
Module 5: Applications, Modern Trends and future of Artificial intelligence	Introduction, Applications of Artificial intelligence, Latest trends of Artificial intelligence, Ethics and risk for developing Artificial Intelligence, Future Trends of Artificial Intelligence	6	5

Textbooks:

1. Nilakshi Jain(2019), "Artificial Intelligence, making a system intelligent", (1st ed), Wiley.
2. Russell S., and Norvig P(2010), Artificial Intelligence: A Modern Approach (3rd ed), Pearson.
3. Marvin Minsky(1998), "Society of Mind"(1st ed). Simon & Schuster.

Reference Books:

4. Rich E., Knight K., Nair S.B.(2008), Artificial Intelligence (3e), Tata McGraw Hill, 2008.
5. Grigoris Antoniou, Paul Groth, Frank van Harmelen and Rinke Hoekstra, (2012) "A Semantic Web Primer", MIT Press.

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Sub Code: **CD207A3** **Credit: 4 (L-3, T-1, P-0)**

Programming in Java

Questions to be set: 05 (All Compulsory)

Course Objectives: The Java Programming Language course provides students with a solid foundation for programming with JAVA. It also highlights the creation of graphical user interfaces (GUIs), exceptions, file input/output (I/O), and threads; and network programming.

Pre-requisites: Object Oriented Programming.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Use the syntax and semantics of java programming language and basic concepts of OOP.

CO 2: Develop reusable programs using the concepts of inheritance, polymorphism and interfaces.

CO 3: Transfer reusable programs using the concepts Strings handling, Interfaces and Packages.

CO 4: Apply the concepts of Multithreading and Exception handling to develop efficient and error free codes.

CO5: Design event driven GUI and web related applications which mimic the real word scenarios.

Module	Topics	Hrs	CO
Module 1: Introduction to Java	Evolution and features of java, Overview of java, Two control statements, Lexical issues, Data types, Variables and arrays, Literals, Variables, Type conversion and casting, Type promotion in expression, arrays, Operators, Bitwise operators, Relational operators, Boolean and logical operators, Assignment Operators, The '?' operator, Operator precedence, JAVA statements.	8	1
Module 2: Introducing classes and Methods	Class fundamentals, Declaring objects, Assigning object reference Variables, Introducing methods, Constructors, 'this' keyword, Garbage collection, The finalize() method, stack class. Overloading methods and constructors, using object as parameters, Argument passing, Returning objects, Recursion, Access control, Static methods, Nested and inner classes, Command line argument.	8	2

Module 3: Strings handling, Interfaces and Packages	String constructors, String length, Special string operators, Character extraction, String comparison, String searching, String modification, Changing case of characters within a string, Compression and String buffer, String builder. Inheritance, Basics of inheritance, Types of inheritance, Using super keyword, method overriding, Dynamic method dispatch, Abstract class, Using final with inheritance, The object class, Defining and implementing interface, Extending interfaces, Nested interfaces, Applying interfaces, Defining and creating packages, Access protection, Importing packages. Exception Handling, Fundamentals, Exception types, Uncaught exceptions, Using try and catch, Multiple catch clauses, Nested try statements, Throws, Finally, Java's built in exceptions, Creating own exception classes.	8	3
Module 4: Input/Output, file handling and Multithreaded programming	Java I/O classes and interfaces, The stream classes, Byte streams, The character streams, The console class, File class, Byte-stream class, Random access files. Thread basics, Java's thread model, Thread priorities, Synchronization, Messaging, Thread class and runnable interface. The main thread, Creating a thread, Creating multiple threads, Interthread communication, Suspending/resuming and stopping threads.	8	4
Module 5: Network programming and Event Based Programming	Networking basics, The networking classes and interfaces, The InetAddress class, Inet4Address, TCP socket, URL, URLConnection, HTTP/URL Connection, TCP/IP server sockets, Datagram socket and Datagram Packet. The applet class, Repaint(), The HTML applet tag, Passing Parameter to applet, Event handling, Using delegation event model, Abstract Window program, Displaying information within a window, AWT controls.	8	5

Text Books:

1. E. Balaguruswami (2006), Programming With JAVA (2nd Edition) TMH Publication.
2. Herbert Scheldt (2007) Java: The Complete Reference (7th Edition) TMH Publication.

Reference Books:

1. Ken Arnold, James Gosling, David Holmes(2005).The Java Programming Language (4th edition) Addison-Wesley
2. Cedric Buest, Subrahmanyam Allamaraju (2007). Professional Java Server Programming: J2EE (3rd edition) Dreamtech Press
3. Patrick Naughton, HarbertSchildt (2017). JAVA2: The Complete Reference (3rd Edition) TMH Publication.

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Sub Code: **CD208A3** **Credit: 4 (L-3, T-1, P-0)**

Speech Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: To enrich the knowledge of the students with a sound understanding of various techniques of speech processing. It begins with the human speech production mechanism and then goes on to the fundamental parameters of speech such as pitch frequency, formants, spectral features like log spectrum, 3-D spectrogram, cepstral features, MFCC, linear prediction coefficients, transform-domain parameters, etc. It deals with applications like speech coding, speech enhancement, speaker and language recognition, speech recognition, text to speech synthesis, and the overview of state-of-the-art techniques like DNN for speech processing

Pre-requisites: Signal Processing (Recommended, but not necessary), Probability and Random Process.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the speech production and perception process.

CO 2: Analyze speech signals in time and frequency domain.

CO 3: Describe statistical modeling techniques for speech signal.

CO 4: Apply channel compensation and classification techniques to speech processing applications.

CO 5: Implement simple algorithms for processing speech signals.

Module	Topics	Hrs	CO
Module 1: Speech Signal: Production, Perception, and Acoustic-phonetic characterization	Process of Speech production and Perceptions in Human Beings, Speech-Production Process, Representing Speech in the Time and Frequency domains, Place and Manner of Articulation, Windowing, Pre-emphasis filter, STFT, Spectrogram. Concept of filter bank, Auditory perception: psycho acoustics	9	1
Module 2: Speech Analysis	Prosodic features:-Energy contour, Pitch contour, and Syllable duration, Voiced /Unvoiced detection using Energy and Zero crossing Rate, AMDF and Pitch.	9	2

	Acoustic features:- LPC- Basic Principles of linear predictive analysis, Auto correlation method, Solution of LPC equations using Durbin's Recursive algorithm, Cepstral analysis of Speech, MFCC, Shifted Delta Cepstral. Perceptual Linear Prediction (PLP) Speech distortion measures – mathematical and perceptual considerations; Spectral–Distortion Measures: Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Liftering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.		
Module 3: Statistical Modeling	K-means clustering and Vector quantization, Gaussian mixture Modeling, Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues	9	3
Module 4: Channel Compensation Techniques and Classifiers	*Overview of Compensation Techniques:* Linear Discriminant Analysis (LDA), Within-class covariance normalization (WCCN), Nuisance Attribute Projection (NAP) *Overview of Classifiers:* Cosine distance scoring, Support vector machine, Gaussian PLDA, Logistic regression, Deep Neural network (DNN)	8	4
Module 5: Application of speech processing	Speech Coding, Speech Enhancement, Speaker and Language recognition, Automatic Speech Recognition, Text to Speech Synthesis	8	5

Text Books:

1. Thomas F, Quatieri (2008). Discrete-Time Speech Signal Processing.(Prentice Hall Pearson Education,2004.
2. Douglas O'Shaughnessy, Speech communication: human and machine, Addison-Wesley Pub.Co.,1987
3. L.R. Rabiner and B. H. Juang, Fundamentals of Speech Recognition, Prentice Hall,1993.

Reference Books:

1. Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, John Wiley and Sons Inc., Singapore, 2004
2. L.R.Rabiner and R.W.Schaffer – Digital Processing of Speech signals – Prentice Hall -1979
3. J.R. Deller, J.H.L. Hansen and J.G. Proakis, Discrete Time Processing of Speech Signals, John Wiley, IEEE Press, 1999.

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Sub Code: **CD209A3** **Credit: 4 (L-3, T-1, P-0)**

Analog Electronics Circuits

Questions to be set: 05 (All Compulsory)

Course Objectives: To enrich the knowledge of the students with a sound understanding of analog electronic circuit, this will help them in the further course of their studies. It starts with basic circuit components and circuit concepts and then, gradually moves to practical building blocks of analog electronic systems. In this course, a serious attempt has been made to make a balance between theory and practice so that the discussed circuits can be constructed in an undergraduate level laboratory class and their measured performance can be easily compared with the analytically predicted performance. It helps to build confidence on theory.

Pre-requisites: Basic Electronics

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the fundamental operations and characteristics of diodes, bipolar junction transistors (BJTs), and metal-oxide-semiconductor field-effect transistors (MOSFETs)

CO 2: Analyze simple non-linear circuits and develop a fundamental understanding of small signal models.

CO 3: Describe the working principles of BJT and MOSFET amplifiers, and gain an understanding of high-frequency models.

CO 4: Explain Multi transistor Amplifiers, Differential Amplifier and Current mirror.

CO 5: Understand the concepts of Feedback system, and Oscillator.

Module	Topics	Hrs	CO
Module 1: Review of Diode, BJT and MOSFET	Revisiting: Simple diode circuit and its analysis, BJT - operation and characteristic equations. MOSFET - operation and characteristic equations	8	1
Module 2:	Analysis of simple non-linear circuits (containing one transistor) and introducing the notion of signal amplification. Input-output transfer characteristic of a non-linear circuit. Linearization of input-	8	2

Analysis of simple non-linear circuits	output transfer characteristic of a non-linear circuit and introducing the notion of small signal equivalent circuit. Small signal models of transistors.		
Module 3: Amplifiers	Amplifier models (equivalent circuits): voltage amplifier, current amplifier, trans-conductance amplifier and trans-resistance amplifier. Cascading of multiple amplifiers. Common emitter (CE) amplifier – biasing, operation, analysis numerical examples and design guidelines. Common source (CS) amplifier – biasing, operation, analysis, Numerical examples and design guidelines. Frequency response of CE and CS amplifiers. Frequency response of CE and CS amplifiers considering High frequency models of BJT and MOSFET. Limitations of CE/CS amplifiers and hence the need of buffers. Common Collector (CC) and Common Drain (CD) amplifiers– biasing, operation, analysis and design. Common Base (CB) and Common Gate (CG) amplifier – biasing, operation, analysis and design.	8	3
Module 4: Multi transistor Amplifiers, Differential Amplifier and Current mirror	Multi transistor Amplifiers (operation and analysis): CE-CC; CS-CD; CC-CC; Darlington pair; Cascode amplifiers (CS-CB and CS-CG); Amplifier with active load Single-ended signaling vs. differential signaling, Differential amplifier: Basic structure and principle of operation, analysis for differential mode gain, common mode gain, ICMR and output swing Current mirror- operation and analysis, Use of current mirror as bias circuit in amplifiers such as in CE/CS, CC/CD, CB/CG and Differential amplifier. Use of current mirror as signal mirror.	8	4
Module 5: Feedback system, and Oscillator	Feedback system: Basic feedback theory; Four different feedback configurations and their characteristics. Effects of feedback on frequency response of an amplifier. Application of feedback in practical circuits. Oscillation in feedback system and oscillation criterion, Stability analysis of a feedback system, Two-stage differential amplifier and its stability analysis in feedback configuration.	8	5

	Oscillator: Phase-shift and LC based sinusoidal oscillators. Comparator. Square wave generator (Optional) : Power efficiency of an amplifier, Different modes of operation of amplifiers and their power efficiency: Class A, Class B, Class AB and Class C		

Books and References

1. J. Millman and C. Halkias, Integrated Electronics: Analog and Digital Circuits and Systems, McGraw Hill, 1985.
2. Paul R. Gray and Robert G.Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley, 3rd Edition Course
3. P. Horowitz and W. Hill, The Art of Electronics, 2nd edition, Cambridge University Press, 1989.
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits,
5. Fundamentals of Microelectronics by Behzad Razhavi, Wiley 2013
6. J. Millman and A. Grabel, Microelectronics, 2nd edition, McGraw Hill, 1988

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Program Elective-III (5th Semester)

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Sub Code: **CD301A3** **Credit: 3 (L-3, T-0, P-0)**

Digital Image Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: To study the image fundamentals and mathematical transformations necessary for image processing. To study image enhancement techniques. To study image restoration procedures. To study the image compression procedures.

Pre-requisites: Digital Signal Processing

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the need for image transforms different types of image transforms and their properties.

CO 2: Learn different techniques employed for the enhancement of images.

CO 3: Summarize the Image restoration.

CO 4: Reframe different feature extraction techniques for image analysis and recognition

CO 5: Apply different causes for image reconstruction from projections

Module	Topics	Hrs	CO
Module 1: Fundamentals of Image Processing; Image Transforms	Need for DIP- Fundamental steps in DIP – Elements of visual perception -Image sensing and Acquisition – Image Sampling and Quantization – Imaging geometry, discrete image mathematical characterization. Two-dimensional Fourier Transform-Properties – Fast Fourier Transform – Inverse FFT,Discrete cosine transform and KL transform. -Discrete Short time Fourier Transform- Wavelet Transform- Discrete wavelet Transform- and its application in Compression.	8	1
Module 2: Image Enhancement	Spatial Domain: Basic relationship between pixels- Basic Gray level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial	7	2

	filters. Frequency Domain: Smoothing frequency domain filters- sharpening frequency domain filters Homomorphic filtering		
Module 3: Image Restoration	Overview of Degradation models –Unconstrained and constrained restorations-Inverse Filtering ,Wiener Filter.	7	3
Module 4: Feature Extraction	Detection of discontinuities – Edge linking and Boundary detection- Thresholding- - Edge based Segmentation-Region based Segmentation- matching-Advanced optimal border and surface detection- Use of motion in segmentation. Image Morphology – Boundary descriptors- Regional descriptors.	7	4
Module 5: Image Reconstruction from Projections	Need- Radon Transform – Back projection operator- Projection Theorem- Inverse Radon Transform.	7	5

Text Books:

1. Rafael C.Gonzalez, Richard E.Woods (2017). Digital Image Processing (4th edition). Pearson Education.
2. Anil.K.Jain (2003).Fundamentals of Digital Image Processing. Pearson Education.

Reference Books:

1. B.Chanda, D.Dutta Majumder (2002).Digital Image Processing and Analysis (2nd edition). Prentice Hall of India.
2. William K. Pratt (1991). Digital Image Processing (2nd Edition). John Wiley & Sons.\

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Sub Code: **CD302A3** **Credit: 3 (L-3, T-0, P-0)**

Optimization Techniques

Questions to be set: 05 (All Compulsory)
Course Objectives: The course is an introduction to optimization techniques, the concepts involved are fairly easy to grasp. However, the topics involved can be used to formulate a wide variety of problems.

Pre-requisites: Linear Algebra and Calculus
Course Outcomes (CO):
Upon successful completion of the course, students should be able to
CO 1: Understand the concept of Convex Sets and Convex functions.
CO 2: Apply Unconstrained Optimization algorithms to solve the problems in practice.
CO 3: Explain the basic concepts of Constrained Optimization.
CO 4: Apply Linear Programming algorithms to solve the problems in practice.
CO 5: Apply Constrained Optimization algorithms to solve the problems in practice.

Module	Topics	Hrs	CO
Module 1: Introduction	Introduction: Optimization, Types of Problems and Algorithms Background: Linear Algebra and Analysis One Dimensional Optimization - Optimality Conditions Convex Sets and Convex Functions	**7**	**1**
Module 2: Unconstrained Optimization	Multi-Dimensional Optimization - Optimality Conditions, Conceptual Algorithm Line Search Techniques, Global Convergence Theorem, Steepest Descent and Classical Newton Method, Trust Region and Quasi-Newton Methods, Quasi-Newton Methods - Rank One Correction, DFP Method, i) Quasi-Newton Methods - Broyden Family ii) Coordinate Descent Method, Conjugate Directions, Conjugate Gradient Method	**8**	**2**
Module 3: Constrained Optimization	Constrained Optimization - Local and Global Solutions, Conceptual Algorithm,	**7**	**3**

	Feasible and Descent Directions, First Order KKT Conditions, Constraint Qualifications, Convex Programming Problem, Second Order KKT Conditions, Duality: Weak and Strong Duality, Geometric Interpretation, Lagrangian Saddle Point and Wolfe Dual		
Module 4: Linear Programming	Linear Programming Problem, Geometric Solution, Basic Feasible Solution, Optimality Conditions and Simplex Tableau, Simplex Algorithm and Two-Phase Method, Duality in Linear Programming, Interior Point Methods - Affine Scaling Method, Karmarkar's Method,	**7**	4
Module 5 Algorithms for Constrained Optimization Problems	Lagrange Methods, Active Set Method, Barrier and Penalty Methods, Augmented Lagrangian Method and Cutting Plane Method	**7**	5

Text Books:

1. Boyd, Stephen, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.
2. Luenberger, David G., and Yinyu Ye. Linear and nonlinear programming. 4th edition. Springer, 2015.
3. E. K. P. Chong and S. W. Zak, An Introduction to Optimization, 4th Edition, John Wiley & Sons, 2013.
4. Fletcher R., Practical Methods of Optimization, John Wiley, 2000.

Reference Books:

5. M. S. Bazaaraa, H. D. Shirali and M. C. Shetty, Nonlinear Programming, Theory and Algorithms, 3rd Edition, John Wiley & Sons, New York (2004).
6. W. Sun and Y.-X. Yuan, Optimization Theory and Methods, Springer Science & Business Media, 2006.
7. P. Drimiti Bertsekas, Nonlinear Programming, Athena Scientific, 3rd Edition, 2016
8. J. E. Dennis Jr and R. B. Schnabel, Numerical Methods for Unconstrained Optimization and Nonlinear Equations, Society for Industrial and Applied Mathematics, 1996.
9. Nocedal, Jorge and Wright, Stephen. Numerical optimization. Springer, 1999
10. CS5020 - Non-linear Optimization : Theory and Algorithms : https://cse.iitm.ac.in/course_details.php?arg=MTMx
11. Ankur A. Kulkarni **, Optimization from fundamentals : https://onlinecourses.nptel.ac.in/noc21_me10/preview**
12. Adrijit Goswami and Debjani Chakraborty, Constrained and Unconstrained Optimization **https://archive.nptel.ac.in/courses/111/105/111105100/**
13. Debdas Ghosh**, A Primer to Mathematical Optimization: https://onlinecourses.nptel.ac.in/noc23_ma45/preview**
14. Dr. Shirish K. Shevade, Numerical Optimization: https://archive.nptel.ac.in/courses/106/108/106108056/

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Sub Code: **CD303A1** **Credit: 3 (L-3, T-0, P-0)**

Internet of Things (IoT)

Questions to be set: 05 (All Compulsory)

Course Objectives: This Course focuses on hands-on AI based IoT concepts such as sensing, actuation and communication. It covers the development of Internet of Things (IoT) prototypes—including devices for sensing, actuation, processing, and communication—to help you develop skills and experiences. The AI based Internet of Things (IOT) is the next wave, world is going to witness. Today we live in an era of connected devices the future is of connected things.

Pre-requisites: Basic programming concept and hardware interface

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the concept of Internet of Things

CO 2: Implement interfacing of various sensors with Arduino.

CO 3: Demonstrate the ability to transmit data wirelessly between different devices.

CO 4: Use ability to upload/download sensor data on cloud and server.

CO 5: Apply the concept of Internet of Things Protocols and Cloud Platforms.

Module	Topics	Hrs	CO
Module 1: Introduction to IOT	Understanding IoT fundamentals , IOT Architecture and protocols , Various Platforms for IoT , Real time Examples of IoT , Overview of IoT components and IoT Communication Technologies , Challenges in IOT	7	1
Module 2: Arduino / Raspberry Pi Simulation Environment	Arduino Uno/ Raspberry Pi Architecture , Setup the IDE, Writing Arduino/ Raspberry Pi Software , Arduino/ Raspberry Pi Libraries , Basics of Embedded C programming for Arduino/ Raspberry Pi , Interfacing LED, push button and buzzer with Arduino, Interfacing Arduino with LCD	8	2

Module 3: Sensor & Actuators with Arduino	Overview of Sensors working, Analog and Digital Sensors, Interfacing of Temperature, Humidity, Motion, Light and Gas Sensor with Arduino , Interfacing of Actuators with Arduino. Interfacing of Relay Switch and Servo Motor with Arduino	7	3
Module 4: Basic Networking with ESP8266 WiFi module	Basics of Wireless Networking , Introduction to ESP8266 Wi-Fi Module, Various Wi-Fi library , Web server- introduction, installation, configuration , Posting sensor(s) data to web server.	7	4
Module 5: IoT Protocols and Cloud Platforms for IOT	M2M vs. IOT, Communication Protocols. Virtualization concepts and Cloud Architecture , Cloud computing, benefits, Cloud services -- SaaS, PaaS, IaaS, Cloud providers & offerings , Study of IOT Cloud platforms , ThingSpeak API and MQTT, Interfacing ESP8266 with Web services.	7	5

Text Books:

1. Cuno Pfister (2011).Getting Started with the Internet of Things: Connecting Sensors and Microcontrollers to the Cloud (1st edition). Make Community, LLC.

Reference Books:

1. Miller Michael (2015).Internet of Things, The: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities Are Changing the World. QUE
2. Andrew Minteer (2017).Analytics for the Internet of Things (IoT): Intelligent analytics for your intelligent devices (1st edition). Packt Publishing.

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Sub Code: **CD304A3** **Credit: 3 (L-3, T-0, P-0)**

ARM Controller

Questions to be set: 05 (All Compulsory)

Course Objectives: Collect knowledge of architecture of ARM 7processor, LPC2148 and assembly programming of ARM. Learn to design, construct, program, verify, analyze and troubleshoot ARM assembly and C language programs and supporting hardware.

Pre-requisites: Knowledge of Digital electronics, Microcontroller Architecture and Programming

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the features of embedded systems, architecture of ARM7 and applications.

CO 2: Analyse and understand the instruction set and development tools of ARM

CO 3:Analyse and understand the THUMB state and achieving competency in assembly programming of ARM.

CO 4: Understand the exception, interrupts and interrupt handling schemes

CO 5: Understand the architectural features of LPC2148 microcontrollers and hardware and interfacing peripheral devices to LPC2148.

Module	Topics	Hrs	CO
Module 1: ARM Embedded Systems and ARM Processor Fundamentals	The RISC design philosophy, ARM design philosophy, embedded system hardware- AMBA bus protocol, embedded system software- applications. ARM core data flow model, Registers, CPSR-Processor modes, Banked registers. Pipeline- Characteristics.	8	1
Module 2: ARM Instruction Set	Fundamentals of ARM instructions, Barrel shifter, Classification and explanation of instructions with examples-Data processing, Branch, Load-store, SWI and Program Status Register instruction.	7	2

Module 3: Introduction to THUMB and ARM Programming	Introduction to THUMB, Differences between ARM and THUMB, Register usage in Thumb,ARM Thumb Interworking. General Structure of ARM assembly module, Assemblerdirectives- AREA, ENTRY, END, SPACE, DCD, DCB, DCW, DCI, DCQ, EQU, EXPORT,ALIGN, CODE16, CODE32, DATA. Simple ALP programs on Arithmetic & logical operations, Factorial, string operation, sorting, searching, and Scan.	7	3
Module 4: Exception and Interrupt handling schemes	Exception handling- ARM processor exceptions and modes, vector table, exception priorities,link register offsets. Interrupts- assigning interrupts, interrupt latency, IRQ and FIQexceptions with example- code for enabling and disabling IRQ and FIQ exceptions,Comparison between exception and interrupts. Interrupt handling schemes- nested interrupt handler, non-nested interrupt handler. Basic interrupt stack design.	7	4
Module 5: LPC 2148 – ARM CPUPeripherals	LPC 2148 - Salient features, block diagram, memory mapping. Functional features of Interrupt controller, RTC, USB, I2C, SPI controllers, watch dog timers, Pin Connect Block- Features, Register description with example. GPIO-Features, Applications, Pin description, Register description with examples PLL-Features, block diagram, PLL frequency Calculation- procedure for determining PLL settings, examples for PLL ConfigurationTimers-Features, applications, Architecture of timer module, register description, Simple C programs for application using -GPIO, PLL, Timer.	7	5

Text Books:

1. Andrew Sloss, Dominic Symes, Chris Wright (2004).*ARM System Developer's Guide: Designing and Optimizing System Software*. Morgan Kaufmann
2. William Hohl, Christopher Hinds. *ARM Assembly Language* (2nd ed.), CRC Press.

Reference Books:

1. Steve Furber (2009), ARM System-on-chip Architecture (2nd ed.). Pearson Education.
2. A P Godse (2020). ARM Controller: ARM Fundamentals, LPC2148 CPU and Peripherals. Amazon Digital Services LLC - KDP Print US
3. James K. Peckol (2008). Embedded Systems: A Contemporary Design Tool. Wiley.

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Sub Code: **CD305A3** **Credit: 3 (L-3, T-0, P-0)**

Parallel and Distributed Algorithms

Questions to be set: 05 (All Compulsory)

Course Objectives: **:** To provide you with an introduction and overview to the computational aspects of parallel and distributed computing. To introduce several important parallel computing models that capture the essence of existing and proposed types of synchronous and asynchronous parallel computers. To study typical models for distributed computing.

Pre-requisites: Multiprocessor systems, Design and Analysis of Algorithms, Parallel Computing.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Develop and apply knowledge of parallel and distributed computing techniques and methodologies.

CO 2: Apply design, development, and performance analysis of parallel and distributed applications.

CO 3: Transfer the design, testing, and performance analysis of a software system, and to be able to communicate that design to others.

CO 4: Correlate the concept of Scheduling and Dictionary Operations

CO 5: Design the application of fundamental Computer Science methods and algorithms in the development of parallel applications.

Module	Topics	Hrs	CO
Module 1: The Idea of Parallelism	A Parallelised version of the Sieve of Eratosthenes, PRAM Model of Parallel Computation, Pointer Jumping and Divide & Conquer: Useful Techniques for Parallelization	8	1
Module 2: PRAM Algorithms	Parallel Reduction, Prefix Sums, List Ranking, Preorder Tree Traversal, Merging Two Sorted Lists, Graph Coloring, Reducing the Number of Processors and Brent's Theorem	7	2
Module 3: Dichotomoy of Parallel Computing Platforms	Cost of Communication, Programmer's view of modern multi-core processors, The role of compilers and writing efficient serial programs, Parallel Programming Languages: Shared Memory Parallel Programming using OpenMP, Parallel Complexity: The P-Complete Class	7	3

Module 4: Scheduling and Dictionary Operations	Mapping and Scheduling, Elementary Parallel Algorithms, Matrix Multiplication, Writing efficient openMP programs, Sorting Parallel Search, Graph Algorithms, Safety, liveness, termination, logical time and event ordering	7	4
Module 5: Algorithms and Synchronization	Global state and snapshot algorithms, Mutual exclusion and Clock Synchronization, Distributed Graph algorithms, Distributed Memory Parallel Programming: Cover MPI programming basics with simple programs and most useful directives; Demonstrate Parallel Monte Carlo	7	5

Text Books:

1. Michael J Quinn (2017). Parallel Computing (2nd edition). McGraw Hill Education TMH
2. Joseph Jaja (1992). An Introduction to Parallel Algorithms(1st edition). Pearson Education India.

Reference Books:

1. Mukesh Singhal , Niranjan G. Shivaratri (2017). Advanced Concepts in Operating Systems. McGraw Hill Education.
2. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar (2003) Introduction to Parallel Computing (2nd edition). Addison-Wesley.

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Program Elective-IV (6th Semester)

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Sub Code: **CD306A3** **Credit: 4 (L-3, T-1, P-0)**

Machine Learning Operations (MLOps)

Questions to be set: 05 (All Compulsory)

Course Objectives: This course is designed to set a strong foundation and provide advanced skills for those looking to excel in the dynamic and demanding realm of Machine Learning Operations (MLOps).

1. **Develop Proficiency in MLOps Tools:** Gain hands-on experience with Python and Rust, two powerful programming languages essential for modern MLOps workflows.
2. **Enhance Productivity with GitHub Copilot:** Learn to integrate GitHub Copilot into your development process, boosting efficiency and code quality.
3. **Master Cloud-Based MLOps Platforms:** Acquire the skills to utilize leading cloud platforms such as Amazon SageMaker, Azure ML, and MLflow for scalable machine learning operations.
4. **Fine-Tune Large Language Models (LLMs):** Understand the intricacies of LLMs and become proficient in fine-tuning them using the Hugging Face platform for tailored AI solutions.
5. **Deploy ONNX Models:** Learn the deployment of binary embedded models in the ONNX format, ensuring your models are sustainable and efficient.
6. **Prepare for Industry Challenges:** Equip yourself with the knowledge to tackle real-world problems and stay ahead in the rapidly advancing field of MLOps.

Pre-requisites: Basics of python programming.

Course Outcomes (CO): ***Upon successful completion of the course, students should be able to***

CO 1: Write, run and debug tests using Pytest to validate the work.
CO 2. Build operations pipelines using DevOps, DataOps, and MLOps.
CO 3: Build end to end MLOps and AIOps solutions
CO 4: Build machine learning modeling solutions using both AWS and Azure technology.
CO 5: Use Hugging Face models and datasets to build your own APIs.

Module	Topics	Hrs	CO
Module 1: Python Essentials for MLOps	Python Functions and Classes; Basics of Python testing: Introduction to Testing, Writing Useful Tests, Testing Failures;Applied Python for MLOps: Working with APIs and SDKs; Automation with Command-line Tools, Building Machine Learning APIs,	9	1
Module 2: DevOps, DataOps, MLOps: Part1	Introduction to MLOps; Operations Pipelines: DevOps, DataOps, MLOps	8	2
Module 3: DevOps, DataOps, MLOps: Part2	End to End MLOps and AIOps Rust for MLOps: The Practical Transition from Python to Rust	8	3
Module 3: MLOps Platforms: Amazon SageMaker and Azure ML	Data Engineering with AWS Technology; Exploratory Data Analysis with AWS technology; Modeling with AWS Technology; MLOps with AWS Technology; Machine Learning Certification	9	4
Module 4: MLOps Tools: MLflow and Hugging Face	Introduction to MLFlow; Introduction to Hugging Face; Deploying Hugging Face; Applied Hugging Face	9	5

Text Books:

1. Treveil, M. and Omont, N. and Stenac, C. and Lefevre, K. and Phan, D. and Zentici, J. and Lavoillotte, A. and Heidmann, L. and Miyazaki, M., *Introducing MLOps: How to Scale Machine Learning in the Enterprise*, O'Reilly Media, Incorporated, 2020
2. Gift, Noah, and Deza, Alfredo. *Practical MLOps: Operationalizing Machine Learning Models*. United States, O'Reilly, 2021.

Reference:

Machine Learning Operations Specialization: https://www.coursera.org/specializations/mlops-machine-learning-duke

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Sub Code: **CD307A3** **Credit: 4 (L-3, T-1, P-0)**

Compiler Design

Questions to be set: 05 (All Compulsory)

Course Objectives: The main objective of this course is to introduce the major concept areas of language translation and compiler design and to develop an awareness of the function and
complexity of modern compilers. This course is a study of the theory and practice required for the design and implementation of interpreters and compilers for programming languages.

Pre-requisites: Discrete Structures for Computer Science, Formal Language and Automata Theory and Programming skills

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Learn the process of translating a modern high-level language to executable code.
CO 2: Develop an awareness of the function and complexity of modern compilers.
CO 3: Apply the code generation algorithms to get the machine code for the optimized
Code.
CO 4: Understand the machine dependent code and intermediate codes.
CO 5: Apply the optimization techniques to have a better code for code generation

Module	Topics	Hrs	CO
Module 1: Compiler structure and Lexical analysis	Analysis-synthesis model of compilation, Various phases of a compiler, Tool based approach to compiler construction, Input Buffering. Interface with input, Parser and symbol table, Token, Lexeme and patterns, Regular definition, Transition diagrams, LEX.	8	1
Module 2: Syntax analysis and Syntax directed translation	CFG's, Ambiguity, Associativity, Precedence, Top down parsing, Recursive descend parsing, Transformation on the grammars, Predictive parsing, Bottom up parsing, Operator precedence grammars, LR parsers (SLR, Canonical, LALR), YACC. Inherited and synthesized attributes, Dependency graph, Evaluation order, Bottom up evaluation of S- attributed definitions L- attributed definitions and top down translation of attributes.	8	2

Module 3: Type checking and Run time environments	Type system, Type expressions, Structural and name equivalence of types, Type conversion. Storage organization, Storage-allocation strategies, Access to nonlocal names, Activation tree, Activation record, Parameter passing, Symbol table and dynamic storage allocation	8	3
Module 4: Intermediate code generation	Intermediate representations, Translation of declarations, Assignments, Control flow, Boolean expressions and procedure calls ,Three-address code, Implementation of three address statements (Quadruples, Triples, Indirect triples).	8	4
Module 5: Code generation	Issues in the design of a code generator, Basic blocks and flow graphs, Next use information, Register allocation, Code generation algorithm, Dag representation of programs, Code generation from dags, Peephole optimization and code generator generators.	8	5

Text Books:

1. A.V. Aho, R. Sethi, J.D. Ullman (2006). Compilers: Principles, Techniques and Tools (2nd edition). Addison Wesley.
2. Steven S. Muchnick (2007). Advanced Compiler Design and Implementation (1st Edition) Elsevier Science & Technology.

Reference Books:

1. W. Appel (2004) Modern Compiler Implementation in C: Basic design. Cambridge Press.
2. C. Fraser, D. Hanson (1985) Retargetable C Compiler: Design and Implementation (1st edition). Addison-Wesley.
3. A. V. Aho, J. D. Ullman (1972) Theory of Parsing, Translation and Compiling Prentice Hall.

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Sub Code: **CD308A3** **Credit: 4 (L-3, T-1, P-0)**

Cloud Computing

Questions to be set: 05 (All Compulsory)

Course Objectives: This course gives an introduction to cloud computing and its techniques - Infrastructure as a Service (IaaS), Platform-as-a-Service (PaaS), Software as a Service (SaaS), issues, ecosystem and case studies

Pre-requisites: Knowledge of computer systems, programming and debugging, with a strong competency in at least one language (such as Java/Python), and the ability to pick up other languages as needed.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understanding Cloud Computing and Privacy /Security in Cloud computing

CO 2: Developing different Cloud Services

CO 3: Reframe Business profit using Cloud

CO 4: Implementation cloud computing every aspect

CO 5: Develop various cloud programming models and apply them to solve problems on the cloud

Module	Topics	Hrs	CO
Module 1: Understanding Cloud Computing and Privacy /Security in Cloud computing	Cloud computing, History of cloud computing, Cloud architecture, Cloud storage, Why cloud computing matters, Advantages of cloud computing, Disadvantages of cloud computing, Companies in the cloud today. Federation in the cloud, Presence in the cloud, Privacy and its relation to cloud-based information systems, Security in the cloud, Common standards in the cloud, End-user access to the cloud computing.	8	1
Module 2: Developing Cloud Services	Web-based application, Pros and cons of cloud service development, Types of cloud service development, Software as a service, Platform as a service, Web services, On demand computing, Discovering cloud services, Development services and tools, Amazon Ec2, Google app engine, IBM clouds.	8	2

Module 3: Cloud Utility and Business profit	Software utility application architecture, Characteristics of a SaaS, Software utility applications, Cost versus value, Software application services framework, Common enablers, Conceptual view to reality, Business profits, Implementing database systems for multitenant architecture.	8	3
Module 4: Cloud Computing for Everyone	Centralizing email communications, Collaborating on schedules, Collaborating on To-Do Lists, Collaborating contact lists, Cloud computing for the community, Collaborating on group projects and events, Cloud computing for the corporation.	8	4
Module 5: Using cloud services	Collaborating on calendars, Schedules and task management, Exploring online scheduling applications, Exploring online planning and task management, Collaborating on event management, Collaborating on contact management, Collaborating on project management, Collaborating on word processing, Collaborating on databases, Storing and sharing files.	8	5

Text Books:

1. Michael Miller (2008). Cloud computing: Web based applications that change the way you work and collaborate online. (1st edition) . Pearson Education India.
2. Haley Beard (2009). Cloud computing best practices for managing and measuring processes for on demand computing, Applications and data centers in the cloud with SLAs.(2nd edition) . Emereo Pty Ltd.

Reference Books:

1. Guy Bunker, Darren Thomson (2007) . Delivering Utility Computing. (1st edition).John Wiley & Sons.
2. George Reese (2009). Cloud Application Architectures.(1st edition).O'Reilly Media.

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Sub Code: **CD309A3** **Credit: 4 (L-3, T-1, P-0)**

Remote Sensing & GIS

Questions to be set: 05 (All Compulsory)

Course Objectives: Remote Sensing and GIS is a relatively recent discipline and is an area of emerging technology with a phenomenal growth over last four decades. The Remote Sensing technology is now beyond the art of Map making from satellite or Aerial images. The demand for Remote Sensing and GIS is increasing day by day in Government and Private sector. The course is not only going to enhance job opportunity for the civil students but shall also open an avenue of effective and viable interaction with national establishments related to various aspects of remote sensing

Pre-requisites: Knowledge of surveying, map reading and basic mathematics

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the concepts of Photogrammetry and compute the heights of objects

CO 2: Relate the principles of aerial and satellite remote sensing, Able to comprehend the energy interactions with earth surface features, spectral properties of water bodies.

CO 3: Categorize the basic concept of GIS and its applications, know different types of data representation in GIS

CO 4: Reframe and Develop models for GIS spatial Analysis and will be able to know what the questions that GIS can answer are

CO 5: Apply knowledge of GIS software and able to work with GIS software in various application fields

Module	Topics	Hrs	CO
Module 1: Remote Sensing and Electromagnetic Radiation	Definition of Remote Sensing; History and development of RS; Benefits of RS over conventional method of resource survey. Components of Remote Sensing System. Electromagnetic Radiation (EMR), Nature and generation of EMR; Effects of atmosphere on EMR and its interaction with rocks minerals vegetation, water, soil etc.	8	1
Module 2: Platform and properties of sensors	Platform, Role of platform in Remote Sensing, Types of platform with their specific uses. Fundamental properties of sensors and their functions. Basic features of different types of sensors in use.	8	2

Module 3: RS data and GIS	RS data products. Principles of RS data analysis and their applications. Fundamentals of Geographic information system. Components of GIS.	8	3
Module 4: Classification schemes in GIS	Classification schemes in GIS. Training site selection; supervised classification.	8	4
Module 5: . Application of RS and GIS	Geographic information system, Data structure of GIS, Raster and vector data for geographical entities. Application of RS and GIS in Geology and Geography. Application of RS and GIS in Environmental Science and Town planning.	8	5

Text Books:

1. Lillesand, T.M., Keifer, R.W., Chipman, J.W(2008) Remote Sensing and Image interpretation. (6th edition). John Wiley & Sons.

Reference Books:

1. Jenson, J.R (2013) Remote Sensing of the Environment. (2nd edition). Pearson Education India.
2. Panda, B.C (2008) Remote Sensing- principles and Application. Viva Books.

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Sub Code: **CD310A3** **Credit:4 (L-3, T-1, P-0)**

Augmented and Virtual Reality

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of the course is to establish and cultivate a broad and comprehensive understanding of this rapidly evolving and commercially viable field of Computer Science. The technology of VR and AR is really hitting the ground right now. With these methods, the businesses are trying to get their brands to a whole new level of success and popularity. Integrating AR/VR in development can provide many advantages like: Improved Experience for Learning in sectors like education, Increasing Efficiency In Business, Unmatchable Virtual Experience, Increase In User Engagement, Boost In Brand Loyalty, Mobility, Better Advertising of products and many more

Pre-requisites: NA

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand fundamental computer vision, computer graphics andhuman-computer interaction techniques related to VR/AR. (Understand)

CO 2: Illustrate geometric modeling and Virtual environment. (Understand)

CO 3: Relate and differentiate VR/AR technology. (Analyse)

CO 4: Use various types of Hardware and software in virtual Reality systems (Apply)

CO 5: Implement Virtual/Augmented Reality applications. (Apply)

Module	Topics	Hrs	CO
Module 1: Introduction to Virtual Reality	Virtual Reality and Virtual Environment: Introduction, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark.	8	1
Module 2: Computer Graphics And Geometric Modelling	Introduction, The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, Colour theory, Conversion From 2D to 3D, 3D space curves, 3D boundary representation, Simple 3D modelling, 3D clipping, Illumination models, Reflection models, Shading algorithms. Geometrical Transformations: Introduction, Frames of reference,	8	2

	Modelling transformations, Instances, Picking, Flying, Scaling the VE, Collision detection. Virtual Environment: Input: Tracker, Sensor, Digital Gloves, Movement Capture, Video-based Input, 3D Menus & 3D Scanner etc. Output: Visual /Auditory / Haptic Devices.		
Module 3: Generic VR system	Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems.	8	3
Module 4: Animating the Virtual Environment	Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object in between, free from deformation, particle system. Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels, Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft.	8	4
Module 5: Augmented Reality	Taxonomy, technology and features of augmented reality, difference between AR and VR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality, enhancing interactivity in AR environments, evaluating AR systems.	8	5

Text Books:

1. Alan Craig, William Sherman, Jeffrey Will (2009) Developing Virtual Reality Applications: Foundations of Effective Design. Morgan Kaufmann.
2. John Vince(1995) Virtual Reality Systems. Addison Wesley.

Reference Books:

1. Grigore C. Burdea, Philippe Coiffet (2006) Virtual Reality Technology. (2nd edition) Wiley .
2. Alan B. Craig (2013) Understanding Augmented Reality: Concepts and Applications. (1st edition) Morgan Kaufmann.

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Sub Code: **CD311A3** **Credit: 4 (L-3, T-1, P-0)**

High Performance Computing

Questions to be set: 05 (All Compulsory)

Course Objectives: To explore the fundamental concepts of Parallel programming and HPC Solutions and their applications. To develop in-depth knowledge and understanding of HPC domain. To understand the various search methods and visualization techniques. To learn to use various HPC tools. To understand the applications using Map Reduce Concepts, OpenMP, CUDA, MPI, Xeon Phi programming.

Pre-requisites: Programming in C/C++, basic knowledge of UNIX/Linux shell, familiarity with basic numerical algorithms and computer architecture.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understanding principles of multi-threading and distributed computing

CO 2: Solving sources and models of costs in parallel environments (cache, memory, network)

CO 3: Relate parallel programming patterns. Being able to design and develop cluster systems and MPI Implementations

CO 4: Estimate and measure performance of a Hybrid programming

CO 5: Collaborate different parallel programming programing Tools

Module	Topics	Hrs	CO
Module 1: Introduction and Categories of machines	High performance computing: Why, and why now? Concepts and scientific applications, Parallel decomposition, basic architecture and OS concepts, Multi-core CPUs, High-speed interconnects, High performance file systems, GPU systems, High performance clusters. Multicore and many core shared memory machines via the work-span model, distributed memory machines like clusters and supercomputers via network models, and sequential or parallel machines with deep memory hierarchies.	8	1

Module 2: Parallel computing and Programming of multicore systems	Parallel computer architecture and parallel software, processor and memory systems of parallel computers, different types of parallelism (on instruction level, on computational task level and data parallelism), performance models for parallel systems Shared memory multiprocessing programming (OpenMP). OpenMP Programming Model, OpenMP API Overview, Compiling OpenMP Programs, OpenMP, Synchronization Constructs, Directives, Data Scope Attribute Clauses, Directive Binding and Nesting Rules, Run-Time Library Routines, Environment Variables, Thread Stack Size and Thread Binding, Monitoring, Debugging and Performance Analysis Tools for OpenMP, Case Studies (Algorithms and Parallelization Approaches), Matrix –Matrix-multiplication.	8	2
Module 3: Programming of cluster systems and MPI Implementations	Message Passing Interface (MPI) and approaches for the parallelization of programs: General Introduction, Point-to-Point Communication, Blocking vs. Non-blocking sends, Collective Communication, MPI hybrid models, profiling, and debugging, Case Studies (Algorithms and Parallelization Approaches). Compilers, Environment Management Routines: Point to Point Communication Routines, MPI Message Passing Routine Arguments, Blocking Message Passing Routines, Non-blocking Message Passing Routines, Collective Communication Routines, Derived Data Types Group and Communicator Management Routines, Virtual Topologies.	8	3
Module 4: Hybrid programming (OpenMP and MPI)	Numerical libraries & high performance I/O libraries, Introduction to multi-threading accelerators, A Brief introduction on MPI-2 and MPI-3.	8	4
Module 5: HPC tools	Profiling and Debugging of codes tools: gprof, Vtune, gdb, Performance library like mkl, lapack, fft , Analysis tools like : ITAC , MPI libraries. Demo of the sample code by using the above tools.	8	5

Text Books:

1. Michael J Quinn (2008). Parallel Programming in C with MPI and OpenMP. McGraw-Hill Higher Education.
2. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar (2003) Introduction to Parallel Computing(2nd edition). Pearson Education India.
3. Rohit Chandra, Ramesh Menon, Leo Dagum, David Kohr,Dror Maydan,Jeff McDonald (11 October 2000). Parallel Programming in OpenMP (1st edition). Morgan Kaufmann.

Reference Books:

Georg Hager, Gerhard Wellein July 7, 2010 Introduction to High Performance Computing for Scientists and Engineers. Chapman & Hall / CRC Computational Science series, 2011.

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Sub Code: **CD312A3** **Credit: 4 (L-3, T-1, P-0)**

Cryptography and Network Security

Questions to be set: 05 (All Compulsory)

Course Objectives: This course provides an overview of computer security principles ranging from cryptography to network security. The course will help students to learn the principles and practices of computer security in various computing environments.

Pre-requisites: Computer Networks and Number theory.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand basic concept of Cryptography and Block Ciphers

CO 1: Transfer knowledge in the emerging areas of cryptography and network security.

CO 1: Implement various networking security.

CO 1: Reframe add-on Protestation any network from the threats in the world.

CO 1: Implement various networking/ web application

Module	Topics	Hrs	CO
Module 1: (Introduction to Cryptography and Block Ciphers)	Introduction to security attacks - services and mechanism - introduction to cryptography - Conventional Encryption: Conventional encryption model - classical encryption techniques - substitution ciphers and transposition ciphers – cryptanalysis – steganography - stream and blockciphers - Modern Block Ciphers: Block ciphers principals - Shannon's theory of confusion anddiffusion - fiestal structure - data encryption standard(DES) - strength of DES - differential and linearcrypt analysis of DES - block cipher modes of operations - triple DES – AES	8	1
Module 2: (Confidentiality and Modular Arithmetic)	Confidentiality using conventional encryption - traffic confidentiality - key distribution - random number generation - Introduction to graph - ring and field - prime and relative prime numbers - modular arithmetic - Fermat's and Euler's theorem - primality testing - Euclid's Algorithm - Chinese Remainder theorem - discrete algorithms.	8	2

Module 3: (Public key cryptography and Authentication requirements)	I Principles of public key crypto systems - RSA algorithm - security of RSA - key management – Diffle-Hellman key exchange algorithm - introductory idea of Elliptic curve cryptography – Elgamel encryption - Message Authentication and Hash Function: Authentication requirements - authentication functions - message authentication code - hash functions - birthday attacks – security of hash functions and MACS.	8	3
Module 4: (Integrity checks and Authentication algorithms)	MD5 message digest algorithm - Secure hash algorithm (SHA) Digital Signatures: Digital Signatures - authentication protocols - digital signature standards (DSS) - proof of digital signature algorithm - Authentication Applications: Kerberos and X.509 - directory authentication service - electronic mail security-pretty good privacy (PGP) - S/MIME.	8	4
Module 5: (IP Security and Key Management and Web and System Security)	IP Security: Architecture - Authentication header - Encapsulating security payloads - combining security associations - key management Secure socket layer and transport layer security - secure electronic transaction (SET) - System Security: Intruders - Viruses and related threads - firewall design principals – trusted systems.	8	5

Text Books:

1. William Stallings (2013). Cryptography and Network Security (6th Edition). Pearson.
2. Behrouz A Frouzan (2011) Cryptography and Network Security (2nd Edition) Tata McGraw Hill

Reference Books:

1. Richard E. Smith (2002). Internet Cryptography (1st Edition). Pearson.
2. D. Chapman, E. Zwicky (2000). Building Internet Firewalls (2nd Edition). O'Reilly.
3. Derek Atkins et al (1997). Internet Security, Professional Reference (2nd Edition).Techmedia.
4. Atul Kahate (2009). Cryptography and Network Security McGraw Hill (2nd Edition). 2nd Edition.

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Sub Code: **CD313A3** **Credit: 4 (L-3, T-1, P-0)**

DevOps Engineering

Questions to be set: 05 (All Compulsory)

Course Objectives: In this comprehensive course, participants will delve into the principles of DevOps, Agile methodologies, and Scrum practices. They'll gain a solid understanding of Git version control and its purpose in managing software development. Additionally, learners will explore Flask, a lightweight web framework, to build RESTful APIs and web services. The course also covers containerization concepts using Docker, along with Kubernetes and OpenShift for orchestrating containerized applications. Lastly, students will acquire essential knowledge about monitoring tools and best practices for maintaining application health.

Pre-requisites: Familiarity with languages like Python, and Java can be beneficial.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the principles of DevOps, Agile methodologies, and Scrum practices.

CO 2: Explain the purpose of Git version control.

CO 3: Explore Flask, a lightweight web framework, for building RESTful APIs and web services

CO 4: Understand containerization concepts, Docker for creating and managing containers, and Kubernetes and OpenShift for orchestrating containerized applications.

CO 5: Understand monitoring tools and practices for maintaining application health.

Module	Topics	Hrs	CO
Module 1: Introduction to DevOps, Agile Development and Scrum,	Overview of DevOps, Thinking DevOps, Working DevOps, Measuring DevOps, Case studies. Introduction to Agile and Scrum, Agile planning, Daily workflow for executing a sprint plan, Create an Agile Plan with Zenhub	8	1
Module 2: Git and GitHub	Git and GitHub Fundamentals, Git Commands and Managing GitHub Projects, Working with Github from your windows Desktop	8	2

Module 3: Developing AI Applications with Python and Flask	Developing AI Applications with Python and Flask: Basic difference between web applications and APIs. Application development lifecycle, from gathering requirements to maintaining the project, Web App Deployment using Flask, Embeddable Watson AI libraries, AI-based apps, Build a Text-based Sentiment Analysis tool.	8	3
Module 4: Introduction to Containers w/ Docker, Kubernetes & OpenShift	**Introduction to Containers w/ Docker, Kubernetes & OpenShift:** Containers and Containerization, Kubernetes basics, Mangaing Applications with Kubernetes , Kubernetes ecosystem: OpenShift, Istio **Application Development using Microservices and Serverless:** Introduction to microservices, WebAPI Essentials: RestAPI and GraphQL, Serverless Overview, Create and Deploy using Serverless,	8	4
Module 5: CI/CD and Monitoring	**Continuous Integration (CI) and Continuous Delivery (CD):** Continuous Integration, Continuous Delivery, DevOps and GitOps with Openshift **Monitoring and Observability for Development and DevOps**: Introduction to Monitoring for Applications, Monitoring Systems and Techniques, Methodologies and Tools in Logging, Observability and Concepts. **DevOps Capstone Project**: Create and Execute Sprint Plans, develop a RESTful service using Test Driven Development, Add continuous Integration (CI) and Security to a Repository, Deploy your Application to Kubernetes, Build an Automated CD DevOps Pipeline,	8	5

Text Books:

1. Joakim Verona. Practical Devops, Second Edition. Ingram short title; 2nd edition (2018). ISBN10: 1788392574
2. Deepak Gaikwad, Viral Thakkar. DevOps Tools from Practitioner's Viewpoint. Wiley publications. ISBN: 9788126579952

Reference Book:

1. Len Bass, Ingo Weber, Liming Zhu. DevOps: A Software Architect's Perspective. Addison Wesley; ISBN-10.

E-Resources:

https://www.coursera.org/professional-certificates/devops-and-software-engineering

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Program Elective-V (6th Semester)

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Sub Code: **CD314A3** **Credit: 4 (L-3, T-1, P-0)**

Generative AI and Prompt Engineering

Questions to be set: 05 (All Compulsory)

Course Objectives: The objectives of Generative AI and Prompt Engineering course equips students with the skills to create and manage AI-generated content. It covers the core principles of generative AI, prompt engineering tactics, and the deployment of AI solutions.

Pre-requisites: Programming Knowledge Required preferably in Python

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand Classical ML and AI.

CO 2: Explain the Generative AI Applications and Prompt Engineering.

CO 3: Apply Generative Text and Speech Models.

CO 4: Explain Generative AI models.

CO 5: Understand LLMOps and cloud computing Tools.

Module	Topics	Hrs	CO
Module 1: Overview of Classical ML and AI	The AI/ML Process and Workflow How to solve a problem using data and algorithms? Data Types and State-of-the-Art Models Tabular Data - Gradient Boosted Models Image Data - Convolutional Neural Networks Sequential and Time Series Data - Recurrent Neural Networks Text and Speech Data - Transformers Generative AI- GPT class of Models for Text, Diffusion for Images/Video	8	1

	Difference between Gen AI and other types of AI, advantages, and disadvantages of Gen AI technologies		
Module 2: Generative AI Applications and Prompt Engineering	Exercises to identify GenAI Use Cases in Diverse Domains LLM Guardrails Responsible AI in Generative Applications Low Code No Code ML/AI Platforms Basic Prompting to Build AI Applications	8	2
Module 3: Generative Text and Speech Models	Tokenization Fundamentals and Byte Pair Encoding How does the GPT class of models Generate Text? Training GPT Models Speech Models Interacting with Trained Models	8	3
Module 4: Generative AI models	Stable Diffusion Fundamentals Image and Video Generation Tools for Generating Images	8	4
Module 5: LLMOps with Low Code, No Code Platforms	LLMOps – Tools, Platforms (incl, but not limited to LangChain, OpenAI API) AWS Sage Maker, Kendra Cloud Computing Tools - AWS ML Tools, Google Cloud, IBM Watson	8	5

Text Books:

1. James Phoenix and Mike Taylor, Prompt Engineering for Generative AI, O'Reilly Media.
2. Altaf Rehmani, Generative AI for everyone,Bluerose Publishers Pvt. Ltd.,February 2024

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Sub Code: **CD315A3** **Credit: 4 (L-3, T-1, P-0)**

Social Network Analytics

Questions to be set: 05 (All Compulsory)

Course Objectives: To understand how the world is connected -- socially, strategically, technologically, and why it matters, To introduce the basic notions and model used for social

Pre-requisites: Data Structure, DBMS

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Develop and apply knowledge of Social Network

CO 2: Analyze master theories of social networks and social behaviour

CO 3: Acquire techniques for analyzing social network data

CO 4: Reframe analytical skills to social network data

CO 5: Apply social network analysis to marketing research.

Module	Topics	Hrs	CO
Module 1: Introduction and Social Network Data	Motivation, The Social network perspective, Different sources of network data, Historical and Theoretical Foundation, Fundamental concepts of network analysis. Preliminaries and definitions, Erdos Number Project, Centrality measures, Balance and Homophily; Definition, Boundary Specification and Sampling, Types of networks – One mode networks, Two mode networks, Ego-centered and Specific Dyadic networks, Network data, Measurement, Collection, Datasets.	8	1
Module 2: Mathematical Representation of Social Network	Notation for Social network data, Graph Theory, Sociometri Notation, Algebraic Notation, Graphs, Directed Graph, Signed graph, Valued graph, Multigraph, Hypergraph, Matrices of graph, digraph, hypergraph, Random graphs and alternative models, Models of network growth, Navigation in social Networks.	8	2

Module 3: Structural Properties of Networks	Cohesiveness of subgroups, roles and positions, Multidimensional Scaling, Ego networks, Weak ties, Structural equivalence, Structural hole, Equitable partitions, Stochastic block models.	8	3
Module 4: Cascading Properties of Networks	Information/influence diffusion on networks, Maximizing influence spread, Power Law and Heavy tail distributions, Preferential attachment models, Small world experiments, Small world models, Origins of small world, Heavy tails, Small Diameter,	8	4
Module 5: Clustering of connectivity Models of Network Formation and Preferential Model	Erdos-Renyi Model- The Model & Threshold Phenomenon, Clustering Models – The Model, Programming Clustering, Clustering Coefficient, Community and cluster detection: random walks, spectral methods; link analysis for web mining.	8	5

Text Books:

1. S. Wasserman , K. Faust(1994). Social Network Analysis: Methods and Applications. (1st edition). Cambridge University Press.
2. D. Easley , J. Kleinber (2010). Networks, Crowds and Markets: Reasoning about a highly connected world. Cambridge University Press.

Reference Books:

1. Peter R. Monge, Noshir S (2003). Contractor, Theories of communication networks.(1st edition) Oxford University Press.
2. Duncan Watts.(2004). Six degrees: the science of a connected age.(Reprint edition) W. W. Norton & Company .

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Sub Code: **CD316A3** **Credit: 4 (L-3, T-1, P-0)**

Blockchain Technologies

Questions to be set: 05 (All Compulsory)

Course Objectives: **:** This course is intended to study the basics of Blockchain technology. During this course learner will explore various aspects of Blockchain technology like application in various domains. By implementing learner will have idea about private and public Blockchain, and smart contract.

Pre-requisites: Cryptography, Data Structure, Networking, OOP

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Describe the basic concepts and technology used for blockchain.

CO 2: Understand the primitives of the distributed computing and cryptography related to blockchain.

CO 3: Relate the concepts of Bitcoin and their usage.

CO 4: Implement Ethereum block chain contract.

CO 5: Apply security features in blockchain technologies.

Module	Topics	Hrs	CO
Module 1: Introduction of Cryptography and Blockchain	What is Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions And Blocks, P2P Systems, Keys As Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain.	8	1
Module 2: BitCoin and Cryptocurrency	What is Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain And Digital Currency, Transactional Blocks, Impact Of Blockchain Technology On Cryptocurrency.	8	2

Module 3: Introduction to Ethereum	What is Ethereum, Introduction to Ethereum, Consensus Mechanisms, How Smart Contracts Work, Metamask Setup, Ethereum Accounts, Receiving Ether's What's a Transaction?, Smart Contracts.	8	3
Module 4: Introduction to Hyperledger and Solidity Programming	What is Hyperledger? Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types (Int, Real, String, Bytes, Arrays, Mapping, Enum, address)	8	4
Module 5: Blockchain Applications	Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.	8	5

Text Books:

1. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller , Steven Goldfeder (2016). Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction.(Illustrated edition)Princeton University Press .
2. Andreas M. Antonopoulos (1 January 2017)Antonopoulos, Mastering Bitcoin.(Second edition)Shroff/O'Reilly

Reference Books:

3. Antonopoulos , G. Wood (2018) Mastering Ethereum. O′Reilly.

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Sub Code: **CD317A3** **Credit: 4 (L-3, T-1, P-0)**

Bio-Inspired Computing

Questions to be set: 05 (All Compulsory)

Course Objectives: To Learn bio-inspired theorem and algorithms, To Understand random walk and simulated annealing, To Learn genetic algorithm and differential evolution, To Learn swarm optimization and ant colony for feature selection, To understand bio-inspired application in image processing

Pre-requisites: Statistics and Optimization Methods,Basic of AI and image processing

Course Outcomes(CO):

Upon successful completion of the course, students should be able to

CO 1: Implement and apply bio-inspired algorithms
CO 2: Explain random walk and simulated annealing
CO 3: Implement and apply genetic algorithms
CO 4: Explain swarm intelligence and ant colony for feature selection
CO 5: Apply bio-inspired techniques in image processing.

Module	Topics	Hrs	CO
Module 1: INTRODUCTION	Introduction to algorithm - Newton ' s method - optimization algorithm - No-Free-Lunch Theorems - Nature-Inspired Mataheuristics -Analysis of Algorithms - Nature Inspires Algorithms -Parameter tuning and parameter control.	8	1
Module 2: RANDOM WALK AND ANEALING	Random variables - Isotropic random walks - Levy distribution and flights - Markov chains - step sizes and search efficiency - Modality and intermittent search strategy - importance of randomization- Eagle strategy-Annealing and Boltzmann Distribution - parameters -SA algorithm - Stochastic Tunneling.	8	2
Module 3: GENETIC ALOGORITHMS AND DIFFERENTIAL EVOLUTION	Introduction to genetic algorithms and - role of genetic operators - choice of parameters - GA varients - schema theorem - convergence analysis - introduction to differential evolution - varients - choice of parameters - convergence analysis - implementation.	8	3

Module 4: SWARM OPTIMIZATION AND FIREFLY ALGORITHM	Swarm intelligence - PSO algorithm - accelerated PSO - implementation - convergence analysis - binary PSO - The Firefly algorithm - algorithm analysis - implementation - varients- Ant colony optimization toward feature selection.	8	4
Module 5: APPLICATION IN IMAGE PROCESSING	Bio-Inspired Computation and its Applications in Image Processing: An Overview - Fine- Tuning Enhanced Probabilistic Neural Networks Using Meta-heuristic-driven Optimization - Fine-Tuning Deep Belief Networks using Cuckoo Search - Improved Weighted Thresholded Histogram Equalization Algorithm for Digital Image Contrast Enhancement Using Bat Algorithm - Ground Glass Opacity Nodules Detection and Segmentation using Snake Model - Mobile Object Tracking Using Cuckoo Search	8	5

Textbooks:

1. Stephan Olariu and Albert Zomaya, (2006) Hanbook of Bioinspired Algorithms and Applications, Taylor & Francis Ltd

Reference Books:

1. Nancy Forbes(2004). Imitation of Life - How Biology Is Inspiring Computing (1st edition) MIT Press.
2. Bonabeau, Eric, Dorigo, Marco, & Theraulaz, Guy(1999). Swarm Intelligence: From Natural to Artificial Systems(1st edition) . Oxford.

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Sub Code: **CD318A3** **Credit: 4 (L-3, T-1, P-0)**

Quantum Computing

Questions to be set: 05 (All Compulsory)
Course Objectives: Analyze the behavior of basic quantum algorithms; ii. Implement simple quantum algorithms and information channels in the quantum circuit model; iii. Simulate a simple quantum error-correcting code; iv. Prove basic facts about quantum information channels
Pre-requisites: Familiarity with linear algebra including concepts such as vector space, inner products, matrices, eigenvalues and eigenvectors will be assumed.
Course Outcomes (CO):
Upon successful completion of the course, students should be able to
CO 1: Understand what quantum computing and quantum protocols are about, why they matter, and what the scientific prospects of the field are.
CO 2: This includes a structural transfer of some basic quantum mechanics, knowledge of important algorithms
CO 3: Analyze Quantum error correction
CO 4: At the same time, the student will evaluate Quantum Entanglement
CO 5: Develop different implementations of quantum computers

Module	Topics	Hrs	CO
Module 1: Introduction of Quantum Cryptography	Introduction of quantum computing Cryptography, classical cryptography, introduction to quantum cryptography. BB84, B92 protocols. Introduction to security proofs for these protocols.	8	1
Module 2: Quantum Algorithm	Introduction to quantum algorithms. Deutsch-Jozsa algorithm, Grover's quantum search algorithm, Simon's algorithm. Shor's quantum factorization algorithm.	8	2

Module 3: Error Correction	Errors and correction for errors. Simple examples of error correcting codes in classical computation. Linear codes. Quantum error correction and simple examples. Shor code.	8	3
Module 4: Quantum Entanglement	Quantum correlations, Bell's inequalities, EPR paradox. Theory of quantum entanglement. Entanglement of pure bipartite states. Entanglement of mixed states. Peres partial transpose criterion. NPT and PPT states, bound entanglement, entanglement witnesses.	8	4
Module 5: Implementations	Different implementations of quantum computers. NMR and ensemble quantum computing, Ion trap implementations. Optical implementations.	8	5

Text Books:

1. M.A. Nielsen, I.L.Chuang (2010). Quantum Computation and Quantum Information Cambridge. University Press.

Reference Books:

1. P. Kaye, R. Laflamme, M. Mosca (2007). An Introduction to Quantum Computing. Oxford.
2. Robert Loredo (2020) Learn Quantum Computing with Python and IBM Quantum Experience: A hands-on introduction to quantum computing and writing your own quantum programs with Python. Packt Publishing Limited.

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Sub Code: **CD319A3** **Credit: 4 (L-3, T-1, P-0)**

Reinforcement Learning

Questions to be set: 05 (All Compulsory)

Course Objectives: The course deals with probabilistic models for problems of dynamic decision making under uncertainty. Stochastic dynamic programming is a general framework for modelling such problems. The course deals with building first the model based dynamic programming techniques and subsequently the model free, data driven algorithms, and deals with the theoretical foundations of these.

Pre-requisites: Probability and Statistics or an equivalent probability course

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Knowledge Creation on Reinforcement Learning

CO 2: Understand Tabular methods and Q-networks

CO 3: Apply different policy optimization technique

CO 4: Analysis different tools and modeling techniques for problems of dynamic decision making under uncertainty

CO 5: They will know the algorithms they can apply when faced with such problems and the convergence and accuracy guarantees that such algorithms would provide.

Module	Topics	Hrs	CO
Module 1: Foundations	Introduction and Basics of RL 2. Defining RL Framework and Markov Decision Process 3. Polices, Value Functions and Bellman Equations 4. Exploration vs. Exploitation 5. Code Standards and Libraries used in RL (Python/Keras/Tensorflow)	8	1
Module 2: Tabular methods and Q-networks	Planning through the use of Dynamic Programming and Monte Carlo 7. Temporal-Difference learning methods (TD(0), SARSA, Q-Learning) 8. Deep Q-networks (DQN, DDQN, Dueling DQN, Prioritised Experience Replay) 2	8	2
Module 3: Policy optimization	Introduction to policy-based methods 10. Vanilla Policy Gradient 11. REINFORCE algorithm and stochastic policy search 12. Actor-critic methods (A2C, A3C) 13. Advanced policy gradient (PPO, TRPO, DDPG)	8	3

Module 4: Model based RL	Model-based RL approach	8	4
Module 5: Recent Advances and Applications	Meta-learning 16. Multi-Agent Reinforcement Learning 17. Partially Observable Markov Decision Process 18. Ethics in RL 19. Applying RL for real-world problems	8	5

Text Books:

1. Richard S. Sutton,Francis Bach,(2019). Reinforcement Learning – An Introduction (Adaptive Computation and Machine Learning series) (Second Edition). MIT Press.
2. Lei, Chen (2021). Deep reinforcement learning. Springer
3. Wiering, Marco, Martijn Van Otterlo (2012). Reinforcement learning Adaptation, learning, and optimization. Springer.

Reference Books:

1. Russell, Stuart J., and Peter Norvig(2016) Artificial intelligence: a modern approach. Pearson Education Limited.
2. Goodfellow, Ian, Yoshua Bengio,Aaron Courville (2016). Deep learning. MIT press.

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Sub Code: **CD320A3** **Credit: 4 (L-3, T-1, P-0)**

Cyber Security

Questions to be set: 05 (All Compulsory)

Course Objectives: The course is designed to present the basic concepts of cyber security. It addresses the key issues of security vulnerabilities on software development, operating system and the web. Solutions provided by cryptography has been discussed especially based on intrusion detection system. The syllabus also gives a brief introduction to cyber forensics.

Pre-requisites: Basics of Computer Networks

Course Outcomes (CO): On completion of the course, it is expected to endow the students with skills to:

1. Discover the concepts of cyber security and its social, technical and political techniques.
2. Illustrate on the various Intrusion detection and prevention techniques.
3. Analyze various algorithms based on Cryptography and Network security.
4. Assess various methods of handling investigations in the field of cyber forensics.
5. Explain the legal and social issues in the development and management of cyber security.

Module	Topics	Hrs	CO
Module 1: Introduction to Cyber Security , Cyber Security Vulnerabilities and Cyber Security Safeguards	Overview of Cyber Security, Internet Governance – Challenges and Constraints, Cyber Threats:- Cyber Warfare-Cyber Crime-Cyber terrorism-Cyber Espionage, Need for a Comprehensive Cyber Security Policy, Need for a Nodal Authority, Need for an International convention on Cyberspace Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards- Overview, Access control, Audit, Authentication, Biometrics, Cryptography, Deception, Denial of Service Filters, Ethical Hacking, Firewalls, Intrusion Detection Systems, Response, Scanning, Security policy, Threat Management.	10	1
Module 2: Securing Web Application,	Introduction, Basic security for HTTP Applications and Services, Basic Security for SOAP Services, Identity Management and Web Services, Authorization, Patterns, Security Considerations, Challenges.	10	1,2

Services and Servers, Intrusion Detection and Prevention	Intrusion, Physical Theft, Abuse of Privileges, Unauthorized Access by Outsider, Malware infection, Intrusion detection and Prevention Techniques, Anti- Malware software, Network-based Intrusion detection, Systems, Network based Intrusion Prevention, Systems, Host based Intrusion Prevention Systems, Security Information Management, Network Session, Analysis, System Integrity Validation		
Module 3: Cryptography and Network Security	Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security Security Protocols: - security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer- IPSec	10	3
Module 4: Cyberspace and the Law	Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013	6	4
Module 5: Cyber Forensics	Introduction to Cyber Forensics, Handling Preliminary Investigations, Controlling an Investigation, Conducting disk-based analysis, Investigating Information-hiding, Scrutinizing E- mail, Validating E-mail header information, Tracing Internet access, Tracing memory in real-time	6	4,5

Text Books:

1. John R Vacca, "Computer and Information Security Handbook", 3rd Edition, Elsevier, 2013, ISBN: 9780128038437.
2. Albert Marcella, Jr., DougMenendez, "Cyber Forensics: A Field Manual for Collecting, Examining, and Preserving Evidence of Computer Crimes", Second Edition, CRC Group, Taylor & Francis, ISBN 9780849383281.
3. William Stallings, "Cryptography and Network Security", Pearson.

Reference Books:

1. George K Kostopoulus, "Cyber space and Cyber Security ", Second Edition, CRC Group, Taylor & Francis, ISBN 9781138057715
2. Behrouz A Frouzan, "Cryptography and Network Security", Tata McGraw Hill.

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Sub Code: **CD321A3** **Credit:4 (L-4, T-0, P-0)**

Wireless Sensor Networks

Questions to be set: 05 (All Compulsory)

Course Objectives: This course provides an introduction to the area of wireless sensor networks. A detailed study on related technologies and standards ranging from networking, OS support and algorithms, to security will constitute the syllabus. Its primary concern will be protocol design, communication and computational challenges posed by Wireless Sensor based networking systems.

Pre-requisites: Data Communication, Computer Networks, Knowledge of Ad Hoc Wireless Networks desirable.

Course Outcomes: On completion of the course, it is expected to endow the students with skills to:

1. List and describe the engineering fundamentals of wireless communication applied in sensor network.
2. Identify and relate the complex engineering problem relating to sensor network architectures and functions.
3. Formulate a solution plan and methodology by Applying appropriate theory, practices and tools to the development of wireless sensor network with respect to its applications area.
4. Differentiate and select optimal design scheme suitable for wireless sensor network.
5. Discuss and compare the design principles and implementation of a variety of key sensor networking protocols and algorithms.

**** not more than 20% of total topics to be allotted for assignment**

Module	Topics	Hrs	CO
Module 1: Introduction to Wireless Sensor Networks and Infrastructure Control & Communication Networks	Definition, Requirement and Evolution of Wireless Sensor Networks (WSN), Examples of WSNs, Difference between WSNs and Ad Hoc Wireless Networks, IEEE 1451 and Smart Sensors, Transducers and Physical Transduction Principles, Sensors for Smart Environments, Commercially Available Wireless Sensor Systems, Self-Organization and Localization, Network Topology, Communication, Protocols and Routing, Topology, Control, Clustering, Time Synchronization, Power Management Network Structure and Hierarchical Networks, Historical Development and Standards.	8	1
Module 2: Canonical Problem Localization and Tracking, Signal Processing and Decision Making and	A Tracking Scenario, Problem Formulation, Distributed Representation and Inference of States, Tracking Multiple Objects, Sensor Models and Performance Comparison and Metrics, Localization, ranging techniques, range-based localization, GPS-based localization; range-free localization; event-driven	9	2

Medium Access Control protocols Module	localization. Signal Conditioning, Digital Signal Processing, Decision Making and User Interface. Carrier Sense Multiple Access, Multiple Access with Collision Avoidance (MACA) and MACAW, MACA By Invitation, IEEE 802.11, IEEE 802.15.4 and ZigBee; Characteristics of MAC Protocols in Sensor Networks, Types of MAC Protocols.		
Module 3: Networking Sensors and Routing	Introduction, Key Assumptions, Medium Access Control, routing metrics, Issues and Challenges for Routing in WSN, Routing Based on Network Structure, Routing Based on Protocol Operation, categories of routing protocol, flooding and gossiping, data-centric routing, proactive routing, on- demand routing, hierarchical routing, location-based routing	7	2,3
Module 4: Security for Sensor Networks	Requirement, Issues and Challenges for different security protocols for WSNs, Security Parameters, Sensor Network Limitations, Requirements for Bootstrapping Security in Sensor Networks, Evaluation Metrics, Single Network-Wide Key, Using Asymmetric Cryptography, Pairwise- shared Keys, Bootstrapping Security off a Trusted Base Station.	8	4
Module 5: Sensor Network Databases and Applications and Future Directions	Sensor Database Challenges, Query Interfaces, High Level Database Organization, In Network Aggregation, Data Centric Storages, Distributed Hierarchal Aggregation, Temporal Data. Emerging Applications, Future Research Directions	8	5

Text Books:

1. Feng Zhao &Leonidas Guibas, Wireless Sensor Networks: An Information Processing Approach, Elsevier Publication.
2. Jun Zheng & Abbas Jamalipour, Wireless Sensor Networks: A Networking Perspective, Wiley Publication.

Reference Books:

3. Waltenegus Dargie & Christian Poellabauer, Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley Publication,
4. Holger Karl &Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, Wiley Publication.
5. Robert Faludi, Building Wireless Sensor Networks, O'Reilly Publication.
6. Shahin Farahani, ZigBee Wireless Networks and Transceivers, 1st Edition, Elsevier Publication

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Sub Code: **CD322A3** **Credit: 4 (L-3, T-1, P-0)**

MERN Stack Development

Questions to be set: 05 (All Compulsory)

Course Objectives: **:** The MERN stack, which stands for MongoDB, Express.js, React, and Node.js, is a powerful technology stack used for building efficient and scalable web applications.

Pre-requisites: Basic Programming Concepts.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Apply HTML, JavaScript, and CSS to create web pages and interactive user interfaces.

CO 2: Gain proficiency in using NoSQL databases, understanding their principles, and implementing data storage and retrieval

CO 3: Develop server-side applications using Node.js, including handling requests, managing modules, and building APIs

CO 4: Use Express.js, a popular Node.js framework, for building robust and scalable web applications

CO 5: Apply React.js, a JavaScript library for building dynamic and responsive user interfaces

Module	Topics	Hrs	CO
Module 1: Introduction to Web Development with HTML, CSS, JavaScript	**Introduction to Fullstack**: Fullstack Web Development, Introduction to Project Management in Web Development, Command Prompt (CMD), Introduction to GitHub **UI Design**: Introduction, Characteristics and Principles of UI Design, Introduction to Figma, UI Designing using Figma Introduction to Application Development, HTML Overview, CSS and HTML5, JavaScript programming for web applications	8	1

Module 2: MongoDB	DBMS using MongoDB: Introduction to Database, Concept of Data Modeling, Relational & Non-relational Databases, Introduction to MongoDB **Assignment:** Creating ERD & DB for E-Commerce Website	8	2
Module 3: NodeJS	Introduction to Node.js, Setting up Node.js, Callbacks and Events, Introduction to File System, Buffers & Streams, Concepts of Objects & Modules **Assignment:** Hosting Website using Node.js:	8	3
Module 4: ExpressJS	Introduction & Setup of Express.js, Concepts of RESTful API, HTTP Methods, Routing, Templating in Express.js, Database & Data Handling in Express.js, Authentication in Express.js **Assignment:** Creating Express APIs for E-Commerce Website	8	4
Module 5: ReactJS	Installation & Introduction to React.js, JSX & its Components, React's Props & State Management, Event Management in React, Concept of React Hooks, Routing in React, React Forms & Client-side Programming **Assignment:** implementing a dynamic and interactive web application	8	5

Text Books:

1. Vasan Subramanian (2017). Pro MERN Stack: Full Stack Web App Development with Mongo, Express, React, and Node. Apress901 Grayson Street Suite 204 Berkely, CAUnited States, ISBN:978-1-4842-2652-0
2. Greg Lim(2021). Beginning MERN Stack: Build and Deploy a Full Stack MongoDB, Express, React, Node.js App, Independently Published

3. Nabendu Biswas (2023). Ultimate Full-Stack Web Development with MERN: Design, Build, Test, and Deploy Production-Grade Applications, Orange Education Pvt Ltd.

E-Resources:

1. https://www.coursera.org/specializations/ibm-cloud-application-development-foundations#courses
2. MERN STACK: https://www.skillvertex.com/blog/mern-stack-course-syllabus/#module-2-ui-design

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Sub Code: **CD323A3** **Credit: 4 (L-3, T-1, P-0)**

Software Engineering

Questions to be set: 05 (All Compulsory)

Course Objectives: This course presents a comprehensive study of software quality assurance, including software quality control management, processes, systems, methods, standards, certification, and reliability measurement.

Pre-requisites: Procedure oriented and object-oriented programming paradigm.

Course Outcomes (CO): On successful completion of this course, students will be able to:

1. Demonstrate competence in using engineering fundamentals to visualize solutions using knowledge of software engineering skills.

2. Extend an ability to formulate a solution plan and methodology for an engineering problem using software engineering.

3. Apply an ability to formulate and interpret a model for project management.

4. Explain an ability to define complex problem, find and analyze requirements

5. Apply new software models, techniques and technologies to bring out innovative and novelistic solutions for the growth of the society in all aspects and evolving into their continuous professional development.

** not more than 20% of total topics to be allotted for assignment

Module	Topics	Hrs	CO
Module 1: <Introduction & Software Life Cycle>	The software engineering discipline-evaluation and impact, Programs vs. software products, Emergence & Software of software engineering, Notable changes in software development practice, System engineering, handling complexity through Abstraction and Decomposition. Life Cycle Models: Classical waterfall model, Iterative waterfall model, Prototype model, Evolutionary model, Spiral model, RAD model, Agile models, Introduction to Agile software development, Extreme Programming and Scrum, DevOps, Domain Analysis **Assignment: Comparison of different life cycle models.	8	1
Module 2: <Software Project Management & Requirements Analysis and Specification>	Responsibilities of project manager, Project planning, Metrics for project size estimation techniques, Empirical estimation techniques, COCOMO, Halstead's software science, Staffing level estimation, & Scheduling, Staffing, Risk management, Software configuration management. Requirements gathering and analysis, Software requirement specification (SRS), Traceability, Overview of formal system development techniques. **Assignment: Organization and team structure. Characteristics of a Good SRS Document, IEEE 830 guidelines.	8	2
Module 3: <Software Design (Function- Oriented and Object-Oriented Software Design)	Good Software Design, Cohesion and coupling, Control Hierarchy: Layering, Control Abstraction, Depth and width, Fan-out, Fan-in, Software design approaches, object oriented vs function oriented and design. Overview of SA/SD methodology, structure analysis, Data flow diagram, Extending DFD technique to real life systems, structured design, detailed design, Design review. Unified Modeling Language (UML), UML Diagrams: Static and Dynamic.	8	3

Module 4: <User interface design, Coding and Testing>	Mode-based Vs Mode-less Interface, Types of user interfaces, Component-based GUI development, User interface design methodology: GUI design methodology, Task and object modeling, Selecting a metaphor, Interaction design and rough layout. Coding, Code review, Testing-Basic Concept of testing, Testing Strategies, Testing in the large vs. testing in the small, Unit testing, Black-box testing, Integration testing, System testing, Some general issues associated with testing, Test driven development, testing tools, Special Value Testing, Combinatorial Testing, Decision Table Testing, Cause effect graphing, Pairwise Testing, White box Testing, Condition Testing, MC/DC Coverage, MC/DC Testing, Path Testing, Dataflow and Mutation Testing, Debugging, Program analysis tools **Assignment: Characteristics of a Good User Interface, User Guidance and Online Help. User interface inspection	8	4
Module 5: <Software Reliability And Quality Management, Computer Aided Software Engineering & Software Maintenance and Reuse>	Software reliability, Statistical testing, Software quality and management, ISO 9000, SEI capability maturity model, Personal software process (PSP), Six sigma, Software quality metrics. Case and its scope, Case environment, Case support in software life cycle. Characteristics of software maintenance, Software reverse engineering, Software maintenance processes model, Estimation maintenance cost. Basics issues in any reuse program. **Assignment: Other characteristics of case tools, Towards second generation case tool, Architecture of a case environment. Reuse approach, Reuse at organization level.	8	5

Text Books:

1. Rajib Mall, “Fundamentals of Software Engineering”, PHI.
2. Richard Fairley, “Software Engineering Concepts”, Tata McGraw Hill.

Reference Books:

1. Jalote Pankaj, “An integrated approach to Software Engineering”, Narosa.
2. Pressman R, “Software Engineering- Practioner Approach”, McGraw Hill.
3. Somerville, “Software Engineering”, Pearson
4. Budgen, “Software Design”, Pearson

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CD324A3 **Credit: 4 (L-3, T-1, P-0)**

AI in Healthcare

Questions to be set: 05 (All Compulsory)

Course Objectives: Data is transforming the health care industry relative to improving quality of care and reducing costs-key objectives for most organizations. Employers are desperately searching for professionals who have the ability to extract, analyze, and interpret data from patient health records, insurance claims, financial records, etc. and more to tell a compelling and actionable story using health care data. The course begins with a study of key components of the Machine Learning and its implications in Healthcare.

Pre-requisites: Basic understanding of Python Programming, Machine Learning basics.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the basic idea of AI and its application in healthcare.
CO 2: Identify current forces disrupting today's health care industry.
CO 3: Summarize data collection, processing, and analysis best practices
CO 4: Introduction to Machine Driven Analytics.
CO 5: Case Studies.

Module	Topics	Hrs	CO
Module 1: Introduction to AI in Healthcare	Introduction: Machine Learning, Data Science, Learning, Role of ML in Healthcare, Applications in Healthcare, Prediction, Diagnosis, Potential in Healthcare, Understanding a learning problem, Common Libraries for Machine Learning, Framing, Data preparation, Training model, Future Scope in healthcare Applications: Disease Prognosis and Management, Disease Detection, Clinical decision support systems, Healthcare information management.	8	1
Module 2: Modern Day AI usage in Healthcare.	Analytics in Healthcare, Intelligent Healthcare, Medical Information System, Identifying Diseases, Medical Imaging Diagnosis, Personalized Medicine, Better Radiotherapy, Smart Health Records, Drug Discovery and Manufacturing, Clinical Trial and Research, Machine Learning-based Behavioral Modification.	6	2

Module 3: Applications of machine learning in healthcare	Data Collection and preprocessing, ML in business and administration of health care: Block chain in health care, Health information and records, Population health, Healthcare analytics, Precision health, Preventive medicine/healthcare. ML applications in diagnostic technologies: Major diagnostic technologies -Diagnostic imaging, Laboratory testing, Genetic testing, etc., Electro diagnosis; Telemedicine; Concurrent medical conditions ("Comorbidity"), Expert Systems; Chabot's. ML applications in medical therapies: Medical care (primary, secondary, tertiary, quaternary care); Pharmaceutical and biopharmaceutical care; Hospital care; Nursing care; Home health care, nursing home, and hospice care; Concurrent medical conditions ("Comorbidity", aka "Multimorbidity"); Precision medicine; Medical/surgical Robotics; Stem cells and regenerative medicine; Genetics and genomics therapies. The Pandemic 2020: ML for clinical considerations for coronavirus infections, Epidemiology and public health considerations.	10	3
Module 4: Machine Driven Analytics	Predictive Analytics and Machine Learning in Medicine: Introduction, Prediction, Research in Medicine, Building a Prediction Model, Selecting and Training, Prediction Models, Reporting, Implementing and Evaluating Predictive Models.	6	4
Module 5: Case Studies	Case Study 1: AI for Imaging of Diabetic Foot Concerns and Prioritization of Referral for Improvements in Morbidity and Mortality Case Study 2: Outcomes of a Digitally Delivered, Low-Carbohydrate, Type 2 Diabetes Self-Management Program: 1-Year Results of a Single-Arm Longitudinal Study Case Study 3: Delivering a Scalable and Engaging Digital Therapy for Epilepsy Case Study 4: Improving Learning Outcomes for Junior Doctors Through the Novel Use of Augmented and Virtual Reality Case Study 5: Do Wearable Apps Have Any Effect on Health Outcomes? A Real World Service Evaluation of the Impact on Activity Case Study 6: Big Data, Big Impact, Big Ethics: Diagnosing Disease Risk from Patient Data	8	5

	Case Study 7: Assessment of a Predictive AI Model for Personalized Care and Evaluation of Accuracy Case Study 8: Can Voice-Activated Assistants Support Adults to Remain Autonomous, a Real-World Service Evaluation of the Impact of a Voice-Activated Smart Speaker Application on Weight and Activity		

Textbooks:

1. Arjun Panesar, Machine Learning and AI for Healthcare Big Data for Improved Health Outcomes, APress, Second Edition, 2021.
2. Ankur Saxena, Shivani Chandra. Artificial Intelligence and Machine Learning in Healthcare, First edition, Springer, 2021
3. Rashmi Agrawal, Jyotir Moy Chatterjee, Abhishek Kumar, Pramod Singh Rathore, Dac-Nhuong Le; Machine Learning for Healthcare: Handling and Managing Data, First Edition, CRC Press, 2021.

Reference Books:

1. Vishal Jain, Jyotir Moy Chatterjee; Machine Learning with Health Care Perspective Machine Learning and Healthcare, Springer 2020.
2. Rashmi Agrawal, Jyotir Moy Chatterjee, Abhishek Kumar, Pramod Singh Rathore, Dac-Nhuong Le; Machine Learning for Healthcare: Handling and Managing Data, First Edition, CRC Press, 2021.

OPEN ELECTIVES/MINOR SPECIALIZATION

List of Minor Specializations/Open Electives

Minor Specialization	Semester	Subject Code (Open/Minor)	Open Electives	CR
Data Science[$]	III	CD201A2/CD201A8	Introduction to Python Programming	4
	IV	CD202A2/CD202A8	Fundamentals of Data Science	4
	V	CD301A2/CD301A8	Mathematical Foundations of Machine Learning	4
	VI	CD302A2/CD302A8	Machine Learning	4
	VII	CD401A2/CD401A8	Deep Learning for Computer Vision	4
	OR			
	VII	CD402A2/CD402A8	Prompt Engineering	4
	OR			
	VII	CD403A2/CD403A8	Backend Development with Java Spring Boot	4
	VIII	CD404A2/CD404A8	Business Analytics	4
	OR			
	VIII	CD405A2/CD405A8	Cyber Security Tools, Techniques and Counter Measures	4
Computer Vision and Speech Technology	III	CD203A2/CD203A8	Digital Signal Processing	4
	IV	CD204A2/CD204A8	Applied Time-Series Analysis	4
	V	CD303A2/CD303A8	Speech Processing	4
	VI	CD304A2/CD304A8	Computer Vision and Image Processing	4
	VII	CD406A2/CD406A8	Medical Image Analysis	4
	VIII	CD407A2/CD407A8	Automatic Speech Recognition	4
Biomedical Technology	III	CD203A2/CD203A8	Digital Signal Processing	4
	IV	CD206A2/CD206A8	Biomedical Signal Processing	4
	V	CD303A2/CD303A8	Speech Processing	4
	VI	CD305A2/CD305A8	Biomedical Instrumentation	4
	VII	CD406A2/CD406A8	Medical Image Analysis	4
	VIII	CD408A2/CD408A8	Bioinformatics	4

$- Data Science specialization not to be offered to CSE(DS) students. The Open Elective/Minor Specialization course in VII and VIII semesters to be decided by the DAC for a particular batch.

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Specialization: Data Science

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Sub Code: CD201A2/CD201A8 **Credit: 4 (L-3, T-1, P-0)**

Introduction to Python Programming

Questions to be set: 05 (All Compulsory)

Course Objectives: To understand the basics of algorithmic problem solving.; To learn to solve problems using Python conditionals and loops. To define Python functions and use function calls to solve problems.; To use Python data structures – lists, tuples, dictionaries to represent complex data.

Pre-requisites: Basic concept of programming

Course Outcomes:

Upon successful completion of the course, students should be able to

CO1: Summarize the strengths and limitations of Python programming tools.

CO2: Implement Python programs using conditionals and looping.

CO3: Use Python functions calls to solve problems.

CO4: Apply Python data structures – lists, tuples, and dictionaries to represent complex data.

CO5: Illustrate a class object, class function, and class methods.

Module	Topics	Hrs	CO
Module 1: Introduction to IDE	Course Introduction, Intro to Programming and The Python Language, Variables, Conditionals, Jupyter Notebook, and IDLE	8	1
Module 2: Python Loops and Functions	Intro to Lists, Loops, and Functions	8	2
Module 3: PyCharm	More with Lists, Strings, Tuples, Sets, and PyCharm [8 Hrs]	8	3
Module 4:	Dictionaries and Files	8	4

Python Dictionaries and Files			
Module 5: Python OOPs	Classes and Objects, Classes and functions, Classes and methods, Inheritance	8	5

Text Books:

1. Allen B. Downey (2016). *Think python: how to think like a computer scientist* (2nd Edition). O'Reilly

Reference Books:

1. Brian K. Jones and David Beazley (2013). *Python Cookbook* (3rd Edition). O'Reilly Media, Inc.

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Sub Code: CD202A2/CD202A8 **Credit: 4 (L-3, T-1, P-0)**

Fundamentals of Data Science

Questions to be set: 05 (All Compulsory)

Course Objectives: The course objective is to provide fundamental knowledge of statistics for Data Science, Visualization Techniques and Tools, and Python programming for implementation.

Pre-requisites: Basic statistical knowledge.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Apply appropriate data analysis techniques.

CO 2 Implement data science problem using python programming.

CO 3 Understand the basic concepts of Estimation and Hypothesis.

CO 4: Apply SciKit Learn tool for machine learning tasks.

CO 5: Analyze data using visualization techniques and tools.

Module	Topics	Hrs	CO
Module 1: Introduction to Data Science	**Introduction:** Data Science, Applications, Relation between Data Science and other fields, **Data:** Introduction, Data types, Data collections, Data Pre-processing **Techniques**: Introduction, Data Analysis and Data Analytics, Descriptive Analysis: Variables, Frequency Distribution, Measures of Central Tendency, Measure of Dispersion Diagnostic Analytics: Correlations Predictive Analytics, Prescriptive Analytics, Exploratory Analysis	8	1

Module 2: Toolboxes for Data Scientist	Introduction to Python, Advantages and Disadvantages *Data Science Ecosystem Installation*, *Integrated Development Environments (IDE) for python*: Jupyter notebook, Pycharm, Spyder *Get Started with Python for Data Scientists:* Reading, Selecting Data, Filtering Data, Filtering Missing Values, Manipulating Data, Sorting, Grouping Data, Rearranging Data, Ranking Data, Plotting. *Information on Fundamental Python Libraries for Data Scientists:* Math: Numpy, SciPy; Data Mining: BeautifulSoup, Scrapy; Data Exploration and Visualization: Pandas, Matplotlib, Plotly, Seaborn; Machine Learning: Scikit Learn, PyCaret, TensorFlow, Keras, PyTorch	8	2
Module 3: Statistical Inference	**Distribution:** Normal Distribution, Standard Normal Distribution, Central Limit Theorem, Standard Error, Estimators and Estimates. **Confidence Intervals**: Population Variance Known-Z-score, Student's T Distribution, Population Variance Unknown-T-score; Two Means-Dependent samples, Independent samples **Hypothesis Testing:** Null and Alternative Hypothesis, Rejection Region and Significance Level, Type I Error and Type II Error, Test for the Mean-Population Variance Known, p-value, Test for the Mean-Population Variance Unknown, Test for the Mean. Dependent Samples, Independent samples	10	3
Module 4: Model Fit & Performance Evaluation	**Regression Models**- Linear and Logistic Model, **Classification Models** – Decision Tree, and SVM, **Clustering Models** – K Means clustering **Performance Evaluation:** Loss Function and Error: Mean Squared Error, Root Mean Squared Error – Model Selection and Evaluation criteria: Accuracy, Precision, F1 score, Recall Score – Binary Predictive Classification – Sensitivity – Specificity	8	3

Module 5: Data Visualization Techniques and Tools	**Data Visualization Techniques**: Line Plot, Pie Chart, Bar Chart, Histogram, Gantt Chart, Heat Map, Box and Whisker Plot, Violin plots, Scatter Plot, Correlation Matrices **Data Visualization Tools:** Microsoft Excel (and Power BI) and/or Tableau.	8	5

Text Books:

3. Shah, C. (2020). A Hands-On Introduction to Data Science. Cambridge: Cambridge University Press.
4. Jesús Rogel-Salazar ,(2014). *Data Science and Analytics with Python* (1st ed). CRC Press.

Reference Books:

7. João Moreira, Andre Carvalho, Tomás Horvath (2018). *A General Introduction to Data Analytics* (3rd ed). Wiley.
8. Rao, R. Nageswara , (2018). *Core python programming* (1st ed). Dreamtech press publication.
9. Grus, Joel (2019). *Data science from scratch: first principles with python* (1st ed). O'Reilly
10. David Dietrich, Barry Heller, and Beibei Yang (2015). *Doing Data Science* (1st ed). O'Reilly.
11. Laura Igual and Santi Seguí (2017). *Introduction to Data Science: A Python Approach to Concepts, Techniques and Applications*, Springer
12. David Dietrich, et.al.(2015). *Data Science & Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data*. John Wiley & Sons.

E-Resource

1. **https://github.com/cmaroblesg/Data_Visualization_with_Tableau/tree/master**
2. https://www.udemy.com/course/the-data-science-course-complete-data-science-bootcamp/

Sub Code: CD301A2/CD301A8 **Credit: 4 (L-3, T-1, P-0)**

Mathematical Foundations for Machine Learning

Questions to be set: 05 (All Compulsory)

Course Objective: The Mathematical Foundations for Machine Learning course aims to equip students with the essential mathematical tools necessary for understanding and excelling in the field of machine learning. Throughout the course, participants will delve into key topics that form the backbone of machine learning mathematics. These topics include: Linear Algebra and Analytic Geometry, Matrix Decompositions, Vector Calculus, Probability and Distributions and Optimization.

Pre-requisites: Basic programming knowledge.

Course Outcomes (CO): ***Upon successful completion of the course, students should be able to***

CO1: Understand the fundamentals of linear algebra, a crucial mathematical concept in machine learning.

CO2: Apply matrix decomposition techniques, such as Cholesky, Eigen, and singular value decomposition, to machine learning issues.

CO3: Use the vector calculus concepts such as partial derivatives, Jacobian, Hessian in Taylor series and relevant problems.

CO4: Apply probability and distribution principles to real-world issues.

CO5: Apply appropriate convex optimization techniques to a particular machine learning problem.

Module	Topics	Hrs.	CO
Module 1: Linear Algebra and Analytic Geometry	*Linear Algebra:* Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings, Affine Spaces *Analytic Geometry:* Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions, Orthogonal Projections, Rotations	10	1

Module 2: Matrix Decompositions	Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition	8	2
Module 3: Vector Calculus	Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series	8	3
Module 4: Probability and Distributions	Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Gaussian Distribution, Conjugacy and the Exponential Family, Change of Variables/Inverse Transform	9	4
Module 5: Continuous Optimization	Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers, Convex Optimization	8	5

Text Books:

3. S.Boyd and L. Vandenberghe. Introduction to Applied Linear Algebra - Vectors, Matrices, and Least Squares. Cambridge University Press, 2019
4. M. P. Deisenroth, A. A. Faisal and Cheng Soon Ong. Mathematics for Machine Learning. Cambridge University Press, 2019

Reference Books:

3. J. A. Gubner, Probability and Random Processes for Electrical and Computer Engineers, Cambridge University Press, 2006.
4. S. L. Miller and D. Childers, Probability and Random Processes: With Applications to Signal Processing and Communications.

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Sub Code: CD302A2/CD302A8 **Credit: 4 (L-3, T-1, P-0)**

Machine Learning

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide knowledge regarding the fundamental concepts in machine learning algorithms such as supervised, unsupervised learning algorithms and their applications.

Pre-requisites: Basic knowledge of Probability, Statistics and basic concept of algorithm.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Apply the knowledge of linear regression and logistic regression for prediction and classification problems.

CO 2: Use supervised learning algorithms to solve classification problems.

CO 3: Explain the theoretical framework for analyzing the generalization error of a learning algorithm.

CO 4: Apply unsupervised learning algorithms for dimensionality reduction and clustering techniques to real world problems.

CO 5: Explain the basic concept of Artificial Neural Network and case study.

Module	Topics	Hrs	CO
Module 1: Basics of ML and Regression	Basic Definition, Types of Learning: Supervised Learning, Unsupervised Learning, Semi supervised Learning and Reinforcement Learning, Examples of Machine Learning Applications., hypothesis space and inductive bias, evaluation, cross-validation **Linear Regression:** Linear Regression with Single Variables- Model Representation and Cost Function; Parameter Learning: Gradient Descent, Gradient Descent Intuition, Gradient Descent for Linear Regression, Linear Regression with Multiple Variables- Multiple Features, Gradient Descent for Multiple Variables, Gradient Descent in Practice: Feature Scaling and Learning Rate; Features and Polynomial Regression; **Logistic Regression**: Classification and Representation- Classification, Hypothesis Representation and Decision Boundary, Logistic Regression Model - Cost Function, Simplified Cost Function and Gradient Descent Multiclass Classification- One-vs-all, **Regularization:** Overfitting problems, Regularized Linear Regression, Regularized Logistic Regression	8	1

Module 2: Supervised Learning	Nearest neighbor (NN), Linear Discriminant Analysis, Support vector machines, Decision Trees, Generative classifiers like naive Bayes;	8	2
Module 3: Computational learning theory	PAC learning model, Sample complexity, VC Dimension, Ensemble learning: Bagging, Boosting, Stacking	8	3
Module 4: Unsupervised Learning	Principle component Analysis, Factor Analysis, Non-negative matrix factorization, Rate-Distortion Theory, K-means, hierarchical clustering, Gaussian mixture model, Expectation-Maximization Algorithm	8	4
Module 5: Neural Networks& case study	Overview of neural networks, perceptron's, Activation functions, Multilayer network, backpropagation Algorithm. Case study for business problem solving.	8	5

Text Books:

1. Ethem Alpaydın (2010). *Introduction to Machine Learning* (2nd edition), MIT Press.
2. Tom M. Mitchell (1997). *Machine Learning.* McGraw-Hill Science.
2. Trevor Hastie, Robert Tibshirani and Jerome Friedman (2009). *The Elements of Statistical Learning* (2nd edition). Springer.

Reference Books:

1. Christopher M. Bishop (2006). *Pattern Recognition and Machine Learning*. Springer.
2. Stephen Marsland (2015). *Machine Learning: An Algorithmic Perspective* (2nd edition). CRC Press.
3. R. O. Duda, P. E. Hart, and D. G. Stork (2012). *Pattern classification.* John Wiley & Sons.
4. Shai Shalev-Shwartz and Shai Ben-David (2017). *Understanding Machine Learning*.. Cambridge University Press.

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Sub Code: CD401A2/CD401A8 **Credit: 4 (L-3, T-1, P-0)**

Deep Learning for Computer Vision

Questions to be set: 05 (All Compulsory)

Course Objectives: The automatic analysis and understanding of images and videos, a field called Computer Vision, occupies significant importance in applications including security, healthcare, entertainment, mobility, etc. The recent success of deep learning methods has revolutionized the field of computer vision, making new developments increasingly closer to deployment that benefits end users. This course will introduce the students to traditional computer vision topics, before presenting deep learning methods for computer vision. The course will cover basics as well as recent advancements in these areas, which will help the student learn the basics as well as become proficient in applying these methods to real-world applications.

Prerequisites: Completion of a basic course in Machine Learning. Knowledge of basics in probability, linear algebra, and calculus.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain Visual features, visual representations, and visual matching.

CO 2: Understand fundamentals of Neural Networks.

CO 3: Describe deep learning techniques such as CNN and its standard architectures.

CO 4: Apply CNN to computer vision tasks such as recognition, verification, detection, and segmentation.

CO 5: Apply RNN+CNN, attention model, GAN in computer vision applications.

Module	Topics	Hrs	CO
Module 1: Visual Features, Representations, and Visual Matching	Motivation; Image Representation; Linear Filtering, Correlation, Convolution, Image in Frequency domain, Visual Features and Representations: Edge, Blobs, Corner Detection; Scale Space and Scale Selection; SIFT, SURF; HoG, LBP, etc. Visual Matching: Bag-of-words, VLAD; RANSAC, Hough transform; Pyramid Matching; Optical Flow.	8	1
Module 2: Neural Networks	Biological Neuron, Perceptron, Activation Functions, Multi-layer Perceptron, Backpropagation. Gradient Descent Algorithm, Regularization, Under-fitting and Overfitting,	8	2

Module 3: Convolutional Neural Network	**Convolutional Neural Networks (CNNs):** Fundamentals of CNNs (Convolution, Padding, Stride, Pooling); CNN Architectures: AlexNet, VGG, InceptionNets, ResNets **Visualization and Understanding CNNs** : Visualization of Kernels; Backprop-to-image/Deconvolution Methods; Deep Dream, Hallucination, Neural Style Transfer; CAM,Grad-CAM, Grad-CAM++; Recent Methods (IG, Segment-IG, SmoothGrad)	9	
Module 4: CNNs for Recognition, Verification, Detection, Segmentation	CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss); CNNs for Detection: Background of Object Detection, R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD, RetinaNet; CNNs for Segmentation: FCN, SegNet, U-Net, Mask-RCNN	9	3
Module 5: RNN, Attention model, and Deep Generative model	**Recurrent Neural Networks**: Introduction; Backpropagation in RNNs; LSTMs and GRUs; Video Understanding using CNNs and RNNs Attention in Vision Models: Introduction, Vision and Language: Image Captioning, Self-Attention and Transformers Deep Generative Models: GANs, VAEs; Applications: Image Editing, Inpainting, Superresolution, 3D Object Generation, Security; (Self-Study) Recent Trends :Few-shot and Zero-shot Learning; Self-Supervised Learning;	9	4

Text Books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville (2016). *Deep Learning*. MIT Press.
2. Simon J.D. Prince (2012). *Computer Vision: Models, Learning, and Inference*.Cambridge University Press
3. Mitchell, Tom (1997). *Machine Learning*. New York, NY: McGraw-Hill.

Reference Books:

1. Michael Nielsen (2016). *Neural Networks and Deep Learning*. [Online]: http://neuralnetworksanddeeplearning.com/index.html
2. Yoshua Bengio (2009). *Learning Deep Architectures for AI*.now publishers Inc.
3. Richard Szeliski (2010), *Computer Vision: Algorithms and Applications* (2nd edition).Springer.
4. David Forsyth and Jean Ponce (2011). Computer Vision: A Modern Approach (2nd edition), Pearson.
5. Bishop, Christopher M. (2005). *Neural Networks for Pattern Recognition*. New York, NY: Oxford University Press.
6. Bishop, Christopher M. (2006). *Pattern Recognition and Machine Learning* (1st edition). Springer.
7. Duda, Richard, Peter Hart, and David Stork (2007). *Pattern Classification* (2nd edition). Wiley.
8. Richard Hartley and Andrew Zisserman (2004). *Multiple View Geometry in Computer Vision* (2nd edition), Cambridge University Press.

E-Resources

1. https://onlinecourses.nptel.ac.in/noc23_cs126/preview
2. https://www.coursera.org/specializations/deep-learning-computer-vision

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Sub Code: CD402A2/CD402A8 **Credit: 4 (L-3, T-1, P-0)**

Prompt Engineering

Questions to be set: 05 (All Compulsory)

Course Objectives: To provide knowledge regarding the fundamental concepts in machine learning algorithms such as supervised, unsupervised learning algorithms and their applications.

Pre-requisites: Basic knowledge of Probability, Statistics and basic concept of algorithm.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand basics of prompt engineering.

CO 2: Explain Advanced Prompt Engineering Techniques.

CO 3 Understand Prompt Engineering Use Cases in Everyday Tasks

CO4: Explain Ethics and Considerations in Prompt Engineering

CO 5: Apply ChatGPT Plugins and Custom Instructions

Module	Topics	Hrs	CO
Module 1: Basics of Prompt Engineering	Introduction, Course Overview and Objectives, What Is Prompt Engineering? Understanding Prompts: Inputs, Outputs, and Parameters Crafting Simple Prompts: Techniques and Best Practices Evaluating and Refining Prompts: An Iterative Process Basic Principles for Interacting with AI Role Prompting and Nested Prompts	8	1
Module 2: Advanced Prompt Engineering Techniques	Introduction, Chain-of-Thought Prompting, Multilingual and Multimodal Prompt Engineering, Understanding the Non-Deterministic Nature of AI, Human-AI Collaboration: Best Practices and Strategies, Generating Ideas Using "Chaos Prompting" Writing Code with the Help of AI, Using Prompt Compression Techniques, Problem-Solving and Generation of Visual Outputs, AI-Assisted Questioning	8	2

Module 3: Prompt Engineering Use Cases in Everyday Tasks - Part 1	Introduction Automating Emails and Social Media Posts Content Generation: Blogs, Articles, and Reports Task Delegation and Project Management Customer Support: Enhancing Human-Agent Collaboration Retail and eCommerce: AI-Driven Personalization and Efficiency Data Analysis: Augmenting Human Insights with AI	8	3
Module 4: Prompt Engineering Use Cases in Everyday Tasks - Part 2	Introduction Creative Writing and Brainstorming: Using AI to Generate Ideas and Drafts Efficient Research and Information Curation: AI-Powered Summarization and Analysis Enhancing Communication Skills: AI-Assisted Proofreading and Writing AI-Driven Task Management and Decision Making AI-Powered Professional Development and Lifelong Learning	8	4
Module 5: Ethics, Considerations and ChatGPT Plugins	**Ethics and Considerations in Prompt Engineering**: Introduction, Ensuring Fairness and Reducing Bias Privacy and Data Security, Responsible AI and the Future of Work **Using ChatGPT Plugins and Custom Instructions**: An Introduction to ChatGPT Plugins, Deep Dive into ChatGPT Plugins The Advanced Data Analysis Plugin (The Code Interpreter) The Advanced Data Analysis Plugin - Part 2, The Advanced Data Analysis Plugin - Part 3 The "Custom Instructions" Feature in ChatGPT	8	5

Text Books:

1. Andrei Gheorghiu (2023) , Prompt Engineering For Everyone with ChatGPT and GPT-4, Packt Publishing, ISBN: 9781805122005

Reference Books:

1. James Phoenix, Mike Taylor (2024). Prompt Engineering for Generative AI. O'Reilly Media, Inc. ISBN: 9781098153434
2. Prompt Engineering Specialization, https://www.coursera.org/specializations/prompt-engineering.
3. https://platform.openai.com/docs/guides/prompt-engineering/strategy-write-clear-instructions

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Sub Code: CD403A2/CD403A8 **Credit: 4 (L-3, T-1, P-0)**

Backend Development with Java Spring Boot

Questions to be set: 05 (All Compulsory)

Course Objectives: Backend Development with Java Spring Boot course offers a comprehensive journey into building robust, scalable, and efficient web applications using the Spring Boot framework in the Java ecosystem. Participants learn to design, develop, and deploy backend systems, focusing on key concepts such as RESTful APIs, database integration, security, and microservices architecture. Through practical exercises and projects, students gain proficiency in leveraging Spring Boot's features for rapid application development, dependency injection, aspect-oriented programming, and testing. Emphasizing best practices and industry standards, the course equips learners with the skills to create high-performance backend solutions that power modern web and enterprise applications effectively.

Pre-requisites:

Course Outcomes (CO):

Upon successful completion of the course, students will:

CO 1: Gain a fundamental understanding of web applications.
CO 2: Gain understanding of Java Programming Language.
CO 3: Gain understanding of NoSQL Database.
CO 4: Gain understanding of dynamic web application using Hibernate and Java Springboot.
CO 5: Gain understanding of REST API, and develop a real world project with Java Spring Boot from scratch.

Module	Topics	Hrs	CO
Module 1:	**Introduction to web applications** **Architecture of scalable web applications**	8	1
Module 2	**Core Java** **Intermediate Java**	8	2
Module 3:	**MongoDB**	8	3
Module 4:	**Hibernate, Spring, Spring Boot**	8	4
Module 5:	**REST API with Spring Boot**	8	5

Text Books:

1. Shagun Bakliwal (2021), Hands-on Application Development using Spring Boot: Building Modern Cloud Native Applications by Learning RESTFul API, Microservices, CRUD Operations, Unit Testing, and Deployment, BPB Publications

2. Shannon Bradshaw, Eoin Brazil, Kristina Chodorow (2019). MongoDB: The Definitive Guide, 3rd Edition, O'Reilly Media, Inc. ISBN: 9781491954461

Online Resources:

https://swayam-plus.swayam2.ac.in/courses/course-details?id=P_SMARTBRIDGE_03

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Sub Code: CD404A2/CD404A8 **Credit: 4 (L-3, T-1, P-0)**

Business Analytics

Questions to be set: 05 (All Compulsory)
Course Objectives: Students can exposure on data analysis, modeling and spreadsheet use with business analytics for decision making. This course will be exclusively quantitative and an application to business/ management related problems. It is connected with problem sets and real life cases to know the relevance of a particular problem and the decision making thereof.

Pre-requisites: Basic Statistics, Basic Mathematics, Basic Management

Course Outcomes (CO):

Upon successful completion of the course, students will have the ability to:

CO 1: Apply descriptive analytics to unravel and understand business challenges.
CO 2: Employ inferential analytics to draw conclusions and make inferences in business contexts.
CO 3: Use predictive analytics to forecast future trends and patterns in business scenarios.
CO 4: Implement prescriptive analytics to formulate strategies and solutions for business issues.
CO 5: Execute decision analytics to support and enhance business decision-making processes.

Module	Topics	Hrs	CO
Module 1: Introduction To Business Analytics and	**Introduction to Business Analytics:** What is Business Analytics, Evolution of Business Analytics, Classification of Business Analytics, Trends of Business Analytics, Framework of Business Analytics, Scope of Business Analytics, Data for Business Analytics, Decision Models, Problem solving and Decision Making;	8	1

Descriptive Analytics	**Exploring Data and Analytics on Spreadsheets:** Data Structure and data view, Use of Microsoft Excel functions, Examples with excel functions, Data Visualization, Data Analysis **Descriptive Analytics :** Measures of central tendency, measure of variations, measures of shape, Excel Descriptive Statistics Tool, Descriptive Statistics for Grouped and Categorical Data, Measures of Association, Probability and Probability distribution, Sampling and Sampling Distribution		
Module 2 Inferential Analytics	Sampling and Confidence Interval, Hypothesis Testing, Goodness of Fit and Independence Tests, t-test and z-test, ANOVA (Analysis of Variance), Chi-Square Test Cases studies in business problems	8	2
Module 3: Predictive Analytics	Simple Linear Regression, Multiple Linear Regression, Non-Linear Regression Analysis, Statistical Inference on Parameters in regression analysis, Coefficient of Determination, ANOVA, Diagnostics of Regression modelling: Multicollinearity, Autocorrelation and Heteroscedasticity Dummy Independent Variable Modelling, Dummy dependent Variable Modelling, Panel Data Model, Time Series Forecasting Machine Learning, Data Mining, Simulation Cases studies in business problems	8	3
Module 4: Prescriptive Analytics	Basics, Linear Programming, Special Issues of linear Programming, Simplex Method of Linear Programing, Primal and Dual Problem, Sensitivity Analysis, Integer Programming Problems, Cases studies in business problems	8	4

Module 5: Decision Analytics	Introduction to Decision Theory, Decision making under uncertainty, Decision making under certainty, Decision Tree, The value of information and utility theory Cases studies in business problems	8	5

Text Books:

1. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, Dennis J. Sweeney, Thomas Williams(2019), Business Analytics,3rd Edition, Cenage , ISBN-13: 9781337406420
2. Winston, W., Albright, S. (2024). Business Analytics: Data Analysis and Decision Making. (n.p.): Cengage South-Western.

Reference Books:

1. Albright, S. C., Winston, W. L., Zappe, C. J. (2009). Data Analysis & Decision Making with Microsoft Excel. United Kingdom: South-Western Educational Publisher
2. Bartlett, R.(2013).A Practitioner's Guide to Business Analytics. McGraw Hill LLC. ISBN, 9780071807609
3. Steven Orla Kimbrough, Hoong Chuin Lau(2016). Business Analytics for Decision Making, 1st Edition, Chapman and Hall/CRC, DOIhttps://doi.org/10.1201/9781315372426

Online Resources:

1. NPTEL Course : Business Analytics For Management Decision, https://onlinecourses.nptel.ac.in/noc24_mg09/preview
2. Harvard Business School Online Business Analytics Course: https://online.hbs.edu/courses/business-analytics/
3. Coursera Course: Business Analytics for Decision Making. https://www.coursera.org/learn/business-analytics-decision-making

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Sub Code: CD405A2/CD405A8 **Credit: 4 (L-3, T-1, P-0)**

Cyber Security Tools, Techniques and Counter Measures

Questions to be set: 05 (All Compulsory)
Course Objectives: The course Cyber Security, Tools, Techniques and Countermeasures aims to provide a foundational platform for Cyber Security Aspirants by providing Cyber Security Awareness and Training that heighten the chances of catching a scam or attack before it is fully enacted, minimizing damage to the resources and ensuring the protection of information technology assets. This course provides a range of career opportunities in Cyber Security Sectors as Network/Application Security Analyst, Cyber Security Analyst, Security Automation, Cyber Security Practitioner, Cyber Defense Analyst, Penetration Tester, Information Security Engineer in leading IT Industries and to act as Cyber Security Experts in in Governmental Organizations.

Pre-requisites: Fundamentals of Computer Network (optional)

Course Outcomes (CO):
Upon successful completion of the course, *students should be able to*

CO 1: Understand the cyber security threat landscape, including various types of cyberattacks, vulnerabilities, and remedies.
CO 2: Apply network defense tools.
CO 3: Apply Web Application tools.
CO 4: Describe Cyber Security Techniques and Countermeasures.
CO 5: Use Legal aspects and protection related to cybercrime.

Module	Topics	Hrs	CO
Module 1: Introduction to Cyber Security	Cyber Security Essentials, Attack Vectors, Threat, Risk and Vulnerability, Advanced Persistent Threat and Cyber Kill Chain, Cyber Security Framework	8	1

Module 2 Network Defense Tools	Firewall and Packet Filters, Introduction to Windows and Linux Firewall, Attacks on Wireless Networks,	8	2
Module 3: Web Application Tools	Scanning for Web Vulnerabilities Tools and HTTP Utilities, Application Inspection Tools, Password Cracking and Brute-Force Tools, Web Attack	8	3
Module 4: Cyber Security Techniques and Countermeasures	Information Security Basics to Policy, Intrusion Detection System, IT Assets and Wireless Security, Cyber Security Assurance Framework, Desktop Security and Malware, E-Commerce and Web-Application Security	8	4
Module 5: Legal aspects and protection	Social Engineering, Internet Crime and Act, Intellectual Property in the Cyber world	8	5

Books:
1. Principles of Cyber Security Course Code: PGDCS-101 Published by Dr. Babasaheb Ambedkar Open University
2. Cyber Security Techniques: PGDCS-103 Published by Dr. Babasaheb Ambedkar Open University

References:
1. Cyber Security – Understanding Cyber Crimes, Computer Forensics and Legal Perspectives Author: Nina Godbole, Sunit Belapure, Publisher: Wiley India
2. Information Systems Security – Security Management, Metrics, Frameworks and Best Practices Author: Nina Godbole, Publisher: Wiley India

E-Resource:

NPTEL Course: https://onlinecourses.swayam2.ac.in/nou22_ge67/preview

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Specialization: Computer Vision and Speech Technology

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Sub Code: CD203A2/CD203A8 **Credit: 4 (L-3, T-1, P-0)**

Digital Signal Processing

Questions to be set: 05 (All Compulsory)

Course Objectives:
(1) To Analyze signals and systems in time and frequency domain.
(2) To attain a good analytical ability in digital filter design.
(3) To investigate the applications of digital signal processing.
Pre-requisites: Calculus

Course Outcomes (CO):
Upon successful completion of the course, students should be able to
CO 1: Illustrate signals, systems and their significance.
CO 2: Analyze the signals using various digital transforms DTFT, DFT etc.
CO 3: Understand Z-transform, the discrete analogue of Laplace Transform.
CO 4: Explain the fundamentals of IIR and FIR filters.
CO 5: Understand the fundamental concepts of adaptive filters and real-world applications of signal processing.

Module	Topics	Hrs	CO
Module 1: Signals and Systems	Continuous-Time and Discrete-Time Signals, Nyquist Sampling Theorem, LTI Systems and its properties, Generation of Signals and basic operations using MATLAB/OCTAVE	**8**	**1**
Module 2: Frequency Analysis	Discrete Time Fourier Transform (DTFT), Properties of DTFT, Discrete Fourier Transform (DFT), Properties of DFT, Frequency analysis of signals and systems using MATLAB/OCTAVE	8	2
Module 3:	Z-Transform, ROC, Poles & Zeros, Properties of Z-Transform	8	3

Module 4: Fundamentals of IIR & FIR Filters	Introduction to Analog IIR Filters; Design of Butterworth IIR LPF Filters. Windowing, Design of FIR filter using Window, Filter structures	8	4
Module 5: Adaptive Filters and DSP Applications	Basics of Adaptive filters; Wiener Filters and LMS Filter, Real-world applications of digital signal processing	8	5

Text Books:

4. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab (1996).*Signals and Systems* (2nd ed.). PHI
5. John G Proakis, Dimitris Manolakis (2007). *Digital Signal Processing* (4th ed.). Pearson
6. S.K.Mitra (2013). *Digital Signal Processing: A Computer - Based Approach* (4th edition). McGraw Hill Education.

Reference Books:

3. K.S. Thyagarajan (2019). *Introduction to Digital Signal Processing Using MATLAB with Application to Digital Communication*s (1st Edition)Springer
4. *Vinay K. Ingle and John G. Proakis (2011). Digital Signal Processing Using MATLAB* (3rd Edition). CL Engineering.

Sub Code: CD204A2/CD204A8 **Credit: 4 (L-3, T-1, P-0)**

Applied Time Series Analysis

Questions to be set: 05 (All Compulsory)

Course Objectives: The subject of time-series analysis is of fundamental interest to data analysts in all fields of engineering, econometrics, climatology, humanities and medicine. This course introduces fundamental concepts and practical methods for analyzing time-series data. Topics covered include stationarity, correlation functions, linear random processes, ARIMA models, spectral analysis, and parameter estimation. Practical implementations in R/Python are emphasized, making it valuable for data analysts across various fields.

Pre-requisites: NIL

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Analyzing relationships between time series variables.
CO 2: Differentiate between AR, MA, ARMA, ARIMA models.
CO 3: Apply Fourier analysis to obtain the frequency components in time series data.
CO 4: Understand the fundamentals of estimation theory.
CO 5: Apply estimation theory to estimate signal properties.

Module	Topics	Hrs	CO
Module 1: Overview of Probability, Statistics, and Random Process	Introduction; Overview of Probability & Statistics; Introduction to Random Processes; Stationarity & Ergodicity; Auto- and cross-correlation functions; Partial correlation functions.	**8**	**1**

Module 2: Modeling Techniques	Linear random processes; Auto-regressive, Moving average and ARMA models ; Models for non-stationary processes; Trends, heteroskedasticity and ARIMA models	8	2
Module 3: Fourier Analysis	Fourier analysis of deterministic signals; DFT and periodogram; Spectral densities and representations; Wiener-Khinchin theorem; Harmonic processes; SARIMA models	8	3
Module 4: Estimation Theory-I	Introduction to estimation theory; Goodness of estimators; Fishers information; Properties of estimators; bias, variance, efficiency; C-R bound; consistency, Least squares, WLS and non-linear LS estimators	8	4
Module 5: Estimation Theory-II	Maximum likelihood and Bayesian estimators.; Estimation of signal properties, time-series models; Case studies	8	5

Text Books:

1. James D. Hamilton (1994). *Time Series Analysis.* Princeton University Press.
2. Shumway R.H., Stoffer, D.S. (2012). *Time Series Analysis and Its Applications with R Examples*, 4th Edition, Springer. ISBN: 978-3319524511
3. Changquan Huang and Alla Petukhina(2023), Applied Time Series Analysis and Forecasting with Python. Springer ISBN: 9783031135866

Reference Books:

1. Škrinjarić, Tihana. (2019). Mills, T. C. (2019.) Applied Time Series Analysis - A Practical Guide to Modeling and Forecasting, United Kingdom: Academic Press.
2. Paul S.P. Cowpertwait and Andrew V. Metcalfe (2009), Introductory Time Series with R (Use R!). Springer.
3. NPTEL Course on Applied Time Series Analysis : https://archive.nptel.ac.in/noc/courses/noc17/SEM1/noc17-ch03/

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Sub Code: CD303A2/CD303A8 **Credit: 4 (L-3, T-1, P-0)**

Speech Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: To enrich the knowledge of the students with a sound understanding of various techniques of speech processing. It begins with the human speech production mechanism and then goes on to the fundamental parameters of speech such as pitch frequency, formants, spectral features like log spectrum, 3-D spectrogram, cepstral features, MFCC, linear prediction coefficients, transform-domain parameters, etc. It deals with applications like speech coding, speech enhancement, speaker and language recognition, speech recognition, text to speech synthesis, and the overview of state-of-the-art techniques like DNN for speech processing

Pre-requisites: Signal Processing (Recommended, but not necessary), Probability and Random Process.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the speech production and perception process.

CO 2: Analyze speech signals in time and frequency domain.

CO 3: Describe statistical modeling techniques for speech signal.

CO 4: Apply channel compensation and classification techniques to speech processing applications.

CO 5: Implement simple algorithms for processing speech signals.

Module	Topics	Hrs	CO
Module 1: Speech Signal: Production, Perception, and Acoustic-phonetic characterization	Process of Speech production and Perceptions in Human Beings, Speech-Production Process, Representing Speech in the Time and Frequency domains, Place and Manner of Articulation, Windowing, Pre-emphasis filter, STFT, Spectrogram. Concept of filter bank, Auditory perception: psycho acoustics	8	1
Module 2: Speech Analysis	Prosodic features:-Energy contour, Pitch contour, and Syllable duration, Voiced /Unvoiced detection using Energy and Zero crossing Rate, AMDF and Pitch. Acoustic features:- LPC- Basic Principles of linear predictive analysis, Auto correlation method, Solution of LPC equations using Durbin's Recursive algorithm,	8	2

	Cepstral analysis of Speech, MFCC, Shifted Delta Cepstral. Perceptual Linear Prediction (PLP) Speech distortion measures – mathematical and perceptual considerations; Spectral–Distortion Measures: Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Liftering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.		
Module 3: Statistical Modeling	K-means clustering and Vector quantization, Gaussian mixture Modeling, Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues	8	3
Module 4: Channel Compensation Techniques and Classifiers	*Overview of Compensation Techniques:* Linear Discriminant Analysis (LDA), Within-class covariance normalization (WCCN), Nuisance Attribute Projection (NAP) *Overview of Classifiers:* Cosine distance scoring, Support vector machine, Gaussian PLDA, Logistic regression, Deep Neural network (DNN)	8	4
Module 5: Application of speech processing	Speech Coding, Speech Enhancement, Speaker and Language recognition, Automatic Speech Recognition, Text to Speech Synthesis	8	5

Text Books:

4. Thomas F, Quatieri (2008). Discrete-Time Speech Signal Processing.(Prentice Hall Pearson Education,2004.
5. Douglas O'Shaughnessy, Speech communication: human and machine, Addison-Wesley Pub.Co.,1987
6. L.R. Rabiner and B. H. Juang, Fundamentals of Speech Recognition, Prentice Hall,1993.

Reference Books:

1. Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, John Wiley and Sons Inc., Singapore, 2004
2. L.R.Rabiner and R.W.Schaffer – Digital Processing of Speech signals – Prentice Hall -1979
3. J.R. Deller, J.H.L. Hansen and J.G. Proakis, Discrete Time Processing of Speech Signals, John Wiley, IEEE Press, 1999.

Sub Code: CD304A2/CD304A8 **Credit: 4 (L-3, T-1, P-0)**

Computer Vision and Image Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: The intent of this course is to familiarize the students to explain the fundamental concepts/issues of Computer Vision and Image Processing, and major approaches that address them. This course provides an introduction to computer vision including image acquisition and image formation models, radiometric models of image formation, image formation in the camera, image processing concepts, concept of feature extraction and selection for pattern classification/recognition, and advanced concepts like motion estimation and tracking, image classification, scene understanding, object classification and tracking, image fusion, and image registration, etc.

Pre-requisites: Basic co-ordinate geometry, matrix algebra, linear algebra and random process.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understanding mathematical formulations of image processing problems.

CO 2: Explain Image Descriptors and Features.

CO 3: Apply OpenCV and Pillow for Image Processing tasks.

CO 4: Apply machine learning for Image Classification tasks.

CO 5: Apply deep learning algorithms for Image classification and Object Detection applications.

Module	Topics	Hrs	CO
Module 1: Fundamental Concepts of Image Formation and Image Processing Concepts [O1]	Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts; Image Transforms. Image Enhancement. Image Filtering, Colour Image Processing, Image Segmentation	9	1
Module 2: Image Descriptors and Features [O1]	Texture Descriptors, Colour Features, Edges/Boundaries. Object Boundary and Shape Representations. Interest or Corner Point Detectors, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Speeded up Robust Features, Saliency	8	2

Module 3: Image Processing with OpenCV and Pillow[O2]	Manipulating Images One Pixel At a Time, Pixel Transformations, Geometric Operations, Spatial Operations in Image Processing, Image processing with Pillow and OpenCV, Basic Image Manipulation with Pillow and OpenCV, Histograms and Intensity Transformations; Geometric Transformations with Pillow and OpenCV, Spatial Filtering with Pillow and OpenCV	8	3
Module 4: Machine Learning for Image Classification [O2]	Introduction to Image Classification, Image Classification with KNN, Linear Classifiers, Logistic Regression Training: Gradient Descent, Mini-Batch Gradient Descent, SoftMax and Multi-Class Classification, Support Vector Machines, Image Features; Obtain IBM Cloud Feature Code and Activate Trial Account; Label your Data and Perform Image Classification with KNN; Logistic Regression with Mini-Batch Gradient Descent; Hand-written Digits Image Classification with Softmax; Support Vector Machines vs Vanilla Linear Classifier; Image Classification with SVM and CV Studio; Set up Computer Vision learning environment; Getting started with CV Studio!	10	4
Module 4: Neural Networks and Deep Learning for Image Classification; Object Detection [O2]	Neural Networks; Fully Connected Neural Network Architecture; Convolutional Networks; CNN Architectures Simple Neural Network for XOR; Neural Network Rectified Linear Unit (ReLU) vs Sigmoid; Training A Neural Network with Momentum; Convolutional Neural Network; Data Augmentation; Use CNN for "Hotdog, Not Hotdog" Classifier and Deploy Model with CV Studio Deploying a Model Object detection using the Haar Cascade classifier, R-CNN and MobileNet. **Class Project/Assignment:** Build a computer vision app that you will deploy on the cloud through Code Engine. For the project, you will create a custom classifier, train it and test it on your own images.	10	5

Text Books:

1. Manas Kamal Bhuyan (2019). Computer Vision and Image Processing: Fundamentals and Applications. CRC Press. https://doi.org/10.1201/9781351248396
2. Nixon, Mark, and Alberto Aguado. (2019). Feature Extraction and Image Processing for Computer Vision. 4th ed. Elsevier Science. https://www.perlego.com/book/1830389/feature-extraction-and-image-processing-for-computer-vision-pdf.
3. Richard Szeliski (2011). Computer Vision: Algorithms and Applications. Springer https://szeliski.org/Book/

Online Reference:

O1: NPTEL Course on Computer Vision and Image Processing – Fundamentals and Applications
by Prof. M. K. Bhuyan, IIT Guwahati. [Online] URL: https://onlinecourses.nptel.ac.in/noc22_ee48/preview

O2: Coursera Course on IBM "Introduction to Computer Vision and Image Processing"
[Online] URL: https://www.coursera.org/learn/introduction-computer-vision-watson-opencv

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Sub Code: CD406A2/CD406A8 **Credit: 4 (L-3, T-1, P-0)**

Medical Image Analysis

Questions to be set: 05 (All Compulsory)

Course Objectives: This course deals with automated analysis of diagnostic medical images, namely X-rays, CT and MRI scans. We will start with some basic material on how to visualize medical images and how to interpret the resolution of medical images correctly in addition to standard techniques for image processing. In successive weeks we will examine often used and powerful algorithms for image segmentation and image registration. We will then look at how these automated methods can be used to enable computer aided diagnosis. In the final 2 weeks, we will discuss deep learning for medial image analysis, especially state of the art 3D convolutional neural networks.

Pre-requisites: Knowledge of calculus, Linear Algebra, introductory optimization and introductory matrix computations

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO1: Describe basic image processing techniques.

CO2: Explain Image registration.

CO3: Apply Image segmentation techniques on Medical Images.

CO4: Understand Computer Aided Diagnosis.

CO5: Apply Deep Learning algorithms for Medical image analysis.

Module	Topics	Hrs	CO
Module 1: Introduction	Introduction to medical imaging , Basic image processing techniques	8	1
Module 2: Image registration	Image registration – 1- Rigid models Image registration – 2- Non-Rigid models Image registration – 3- Application and demonstration	8	2

Module 3: Image segmentation	Image segmentation - Statistical shape model Image segmentation – PDE based methods Image segmentation – application and demonstration	8	3
Module 4: Computer Aided Diagnosis	Computer Aided Diagnosis – Case Study 1 Computer Aided Diagnosis – Case Study 2	8	4
Module 5: Deep Learning for Medical image analysis	Deep Learning for Medical image analysis – 3D Convolutional Neural Networks Deep Learning for Medical image analysis – Generative models for synthetic data	8	5

Text Books:

1. S. Kevin Zhou, Hayit Greenspan, Dinggang Shen(2017) Deep Learning for Medical Image Analysis. Elsevier Science
2. Lena Costaridou (2005) Medical Image Analysis Methods. CRC Press. ISBN 9780429210365

References Online:

1. Ganapathy krishnamurthi, Medical Image Analysis. https://onlinecourses.nptel.ac.in/noc22_bt34/preview

Sub Code: CD407A2/CD407A8 **Credit: 4 (L-3, T-1, P-0)**

Automatic Speech Recognition

Questions to be set: 05 (All Compulsory)

Course Objectives: The course offers an in-depth introduction to automatic speech recognition (ASR), the problem of automatically converting speech into text. This class will cover many theoretical and practical aspects of machine learning (ML) techniques that are employed in large-scale ASR systems. Apart from teaching classical algorithms that form the basis of statistical speech recognition, this class will also cover the latest deep learning techniques that have made important advances in achieving state-of-the-art results for speech recognition and related problems in spoken language processing.

Pre-requisites: Machine Learning and Speech Processing

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO1: Understand the fundamentals of HMMs.
CO2: Explain language modeling techniques.
CO3: Describe acoustic modeling techniques.
CO4: Understand Decoding and Recognition techniques.
CO5: Explain deep learning architectures for ASR.

Module	Topics	Hrs	CO
Module 1: Review of Speech Processing and Hidden Markov Models (HMMs)	Review of Speech Processing: Short-Time Fourier Transform (STFT) and spectrogram analysis; Linear Predictive Coding (LPC) analysis; Cepstral analysis; Mel-Frequency Cepstral Coefficients (MFCCs); Perceptual Linear Prediction (PLP); Feature normalization and feature space transformations Introduction to HMMs and their application in ASR, Basics of probabilistic graphical models, HMM training (Baum-Welch algorithm), Viterbi decoding algorithm	8	1
Module 2: Language Modeling	Statistical language modeling techniques: N-gram language models: Unigram, Bi-gram, Trigram and N-gram (N > 3)	8	2

	Smoothing Techniques, Interpolation and Back-off, Modified Kneser-Ney Smoothing, Neural Network Language Models, Word Embeddings Language model training and evaluation: **Training Process, Evaluation Metrics: Perplexity:** Cross-Entropy **, Word Error Rate (WER):** Accuracy, Cross-Validation**,** Fine-Tuning and Adaptation		
Module 3: Acoustic Modeling	Gaussian Mixture Models (GMMs) for acoustic modelling; Context-Dependent Phoneme Models; Deep Neural Networks (DNNs) for acoustic modelling; Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) for acoustic modeling	8	3
Module 4: Decoding and Recognition	Introduction to decoding algorithms (Viterbi, Beam Search) Language model integration with acoustic models Evaluation metrics for ASR systems (Word Error Rate, Accuracy, etc.)	8	4
Module 5: Advanced Topics	Deep Learning architectures for ASR (e.g., Connectionist Temporal Classification (CTC), Sequence-to-Sequence models); End-to-End ASR systems; Speaker adaptation and normalization techniques; Multi-lingual and multi-speaker ASR Real-world applications of ASR (e.g., virtual assistants, voice-controlled systems, transcription services)	8	5

Course Project/Assignments: Implementation of a basic ASR system using open-source libraries (e.g., Kaldi, TensorFlow, PyTorch)

References:

All the suggested readings will be freely available online. No single textbook will serve as a reference for this course. ([JM-2019] is a good starting point for anyone interested in this material.)

1. **Daniel Jurafsky and James H. Martin,** "Speech and Language Processing"**, 3rd edition draft, 2019 [JM-2019]**
2. *L R Rabiner and R W Schafer, "Theory and Application of Digital Speech Processing", PH, Pearson, 2011.*
3. *L R Rabiner, B-H Juang and B Yegnanarayana, "Fundamentals of Speech Recognition", Pearson, 2009 (Indian subcontinent adaptation).*

4. *Xuedong Huang, Alex Acero, Hsiao-wuen Hon, "Spoken Language Processing: A guide to Theory, Algorithm, and System Development", Prentice Hall PTR, 2001.*
5. *Thomas Quatieri, "Discrete-time Speech Processing: Principles and Practice", PH, 2001.*
6. *Rabiner and Schafer, "Digital Processing of Speech Signals", Pearson Education, 1993.*
7. Mark Gales and Steve Young, The application of hidden Markov models in speech recognition, Foundations and Trends in Signal Processing, 1(3):195-304, 2008.
8. Geoffrey Hinton, Li Deng, Dong Yu, George E. Dahl, Abdel-rahman Mohamed, Navdeep Jaitly, Andrew Senior, Vincent Vanhoucke, Patrick Nguyen, Tara N. Sainath, and Brian Kingsbury, Deep Neural Networks for Acoustic Modeling in Speech Recognition, IEEE Signal Processing Magazine, 29(6):82-97, 2012.
9. S. Young, Large vocabulary continuous speech recognition: A review, IEEE Signal Processing Magazine, 1996.
10. L. Rabiner, A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition, 1989.
11. J. Bilmes, A gentle tutorial of the EM algorithm and its application to Gaussian-mixture HMMs, 1998.
12. M. Mohri, F. Pereira, M. Riley, Speech recognition with weighted finite-state transducers, Springer Handbook of Speech Processing, 559-584, 2008.
13. M. Mohri, F. Pereira, M. Riley, The Design Principles of a Weighted Finite-State Transducer Library, Theoretical Computer Science, 231(1): 17-32, 2000.
14. M. Mohri, Semiring frameworks and algorithms for shortest-distance problems, Journal of Automata, Languages and Combinatorics, 7(3):321-350, 2002.
15. M. Mohri, F. Pereira, M. Riley, Weighted finite-state transducers in speech recognition, Computer Speech and Language, 2001.
16. S. J. Young, J. J. Odell, P. C. Woodland, Tree-Based state tying for high accuracy acoustic modelling, Proc. of the workshop of HLT, ACL, 1994.
17. J. Zhao, X. Zhang, A. Ganapathiraju, N. Deshmukh, and J. Picone, Tutorial for Decision Tree-Based State Tying For Acoustic Modeling, 1999.
18. N. Morgan and H. A. Bourlard An Introduction to Hybrid HMM/Connectionist Continuous Speech Recognition, 1995.
19. H. Hermansky, D. Ellis, and S. Sharma, Tandem Connectionist Feature Extraction for Conventional HMM Systems, ICASSP, 2000.
20. V. Peddinti, D. Povey, S. Khudanpur, A time delay neural network architecture for efficient modeling of longtemporal contexts, Interspeech, 2015.
21. A. Graves, A. Mohamed, G. Hinton, Speech recognition with deep recurrent neural networks, ICASSP 2013.
22. S. F. Chen, J. Goodman, An empirical study of smoothing techniques for language modeling, Computer Speech and Language, 13, pp. 359-394, 1999.

23. A. Graves, N. Jaitly, Towards End-to-end Speech Recognition with Recurrent Neural Networks, ICML, 2014.
24. Awni Hannun, Sequence modeling with CTC, 2017.
25. W. Chan, N. Jaitly, Q. V. Le, O. Vinyals, Listen, Attend and Spell, 2015.

Online Resources:

1. https://www.cse.iitb.ac.in/~pjyothi/cs753/index.html
2. https://www.openslr.org/resources.php
3. https://ocw.mit.edu/courses/6-345-automatic-speech-recognition-spring-2003/pages/lecture-notes/
4. https://www.youtube.com/playlist?list=PLZ2ps__7DhBaI_g3_V-CFrgFIf-0Yksiv

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SPECIALIZATION: BIOMEDICAL TECHNOLOGY

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Sub Code: CD203A2/CD203A8 **Credit: 4 (L-3, T-1, P-0)**

Digital Signal Processing

Questions to be set: 05 (All Compulsory)

Course Objectives:
(1) To Analyze signals and systems in time and frequency domain.
(2) To attain a good analytical ability in digital filter design.
(3) To investigate the applications of digital signal processing.
Pre-requisites: Calculus

Course Outcomes (CO):
Upon successful completion of the course, students should be able to
CO 1: Illustrate signals, systems and their significance.
CO 2: Analyze the signals using various digital transforms DTFT, DFT etc.
CO 3: Understand Z-transform, the discrete analogue of Laplace Transform.
CO 4: Explain the fundamentals of IIR and FIR filters.
CO 5: Understand the fundamental concepts of adaptive filters and real-world applications of signal processing.

Module	Topics	Hrs	CO
Module 1: Signals and Systems	Continuous-Time and Discrete-Time Signals, Nyquist Sampling Theorem, LTI Systems and its properties, Generation of Signals and basic operations using MATLAB/OCTAVE	**8**	**1**
Module 2: Frequency Analysis	Discrete Time Fourier Transform (DTFT), Properties of DTFT, Discrete Fourier Transform (DFT), Properties of DFT, Frequency analysis of signals and systems using MATLAB/OCTAVE	8	2
Module 3:	Z-Transform, ROC, Poles & Zeros, Properties of Z-Transform	8	3

Module 4: Fundamentals of IIR & FIR Filters	Introduction to Analog IIR Filters; Design of Butterworth IIR LPF Filters. Windowing, Design of FIR filter using Window, Filter structures	8	4
Module 5: Adaptive Filters and DSP Applications	Basics of Adaptive filters; Wiener Filters and LMS Filter, Real-world applications of digital signal processing	8	5

Text Books:

7. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab (1996).*Signals and Systems* (2nd ed.). PHI
8. John G Proakis, Dimitris Manolakis (2007). *Digital Signal Processing* (4th ed.). Pearson
9. S.K.Mitra (2013). *Digital Signal Processing: A Computer - Based Approach* (4th edition). McGraw Hill Education.

Reference Books:

5. K.S. Thyagarajan (2019). *Introduction to Digital Signal Processing Using MATLAB with Application to Digital Communication*s (1st Edition)Springer
6. *Vinay K. Ingle and John G. Proakis (2011). Digital Signal Processing Using MATLAB* (3rd Edition). CL Engineering.

Sub Code: CD206A2/CD206A8 **Credit: 4 (L-3, T-1, P-0)**

Biomedical Signal Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: The course aims to explain the sources, types, and characteristics of different noises and artifacts present in biomedical signals. Students will learn to design time domain and frequency domain filters for noise and artifact removal from biomedical signals. Additionally, we'll explore various methods for analyzing biomedical signal characteristics and discuss alternative techniques in both time and frequency domains. The course also covers modeling of biomedical systems.

Pre-requisites: Signals and Systems, Basics of Probability

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the Sources, Types & Characteristics of Different Noises and Artifacts Present in Biomedical Signals.

CO 2: Design Time Domain and Frequency Domain Filters for Noise and Artifact Removal from Biomedical signals.

CO 3: Apply Various Methods for Analyzing Biomedical Signal Characteristics.

CO 4: Explore Alternative Techniques of Analyzing Biomedical Signals in Time and Frequency Domain.

CO 5: Explain Modelling of Biomedical Systems.

Module	Topics	Hrs	CO
Module 1: Introduction to Biomedical Signals	Action Potential and Its Generation, Origin and Waveform Characteristics of Basic Biomedical Signals Like: Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG), Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis.	**8**	**1**
Module 2: Removal of Noise and Artifacts from Biomedical Signal	Random and Structured Noise, Physiological Interference, Stationary and Nonstationary Processes, Noises and Artifacts Present in ECG, Time and Frequency Domain Filtering.	8	2

Module 3: EEG Signal Processing and Event Detection in Biomedical Signals	EEG Signal and Its Characteristics, EEG Analysis, Linear Prediction Theory, Autoregressive Method, Sleep EEG, Application of Adaptive Filter for Noise Cancellation in ECG and EEG Signals; Detection of P, Q, R, S and T Waves in ECG, EEG Rhythms, Waves and Transients, Detection of Waves and Transients, Correlation Analysis Ad Coherence Analysis of EEG Channels.	8	3
Module 4: Analysis of Nonstationary Signals	Heart Sounds and Murmurs, Characterization of Nonstationary Signals and Dynamic Systems, Short-Time Fourier Transform, Considerations in Short-Time Analysis and Adaptive Segmentation.		
Module 5: Modelling of Biomedical Systems	Modelling of Biomedical Systems: Motor unit firing pattern, Cardiac rhythm, Formants and pitch of speech, Point process, Parametric system modelling, Autoregressive model, Autocorrelation method, Application to random signals, Computation of model parameters, Levinson-Durbin algorithm, Computation of gain factor, Covariance method, Spectral matching and parameterization, Model order selection, Relation between AR and Cepstral coefficients	8	5

Textbooks

1. Rangayyan, R.M., 2015. Biomedical signal analysis (Vol. 33). John Wiley & Sons.
2. Reddy, D.C., 2005. Biomedical Signal Processing: Principles and Techniques, McGraw Hill Education.

Reference Books

1. Tompkins, W.J., 2004. Biomedical digital signal processing. EEE, PHI, 2004
2. Sörnmo, L. and Laguna, P., 2005. Bioelectrical signal processing in cardiac and neurological applications (Vol. 8). Academic Press
3. J G Webster “Medical Instrumentation: Application & Design”, John Wiley & Sons Inc., 2001
4. C Raja Rao, S K Guha “Principles of Medical Electronics and Biomedical Instrumentation”, Universities Press, 2001
5. AV Oppenheim and RW Shafer "Discrete-time Signal Processing", Prentice Hall, Englewood Cliffs, NJ, 1989.
6. Steven M. Kay, "Modern spectral estimation theory and application ", Prentice Hall, Englewood Cliffs, NJ, 198

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Sub Code: CD303A2/CD303A8 **Credit: 4 (L-3, T-1, P-0)**

Speech Processing

Questions to be set: 05 (All Compulsory)

Course Objectives: To enrich the knowledge of the students with a sound understanding of various techniques of speech processing. It begins with the human speech production mechanism and then goes on to the fundamental parameters of speech such as pitch frequency, formants, spectral features like log spectrum, 3-D spectrogram, cepstral features, MFCC, linear prediction coefficients, transform-domain parameters, etc. It deals with applications like speech coding, speech enhancement, speaker and language recognition, speech recognition, text to speech synthesis, and the overview of state-of-the-art techniques like DNN for speech processing

Pre-requisites: Signal Processing (Recommended, but not necessary), Probability and Random Process.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the speech production and perception process.

CO 2: Analyze speech signals in time and frequency domain.

CO 3: Describe statistical modeling techniques for speech signal.

CO 4: Apply channel compensation and classification techniques to speech processing applications.

CO 5: Implement simple algorithms for processing speech signals.

Module	Topics	Hrs	CO
Module 1: Speech Signal: Production, Perception, and Acoustic-phonetic characterization	Process of Speech production and Perceptions in Human Beings, Speech-Production Process, Representing Speech in the Time and Frequency domains, Place and Manner of Articulation, Windowing, Pre-emphasis filter, STFT, Spectrogram. Concept of filter bank, Auditory perception: psycho acoustics	8	1
Module 2: Speech Analysis	Prosodic features:-Energy contour, Pitch contour, and Syllable duration, Voiced /Unvoiced detection using Energy and Zero crossing Rate, AMDF and Pitch. Acoustic features:- LPC- Basic Principles of linear predictive analysis, Auto correlation method, Solution of LPC equations using Durbin's Recursive algorithm,	8	2

	Cepstral analysis of Speech, MFCC, Shifted Delta Cepstral. Perceptual Linear Prediction (PLP) Speech distortion measures – mathematical and perceptual considerations; Spectral–Distortion Measures: Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Liftering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, Time Alignment and Normalization – Dynamic Time Warping, Multiple Time – Alignment Paths.		
Module 3: Statistical Modeling	K-means clustering and Vector quantization, Gaussian mixture Modeling, Hidden Markov Models: Markov Processes, HMMs – Evaluation, Optimal State Sequence – Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issues	8	3
Module 4: Channel Compensation Techniques and Classifiers	*Overview of Compensation Techniques:* Linear Discriminant Analysis (LDA), Within-class covariance normalization (WCCN), Nuisance Attribute Projection (NAP) *Overview of Classifiers:* Cosine distance scoring, Support vector machine, Gaussian PLDA, Logistic regression, Deep Neural network (DNN)	8	4
Module 5: Application of speech processing	Speech Coding, Speech Enhancement, Speaker and Language recognition, Automatic Speech Recognition, Text to Speech Synthesis	8	5

Text Books:

7. Thomas F, Quatieri (2008). Discrete-Time Speech Signal Processing.(Prentice Hall Pearson Education,2004.
8. Douglas O'Shaughnessy, Speech communication: human and machine, Addison-Wesley Pub.Co.,1987
9. L.R. Rabiner and B. H. Juang, Fundamentals of Speech Recognition, Prentice Hall,1993.

Reference Books:

1. Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, John Wiley and Sons Inc., Singapore, 2004
2. L.R.Rabiner and R.W.Schaffer – Digital Processing of Speech signals – Prentice Hall -1979
3. J.R. Deller, J.H.L. Hansen and J.G. Proakis, Discrete Time Processing of Speech Signals, John Wiley, IEEE Press, 1999.

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Sub Code: CD306A2/CD306A8 **Credit: 4 (L-3, T-1, P-0)**

Biomedical Instrumentation

Questions to be set: 05 (All Compulsory)

Course Objectives:

The course will enable the students to:

1. Understand the Physiology of the heart, lung, blood circulation and respiration including different transducers used.
2. Learn about various sensing and measurement devices of electrical and non-electrical origin.
3. Understand modern methods of imaging techniques.
4. Study about medical assistance techniques and therapeutic equipmentS.

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the basic concepts of Anatomy & Physiology
CO 2: Describe non-electrical parameters measurement and diagnostic procedures
CO 3: Explain different types of Electrodes, Transducers and Amplifiers
CO 4: Understand the important and modern methods of imaging techniques
CO 5: Comprehend about the Human Assist Devices and Therapeutic Equipments

Module	Topics	Hrs	CO
Module 1: FUNDAMENTALS OF BIOMEDICAL ENGINEERING	Cell and its structure - Resting and Action Potential - Nervous system and its fundamentals - Basic components of a biomedical system - Cardiovascular systems - Respiratory systems - Kidney and blood flow - Biomechanics of bone - Biomechanics of soft tissues - Physiological signals and transducers - Transducers -	8	1

	selection criteria - Piezo electric, ultrasonic transducers - Temperature measurements - Fibre optic temperature sensors.		
Module 2: NON-ELECTRICAL PARAMETERS MEASUREMENT AND DIAGNOSTIC PROCEDURES	Measurement of blood pressure - Cardiac output - Heart rate - Heart sound - Pulmonary function measurements - spirometer - Photo Plethysmography, Body Plethysmography - Blood Gas analysers, pH of blood - measurement of blood pCO2, pO2, finger-tip oxymeter - ESR, GSR measurements.	8	2
Module 3: ELECTRICAL PARAMETERS ACQUISITION AND ANALYSIS	Electrodes - Limb electrodes - floating electrodes - pregelled disposable electrodes - Micro, needle and surface electrodes - Amplifiers, Preamplifiers, differential amplifiers, chopper amplifiers - Isolation amplifier - ECG - EEG - EMG - ERG - Lead systems and recording methods - Typical waveforms - Electrical safety in medical environment, shock hazards - leakage current - Instruments for checking safety parameters of biomedical equipments.	8	3
Module 4: IMAGING MODALITIES AND ANALYSIS	Radio graphic and fluoroscopic techniques - Computer tomography - MRI - Ultrasonography - Endoscopy - Thermography - Different types of biotelemetry systems - Retinal Imaging - Imaging application in Biometric systems	8	4
Module 5: LIFE ASSISTING, THERAPEUTIC AND ROBOTIC DEVICES	Pacemakers - Defibrillators - Ventilators - Nerve and muscle stimulators - Diathermy - Heart - Lung machine - Audio meters - Dialysers - Lithotripsy - ICCU patient monitoring system - Nano Robots - Robotic surgery - Orthopedic prostheses fixation.	8	5

TEXT BOOKS:

1. Leslie Cromwell, Biomedical Instrumentation and Measurement, Prentice hall of India, New Delhi,2007.
2. M.Arumugam, 'Bio-Medical Instrumentation', Anuradha Agencies, 2003.
3. Khandpur R.S, Handbook of Biomedical Instrumentation, Tata McGraw-Hill, New Delhi, 2 Edition, 2003.

REFERENCES:

1. John G. Webster, Medical Instrumentation Application and Design, John Wiley and sons, NewYork, 1998.

2. Duane Knudson, Fundamentals of Biomechanics, Springer, 2nd Edition, 2007.
3. Suh, Sang, Gurupur, Varadraj P., Tanik, Murat M., Health Care Systems, Technology and Techniques, Springer, 1st Edition, 2011.
4. Ed. Joseph D. Bronzino, The Biomedical Engineering Hand Book, Third Edition, Boca Raton, CRC Press LLC, 2006.
5. Joseph J.carr and John M. Brown, Introduction to Biomedical Equipment Technology, John Wiley and sons, New York, 4th Edition, 2012.

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Sub Code: CD406A2/CD406A8 **Credit: 4 (L-3, T-1, P-0)**

Medical Image Analysis

Questions to be set: 05 (All Compulsory)

Course Objectives: This course deals with automated analysis of diagnostic medical images, namely X-rays, CT and MRI scans. We will start with some basic material on how to visualize medical images and how to interpret the resolution of medical images correctly in addition to standard techniques for image processing. In successive weeks we will examine often used and powerful algorithms for image segmentation and image registration. We will then look at how these automated methods can be used to enable computer aided diagnosis. In the final 2 weeks, we will discuss deep learning for medial image analysis, especially state of the art 3D convolutional neural networks.

Pre-requisites: Knowledge of calculus, Linear Algebra, introductory optimization and introductory matrix computations

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO1: Describe basic image processing techniques.

CO2: Explain Image registration.

CO3: Apply Image segmentation techniques on Medical Images.

CO4: Understand Computer Aided Diagnosis.

CO5: Apply Deep Learning algorithms for Medical image analysis.

Module	Topics	Hrs	CO
Module 1: Introduction	Introduction to medical imaging , Basic image processing techniques	8	1
Module 2: Image registration	Image registration – 1- Rigid models Image registration – 2- Non-Rigid models Image registration – 3- Application and demonstration	8	2
Module 3: Image segmentation	Image segmentation - Statistical shape model Image segmentation – PDE based methods Image segmentation – application and demonstration	8	3
Module 4: Computer Aided Diagnosis	Computer Aided Diagnosis – Case Study 1 Computer Aided Diagnosis – Case Study 2	8	4

Module 5: Deep Learning for Medical image analysis	Deep Learning for Medical image analysis – 3D Convolutional Neural Networks Deep Learning for Medical image analysis – Generative models for synthetic data	8	5

Text Books:

1. S. Kevin Zhou, Hayit Greenspan, Dinggang Shen(2017) Deep Learning for Medical Image Analysis. Elsevier Science
2. Lena Costaridou (2005) Medical Image Analysis Methods. CRC Press. ISBN 9780429210365

References Online:

2. Ganapathy krishnamurthi, Medical Image Analysis. https://onlinecourses.nptel.ac.in/noc22_bt34/preview

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Sub Code: CD408A2/CD408A8 **Credit: 4 (L-3, T-1, P-0)**

Bioinformatics

Questions to be set: 05 (All Compulsory)

Course Objective:The objective of the course is to introduce students to the rapidly evolving field of bioinformatics. The aim is to cover in the lectures the most fundamental topics, such as molecular biology data generation, storage, retrieving, sequence alignments and pattern findings.

Pre-requisites: Basics of Biology, Probability and Statistics

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain bioinformatics, generation of molecular biology data, and associated tools/software.

CO 2: Describe several types of biological database and file formats.

CO 3: Explain Metadata and Ontologies for bioinformatics.

CO 4: Analyse biological data using visualization tools.

CO 5: Explain Gene expression and regular expression.

Module	Topics	Hrs	CO
Module: 1 Bioinformatics and Data Generation	Introduction to bioinformatics and data generation: What is bioinformatics and its relation with molecular biology. Examples of related tools(FASTA, BLAST, BLAT, RASMOL), databases(GENBANK, Pubmed, PDB) and software(RASMOL,Ligand Explorer). Data generation: Generation of large scale molecular biology data. (Through Genome sequencing, Protein sequencing, Gel electrophoresis, NMR Spectroscopy, X-Ray Diffraction, and microarray). Applications of Bioinformatics.	8	1
Module: 2 Biological Database, Storage, and retrieval	Biological Database and its Types: Introduction to data types and Source. Population and sample, Classification and Presentation of Data. Quality of data, private and public data sources. General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL). Protein databases (Primary,	8	2

	Composite, and Secondary). Specialized Genome databases: (SGD, TIGR, and ACeDB).Structure databases (CATH, SCOP, and PDBsum) Data storage and retrieval and Interoperability: Flat files, relational, object oriented databases and controlled vocabularies. File Format(Genbank, DDBJ, FASTA, PDB, SwissProt).		
Module: 3 Metadata and Search	Introduction to Metadata and search; Indices, Boolean, Fuzzy, Neighboring search. The challenges of data exchange and integration. Ontologies, interchange languages and standardization efforts. General Introduction to XML, UMLS, CORBA, PYTHON and OMG/LIFESCIENCE.	8	3
Module: 4 Sequence Alignments and Visualization	Sequence Alignments and Visualization: Introduction to Sequences, alignments and Dynamic Programming; Local alignment and Global alignment (algorithm and example),Pairwise alignment (BLAST and FASTA Algorithm) and multiple sequence alignment(Clustal W algorithm).Methods for presenting large quantities of biological data: sequence viewers (Artemis,SeqVISTA), 3D structure viewers (Rasmol, SPDBv, Chime, Cn3D, PyMol), Anatomical visualization.	8	4
Module: 5 Gene Expresseion and Regular Expression	Gene Expression and and Representation of patterns and relationship General introduction to Gene expression in prokaryotes and eukaryotes, transcription factors binding sites. SNP, EST, STS. Introduction to Regular Expression, Hierarchies, and Graphical models (including Markov chain and Bayes notes), Genetic variability and connections to clinical data.	8	5

Text Book:

1. Sundar Rao & Richard (2012). *An Introduction to Biostatistics and Research Methods* (5rd edition). PHI.
2. Phillip Compeau and Pavel Pevzner (2014). *Bioinformatics Algorithms: An Active Learning Approach* (3rd edition). Active Learning Publishers.
3. D. Baxevanis and F. Oulette, (2002). *Bioinformatics: A practical guide to the analysis of genes and proteins*, Wiley Indian Edition
4. Bryan Bergeron MD (2003). *Bioinformatics Computing*. Prentice Hall India

Reference Book:

1. Jenny Olive (2004). *Maths-A Self Study Guide* (2nd edition*)*. Cambridge University Press
2. James Stewart (2018). Calculus: Early Transcendentals (8th edition). Cengage Learning.
3. Seymour Lipschutz and Marc Lipson(2022). Probability (3rd edition). Shaum's Outline Series, Tata McGraw Hill.
4. Hema Ramachandran and Achuthsankar S Nair (2012). *SCILAB (A Free Software to Matlab)*. S.Chand Publishers.
5. A.K. Mukhopadhyay & S. Sengupta (2010). *A Course in Vector and Matrix Analysis for Engineers and Physicists*. IK International Publishing House Pvt. Ltd

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CHOICE BASED ELECTIVE

List of Choice based Electives

Subject Code	Choice based Electives (Seventh Semester)
CD401A3	Introduction to Japanese Language and Culture
CD402A3	Mandarin (Chinese) for beginners
CD403A3	Spoken Sanskrit: Basic and Intermediate Levels
CD404A3	Essence of Indian Traditional Knowledge
CD405A3	Indian Knowledge System(IKS): Concepts and Applications in Engineering
CD406A3	Introduction to Language and Linguistics
CD407A3	Understanding Incubation and Entrepreneurship
CD408A3	Principles of Economics
CD409A3	Science, Technology and Society

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Sub Code: CD401A3 **Credit: 3 (L-3, T-0, P-0)**

Introduction to Japanese Language and Culture

Questions to be set: 05 (All Compulsory)

Course Objectives: With increasing technical and economic ties between India and Japan, more Japanese companies are doing business in India and vice versa. This gives rise to the urgent need for more Indians to learn at least the rudiments of Japanese for their professional advancement. This course has been designed with the above background and keeping in mind the requirements of Level's 5 of the 'Japanese Language Proficiency Test', held by Japan Foundation. It focuses on conversational skills and basic training in sentence construction, simple situational conversation, grammatical knowledge and elements of Kanji (Chinese pictograms), and the kana (Katakana and Hiragana) scripts.
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Pre-requisites: NIL

Course Outcomes (CO):

Upon successful completion of the course,

CO 1: Students will be able to introduce themselves in Japanese, understand basic scripts and particles, use interrogative words, describe time, and discuss hobbies.

CO 2: Students will be able to engage in conversations using time expressions and simple verbs, understand the negative form of verbs, and describe locational nouns

CO 3: Students will be able to engage in simple phone conversations, use conjunctions, understand the volitional form of verbs, differentiate between ‘i’ and ‘na’ adjectives, and recognize the negative form of adjectives and plain verb forms.

CO 4: Students will be able to use negative forms of verbs, express giving and receiving things or gifts, understand the potential form of verbs, and recognize some proverbs and expressions.

CO 5: Students will be able to express intent or purpose, provide examples from Japanese way of life, seek permission and approval, understand basic Kanji, and confidently fill out simple forms using conditional verb form

Module	Topics	Hrs	CO
Module 1:	Introduction to Japanese scripts and particles; Introducing oneself Interrogative words; Demonstrative pronouns and adjectives; Time; Hobbies	8	1
Module 2:	Conversation with time expressions and simple verbs Negative form of verb; Locational nouns	8	2
Module 3:	Simple conversation on phone; Conjunctions; Volitional form of verb Types of Adjectives – 'i' and 'na' adjectives Negative form of adjectives; Plain form of verbs	8	3
Module 4:	Negative forms of verbs; Expressions for giving or receiving things, gifts, etc. Potential form of verbs; Some proverbs and expressions	8	4
Module 5:	Expressing intent or purpose; Examples from Japanese way of life Permission and seeking approval; Basic Kanji Filling out simple forms; Conditional form of verbs; Kanji	8	5

Books and references

1 Japanese Grammar for Beginners: Read, Speak, and Write Japanese.Talk in Japanese. 2022.

E-Resources

1. https://onlinecourses.nptel.ac.in/noc21_hs90/preview

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Sub Code: CD402A3 **Credit: 3 (L-3, T-0, P-0)**

Mandarin (Chinese) for beginners

Questions to be set: 05 (All Compulsory)

Course Objectives: This course is aimed at imparting basic skills in Mandarin Chinese language to the learner. The course focuses on gradual inculcation of speaking, writing and reading ability in the language. It has sections on sounds, pronunciation, tones and the basic grammar. It aims at enabling the beginners to comprehend and communicate in basic Mandarin. It not only enables the learner to speak and communicate in Chinese, but also teaches Chinese characters following the rules of stroke and stroke order.

Pre-requisites: NIL

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Understand the sound system and methods of articulation. of Mandarin Chinese language.

CO 2: Understand the pronunciation and tones of Mandarin Chinese language.

CO 3: Understand the short dialogues in Chinese language

CO 4: Understand the basic communication-1 in Chinese language.

CO 5: Understand the basic communication-2 in Chinese language.

Module	Topics	Hrs	CO
Module 1: Introduction	Introduction to Mandarin Chinese, Introduction to Sound System, Methods of Articulation, ,	8	1
Module 2: Pronunciation Tones	Pronunciation Practice-1, Pronunciation Practice-2Introduction to Tones, Tone Practice-1, Tone Practice-2, Greetings-1, Greetings-2	8	2

Module 3: Short Dialogues	Introduction to Chinese character-1, Introduction to Chinese character-2, I am a student **我是学生**, He is not a doctor **他不是大夫**, This is my book 这是我的书, He and I are friends **他和我是朋友**, What is your name **你叫什么**, Who is he **他是**谁, Where are you going**你去哪儿**, What is your nationality **你是哪国人**	8	3
Module 4: **Basic Communication-1**	Do you have any notebook **你有本子**吗, I have two books **我有两本**书, How many members are there in your family **你家有几口人**, How much is this 这是多**少**, Today is Monday **今天星期一**, What's the time now 现在几**点**, What's the date today**今天几月几号**, Where do you Study **你在哪儿学**习, We all are students too **我**们也都是学**生**	8	4
Module 5: **Basic Communication-2**	Self-Introduction-1, Self-Introduction-2 I am happy **我很高**兴., This book is new, that one is old 这本书新，那本书**旧**, How much money do you have **你有多少**钱. Let's go shopping **跟朋友一起**买东**西**What do you want to eat? **你想吃什么**, I Would like to have tea **我要喝茶**, Can you speak Chinese? **你会**说汉语吗, I can drive a car **我能开**车, India	8	5

Books and references

1 Katy R. Kudela (2009). My First Book of Mandarin Chinese Words. Capstone Press; Bilingual edition
2. Zhaoxia Pang and Ruth Herd (2022) .Complete Mandarin Chinese (Learn Mandarin Chinese). 4th Edition ,Teach Yourself.

E-Resources

1. https://onlinecourses.swayam2.ac.in/nou22_lg10/preview
2. https://www.coursera.org/learn/learn-chinese

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Sub Code: CD403A3 **Credit: 3 (L-3, T-0, P-0)**

Spoken Sanskrit: Basic and Intermediate Levels

Questions to be set: 05 (All Compulsory)
Course Objectives: The objective of this course is to give students a taste of Sanskrit as a living language by introducing them to its basic grammatical structures so that they can start understanding simple texts as well as allow them to use it in daily life. It also seeks to give them an understanding and appreciation of the beauty of the different aspects of this language from its sounds to its rich content so that they feel enthused enough to delve further into it.
Pre-requisites: NIL
Course Outcomes (CO):
Upon successful completion of the course,

CO 1: Students gain a comprehensive understanding of Sanskrit language, including basic self-introduction, simple verbs, daily vocabulary, and an introduction to different declensions and tenses.
CO 2: Students develop proficiency in using various verb forms across different moods and tenses, while also mastering sentence structures and constructing questions. Additionally, they gain familiarity with unique characteristics of Sanskrit and expand their daily vocabulary.
CO 3: Students develop proficiency in different declensions in the plural and tenses, enhance their daily vocabulary, analyze poetic verses, engage in conversations, and construct sentences using plural forms. Additionally, they practice various verbs across different moods and tenses
CO 4: Students acquire proficiency in declensions of words ending with consonants, explore alternative verb conjugations, expand their daily vocabulary, analyze poetic verses, engage in conversations, and appreciate stories. Additionally, they learn about declensions in singular, dual, and plural forms and practice new verb forms.
CO 5: Students understand Sandhi rules, mastering sound combinations, exploring poetic verses, practicing conversations, and summarizing sentence structures with plurals and questions.

Module	Topics	Hrs	CO
Module 1:	Introduction: Some Unique characteristics of Sanskrit -Basic introduction of oneself -Simple verbs Daily vocabulary; Introducing different declensions and tenses-1 & 2	8	1

Module 2:	Practice with various verbs in different moods and tenses Summary of the Sentence structure with different questions Introduction: Some Unique characteristics of Sanskrit, Different verb forms, Daily vocabulary	8	2
Module 3:	Introduction of different declensions in the plural and tenses – 1, Daily Vocabulary, Poetic verses, conversations and stories Practice with various verbs in different moods and tenses, Summary of the Sentence structures using the plural with different questions	8	3
Module 4:	Introduction of a few more words ending with consonants and their declensions, An Alternative Conjugation of verbs, Daily vocabulary, Poetic verses, conversations and stories Introduction to their different declensions in singular, dual and plural, New verb forms, Daily Vocabulary, Poetic verses, conversations and stories	8	4
Module 5:	Introduction to Sandhi, Vowel with vowel / Vowel with consonant / Consonant with consonant / Aspirant with vowel or consonant, Poetic verse, reading and comprehension, conversations Practice with a variety of word endings, various verbs in different moods and tenses, Summary of the Sentence structures using the plural with different questions	8	5

Books and references

1.Kumari, S. (1993) Sanskrita Chitrapadakoshah, Mysuru: Bharatiya Bhasha Sansthanam
2.Samkrita-vyavahaara-saahasree(Samskrit-English), New Delhi: Sanskrita Bharati
3.Sampad, & Vijay. (2005). The Wonder that is Sanskrit. Pondicherry: Sri Aurobindo Society.
4.Satvlekar, S. D. (2013). SanskritSwayamShikshak. Delhi: Rajpal&Sons (Rajpal Publishing).
5.Shastri, V K. (2012). Teach Yourself Samskrit, Prathama Diksha. Delhi: RashtryiaSanskritaSamsthana.
6.Vishwasa (2014). Abhyāsa-pustakam, New Delhi: SamskritaBharati.

E-Resources

https://onlinecourses.nptel.ac.in/noc21_hs107/preview

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Sub Code: CD404A3 **Credit: 3 (L-3, T-0, P-0)**

Essence of Indian Traditional Knowledge

Questions to be set: 05 (All Compulsory)
Course Objectives: To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.
Pre-requisites: NIL
Course Outcomes (CO):
Upon successful completion of the course, students should be able to
CO 1: Understand the concept of Traditional knowledge and its importance
CO 2: Explain the need and importance of protecting traditional knowledge
CO 3: Describe the various enactments related to the protection of traditional knowledge
CO 4: Understand the concepts of Intellectual property to protect the traditional knowledge
CO 5: Understand the traditional knowledge in different sectors.

Module	Topics	Hrs	CO
Module 1: Introduction to traditional knowledge	Introduction to traditional knowledge: Define traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, the physical and social contexts in which traditional knowledge develop, the historical impact of social change on traditional knowledge systems. Indigenous Knowledge (IK), characteristics, traditional knowledge vis-à-vis indigenous knowledge, traditional knowledge Vs western knowledge traditional knowledge vis-à-vis formal knowledge	8	1
Module 2: Protection of traditional knowledge:	Protection of traditional knowledge: The need for protecting traditional knowledge Significance of TK Protection, value of TK in global economy, Role of Government to harness TK.	8	2

Module 3: Legal frame work and TK	Legal frame work and TK: A: The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmer's Rights Act, 2001(PPVFR Act); B: The Biological Diversity Act 2002 and Rules 2004, the protection of traditional knowledge bill, 2016. Geographical indicators act 2003.	8	3
Module 4: Traditional knowledge and intellectual property	Traditional knowledge and intellectual property: Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Certain non IPR mechanisms of traditional knowledge protection, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge, global legal FORA for increasing protection of Indian Traditional Knowledge	8	4
Module 5: Traditional knowledge in different sectors	**Traditional knowledge in different sectors**: Traditional knowledge and engineering, Traditional medicine system, TK and biotechnology, TK in agriculture, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK.	8	5

Text Books:

Jha, A. (2009). Traditional Knowledge System in India. ISBN: 9788126912230, Atlantic Publishers \& Distributors

Reference Books:

1. Knowledge Traditions and Practices of India, NCERT, First Edition (October 2020), ISBN: 978-93-5292-345-8
2. Basanta Kumar Mohanta and Vipin Kumar Singh (2012), Traditional knowledge system and technology in India Pratibha Prakashan, 1st edition, ISBN : 978-81-71 02-310-7

E-Resources:

1. https://www.youtube.com/watch?v=LZP1StpYEPM
2. http://nptel.ac.in/courses/121106003

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Sub Code: CD405A3 **Credit: 3 (L-3, T-0, P-0)**

Indian Knowledge System(IKS): Concepts and Applications in Engineering

Questions to be set: 05 (All Compulsory)

Course Objectives: The Indian Knowledge System (IKS) course aims to introduce the epistemology and ontology of IKS to engineering and science students. It provides a fresh perspective on the corpus of Indian knowledge, emphasizing key concepts and their practical applications.

Pre-requisites: NIL

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain fundamentals of IKS and Vedas.

CO 2: Apply number systems and Indian mathematics in solving the problems.

CO 3: Explain Indian contributions to astronomy, including solar and lunar calendars, the celestial coordinate system, the Indian calendar (Pañcāṅga), and the role of astronomical instruments (Yantras), with a focus on Jantar Mantar.

CO 4: Understand the historical importance of Wootz Steel in ancient India, analyzing its impact on technology, describing metalworking techniques, exploring lost wax casting, and recognizing the significance of extraction apparatuses.

CO 5: Describe the Indian Scheme of Knowledge Framework, classifications and Linguistics.

Module	Topics	Hrs	CO
Module 1: Introduction to IKS and Vedas	Indian Knowledge System – An Introduction 1. What is IKS? 2. Why do we need IKS? 3. Organization of IKS 4. Historicity of IKS 5. Some salient aspects of IKS The Vedic Corpus: 1. Introduction to Vedas 2. A synopsis of the four Vedas 3. Sub-classification of Vedas 4. Messages in Vedas 5. Introduction to Vedāṅgas 6. Prologue on Śikṣā and Vyākaraṇa 7. Basics of Nirukta and Chandas 8. Introduction to Kalpa and Jyotiṣa 9. Vedic Life: A Distinctive Features	8	1
Module 2: Number systems and Indian Mathematics	*Number Systems and Units of Measurement*: Number systems in India - Historical evidence 2. Salient aspects of Indian Mathematics 3. Bhūta-Saṃkhyā system 4.	8	2

	Kaṭapayādi system 5. Measurements for time, distance, and weight 6. Piṅgala and the Binary system *Mathematics:* 1. Introduction to Indian Mathematics 2. Unique aspects of Indian Mathematics 3. Indian Mathematicians and their Contributions 4. Algebra 5. Geometry 6. Trigonometry 7. Binary mathematics and combinatorial problems in Chandaḥ Śāstra 8. Magic squares in India		
Module 3: Astronomy	Introduction to Indian astronomy 2. Indian contributions in astronomy 3. The celestial coordinate system 4. Elements of the Indian calendar 5. Notion of years and months 6. Pañcāṅga – The Indian calendar system 7. Astronomical Instruments (Yantras) 8. Jantar Mantar of Rājā Jai Singh Sawai	8	3
Module 4: Engineering and Technology	*Engineering and Technology*: Metals and Metalworking: 1. Wootz Steel: The rise and fall of a great Indian technology 2. The Indian S & T heritage 3. Mining and ore extraction 4. Metals and metalworking technology 5. Iron and steel in India 6. Lost wax casting of idols and artefacts 7. Apparatuses used for extraction of metallic components *Engineering and Technology: Other applications*: 1. Irrigation systems and practices in South India 2. Literary sources for science and technology 3. Physical structures in India 4. Irrigation and water management 5. Dyes and painting technology 6. The art of making perfumes 7. Surgical techniques 8. Shipbuilding 9. Sixty-four art forms (64 Kalās) 10. Status of Indigenous S & T *Town Planning and Architecture*: 1. Perspective of Arthaśāstra on town planning 2. Vāstu-śāstra – The science of architecture 3. Eight limbs of Vāstu 4. Town planning 5. Temples in India: marvelous stone architecture for eternity 6. Temple architecture in India 7. Iconography	10	4
Module 5: *Knowledge Framework, classifications and*	*Knowledge Framework and classifications*: 1. Indian scheme of knowledge 2. The knowledge triangle 3. Prameya – A vaiśeṣikan approach to physical reality 4. Dravyas – the constituents of the physical reality 5. Attributes – the properties of substances and Action – the driver of conjunction and disjunction 6. Sāmānya, viśēṣa, samavāya 7.	10	5

Linguistics	Pramāṇa – the means of valid knowledge 8. Saṃśaya – ambiguities in existing knowledge 9. Framework for establishing valid knowledge 10. Deductive or inductive logic framework 11. Potential fallacies in the reasoning process 12. Siddhānta: established tenets in a field of study *Linguistics* 1. Introduction to Linguistics 2. Aṣṭādhyāyī 3. Phonetics 4. Word generation 5. Computational aspects 6. Mnemonics 7. Recursive operations 8. Rule based operations 9. Sentence formation 10. Verbs and prefixes 11. Role of Sanskrit in natural language processing		

Text Books:

Mahadevan, B., Bhat Vinayak Rajat, Nagendra Pavana R.N. (2022), "Introduction to Indian Knowledge System: Concepts and Applications", PHI Learning Private Ltd. Delhi.

Additional Readings:

- Pride of India: A Glimpse into India's Scientific Heritage, Samskrita Bharati, New Delhi.
- Sampad and Vijay (2011). "The Wonder that is Sanskrit", Sri Aurobindo Society, Puducherry.
- Bag, A.K. (1979). Mathematics in Ancient and Medieval India, Chaukhamba Orientalia, New Delhi.
- Datta, B. and Singh, A.N. (1962). History of Hindu Mathematics: Parts I and II, Asia Publishing House, Mumbai.
- Kak, S.C. (1987). "On Astronomy in Ancient India", Indian Journal of History of Science, 22(3), pp. 205–221.
- Subbarayappa, B.V. and Sarma, K.V. (1985). Indian Astronomy: A Source Book, Nehru Centre, Mumbai.
- Bag, A.K. (1997). History of Technology in India, Vol. I, Indian National Science Academy, New Delhi.
- Acarya, P.K. (1996). Indian Architecture, Munshiram Manoharlal Publishers, New Delhi.
- Banerjea, P. (1916). Public Administration in Ancient India, Macmillan, London.
- Kapoor Kapil, Singh Avadhesh (2021). "Indian Knowledge Systems Vol – I & II", Indian Institute of Advanced Study, Shimla, H.P.

E-Resources:

NPTEL Course: **Indian Knowledge System(IKS): Concepts and Applications in Engineering:**
https://onlinecourses.swayam2.ac.in/imb23_mg53/preview

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Sub Code: CD406A3 **Credit: 3 (L-3, T-0, P-0)**

Introduction to Language and Linguistics

Questions to be set: 05 (All Compulsory)

Course Objectives: The course tries to give an idea about the knowledge of language and different levels of linguistic analysis, keeping in mind various types of linguistic data. After attending the course, one will be able to conduct basic linguistic analysis in phonology and morphology; transcribe using the International Phonetic Alphabet (IPA), draw basic syntax trees and do parsing. Additionally, the course gives an overview of relevant topics like language and script, linguistic areas, dialects etc.

Pre-requisites: NIL

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Discuss the philosophical aspects of language, including Plato's problem, the nature of linguistic competence and performance, and the role of Universal Grammar in language acquisition.

CO 2: Explain fundamental concepts of phonetics and phonology

CO 3: Describe fundamental concepts in formal theories of syntax and semantics

CO 4: Understand the computational linguistic and linguistic topology.

CO 5: Demonstrates an understanding of the basic themes and methods in the field of Sociolinguistics.

Module	Topics	Hrs	CO
Module 1:	What is Knowledge of Language? What is Plato's problem? What do we do in Linguistics? Competence and Performance Universal Grammar, Rules of Language	8	1
Module 2:	Phonetics and Phonology, IPA Morphology	8	2
Module 3:	Introduction to Syntax, Syntax and Semantics	8	3
Module 4:	Pragmatics, Computational Linguistics, Introduction to Typology, Linguistic Typology and Linguistic Area	8	4

Module 5:	Introduction to Sociolinguistics, Sociolinguistics and Endangered Languages, Language Documentation and Language Teaching, Summing up	8	5

Books and References:

1. Carnie, A. 2013. Syntax: A Generative Introduction. Wiley-Blackwell.
2. Fromkin, V., Rodman, R. and Hyams, N. 2003. An Introduction to Language. Thomson/Heinle.
3. Haegeman, L. 1994. Introduction to Government and Binding Theory. Wiley- Blackwell.
4. Katamba, F. 1993. Morphology. Palgrave-Macmillan.
5. Yule, G. 2006. The Study of Language. Cambridge University Press.
6. Akmajian, A., Demers, R.A. and Harnish, R.M. 2001. Linguistics: An Introduction to Language and Communication. MIT Press.
7. Jurafsky, D.and Martin J.H. 2008. Speech and Language Processing: An Introduction to Speech Recognition, Computational Linguistics and Natural Language Processing. Pearson.

E-Resources:

NPTEL Course : **Introduction to Language and Linguistics:** https://onlinecourses.nptel.ac.in/noc23_hs87/preview

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Sub Code: CD407A3 **Credit: 3 (L-3, T-0, P-0)**

Understanding Incubation and Entrepreneurship

Questions to be set: 05 (All Compulsory)

Course Objectives: The course 'Understanding Incubation and Entrepreneurship' uncovers the basics of what it takes to develop an entrepreneurial mindset thereby encouraging the journey of transformation to convert an idea or a solution into a business.

Pre-requisites: NIL

Course Outcomes (CO):

Upon successful completion of the course, students should be able to

CO 1: Explain the concept of entrepreneurship, compare it to other forms of employment, and identify various types of entrepreneurial ventures.

CO 2: Apply theory and practice on innovation, entrepreneurship, and entrepreneurial venturing.

CO 3: Apply the Business Model Canvas framework to develop comprehensive business strategies, analyze real-world business models, and transform innovative business ideas into viable models.

CO 4: Understand various aspects of entrepreneurship, specifically, into technology-led entrepreneurship.

CO 5: Understand the journey from idea to proof of concept, and insights into network entrepreneurship

Module	Topics	Hrs	CO
Module 1:	Introduction to Entrepreneurship, Entrepreneurship GDC Program, Hand holding for Entrepreneurship GDC start-up stories, Entrepreneurship Types, Team Building.	8	1
Module 2:	Innovation and Entrepreneurship, Solar Oven case-study Paradigm shift from Design to Entrepreneurship Bio- Med Innovation and Entrepreneurship	8	2
Module 3:	New-age Entrepreneurship Business Model Canvas	8	3
Module 4:	Technology led Entrepreneurship Entrepreneurship as Academic Program - IITH case study	8	4

Module 5:	Creativity and Generating Product Ideas, From Idea to Proof of Concept, Network Entrepreneurship Learning from examples Start-up PITCHES - Using Lean Canvas Model Part 1 Learning from examples Start-up PITCHES - Using Lean Canvas Model Part 2	8	5

Books and References:

1. Disciplined Entrepreneurship: 24 Steps to a Successful Startup by Bill Aulet
2. The Essence of Medical Device Innovation by B Ravi
3. THE FORTUNE AT BOTTOM OF PYRAMID: Eradicating Poverty Through Profits by C.K.Prahalad Stay Hungry
4. Stay Foolish by Rashmi Bansal
5. The Entrepreneurial Connection: East Meets West in the Silicon Valley by Gurmeet Naroola
6. Innovation By Design: Lessons from Post Box Design & Development by B. K. Chakravarthy , Janaki Krishnamoorthi

E-Resources:

NPTEL Course : **Understanding Incubation and Entrepreneurship:** https://onlinecourses.nptel.ac.in/noc22_de08/preview

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Sub Code: CD408A3 **Credit: 3 (L-3, T-0, P-0)**

Principles of Economics

Questions to be set: 05 (All Compulsory)

Course Objectives: The objective of this course is to understand the fundamental concepts such as demand, supply, elasticity, and government policies. Analyze efficient resource allocation and macroeconomic aspects like national income measurement and inflation. By completing this course, students will enhance their decision-making skills and gain insights into public policy implications from an economist's perspective.

Pre-requisites: NIL

Course Outcomes (CO):

Upon successful completion of the course, students will

CO 1: gain insights into decision-making, resource allocation, and the gains from trade, while also exploring interdependence among economic agents and the implications of government policies.

CO 2: gain insights into how market forces of supply and elasticity, along with the application of elasticity in the context of supply, demand, and government policies, shape market outcomes.

CO 3: Understand consumer and producer surplus, market interventions, international trade, and externalities

CO 4: Understand competitive markets, monopoly markets, game theory, oligopoly, and the measurement of national income and cost of living

CO 5: "Understanding production and growth, saving, investment, the financial system, the monetary system, and money growth and inflation.

Module	Topics	Hrs	CO
Module 1:	Ten principles of Economics Thinking like an Economist; Interdependence and the gains from Trade.	8	1
Module 2:	Market forces of supply and Elasticity Application of elasticity; supply, demand and government policies	8	2
Module 3:	Consumer and producer surplus; cost of taxation and international trade Externalities and cost of production	8	3
Module 4:	Competitive market and monopoly market	8	4

	Game theory and oligopoly, Measures national income, measuring cost of living		
Module 5:	Production and growth; Saving, Investment and the financial system The monetary system Money growth and inflation	8	5

Text Book:

Mankiw, N.G. (2014). *Principles of Economics*. Cengage Learning, ISBN : 9781305156043
https://books.google.co.in/books?id=K-jKAgAAQBAJ

E-Resources:

NPTEL Course : Principle of Economics: https://onlinecourses.nptel.ac.in/noc23_ec06/preview

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Sub Code: CD409A3 **Credit: 3(L-3, T-0, P-0)**

Science, Technology and Society

Questions to be set: 05 (All Compulsory)

Course Objectives: This course aims to foster an understanding of science as a cultural and societal practice, exploring its historical, philosophical, and sociological dimensions and the dynamic interplay between science, technology, and society.

Pre-requisites: Nil

Course Outcomes (CO): On completion of the course it is expected to endow the students with skills to:

1. Understand science as a socio- cultural product in specific historical context.
2. Analyze philosophical, historical, and sociological perspectives on science and technology, recognizing science as a practice deeply embedded in culture and society
3. Emphasize the dynamic nature of the relations between wider cultural practices, on the one hand, and, scientific practices, on the other in a comparative analytical framework.
4. Explain the perspectives on the relationships between science and technology, and between science, technology, and society
5. Identify the essential theories needed to analyze the dynamics between science and society across various contexts and disciplines.

**** not more than 20% of total topics to be allotted for assignment**

Module	Topics	Hrs	CO
Module 1: **Science as Culture**	Methods of Science: Issues and Perspectives, Social Context of Production of Scientific Knowledge, Demarcation, Autonomy and Cognitive Authority of Science, Challenges: Cognitive, Legal, Ethical, Feminist and Ideological.	7	1
Module 2: **Organisation of Production of Scientific Knowledge and Professionalisation of Science**	Science as Social Institution and Ethos of Science, Inequalities in Science, Critique of the Mertonian Paradigm, Knowledge Production: Social and Cultural Contexts.	5	1
Module 3: < **Society and Culture: Resourcesand Legitimation of Knowledge**	Social Legitimation, Meanings, Interests, Values and the Modern State..	5	2
Module 4: **Perspectives on Science - Technology Relationship:**	Hierarchical, Symbiotic and Coalescing, Science and Technology, and their Human Roots: Philosophy of Science and Technology, Technology as Knowledge, Technological Shaping of Society and Social Shaping of Technology	6	2
Module 5: **Science in Colonial and Post-colonial India**	Science in Colonial India, Reception of Modern Science in India, Science after Independence	5	3
Module 6: **Emerging Technologies**	Information and Communication Society - Implications for Work, Social Relations, Governance and Control, Biotechnology - Implications for the Meanings of Life and Life, Processes, Application in Agriculture, Healthcare and Environment.	6	4
Module 7: **New Ethical Codes for New Technologies**	Responses of the Civil Society.	2	4
Module 8: **Science: From Public Resourceto Intellectual Property**	Changing Context of the Production of Knowledge, The Intellectual Property Rights Regime, Science: From Curiosity- driven Research to Contract Obligations	4	5

References:

1. A.F. Chalmers (1976) What is this thing called Science? Milton Keynes: The Open University Press
2. T.S. Kuhn (1970) The Structure of Scientific Revolutions. Chicago: Chicago University Press (first published in 1962).
3. D. Oldroyd (1986) The Arch of Knowledge: An Introductory Study of the Philosophy and Methodology of Science. New York and London: Methuen.
4. D. Bloor (1991) Knowledge and Social Imagery. Chicago: The University of Chicago Press (first published in 1976).
5. M. Biagioli ed., (1999) The Science Studies Reader.

E-Resources:

NPTEL Course: Science, Technology and Society; https://onlinecourses.nptel.ac.in/noc20_hs85/preview

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INVITATION TO BOS MEMBERS AND THEIR CONSENT:

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Invitation to the Board of Studies meeting for the discussion and approval of B. Tech Computer Science and Engineering (Data Science) detailed Syllabus of the Dept. of AI&DS, SMIT, SMU following NEP 2020 and SMU guidelines.

Invitation to BOS Meeting for B.Tech CSE (Data Science) Syllabus for discussion and approval

HOD, AI & DS <hod.ai@smit.smu.edu.in>

Tue 5/28/2024 8:15 PM

To:bhanu.murthy.modali@dell.com <bhanu.murthy.modali@dell.com>;Rohit Sinha <rsinha@iitg.ac.in>;Sumantra Dutta Roy <sumantra@ee.iitd.ac.in>; hirenkdsarma@gauhati.ac.in <hirenkdsarma@gauhati.ac.in>;swastika.chakraborty@nit.ac.in <swastika.chakraborty@nit.ac.in>;paramartha.dutta@gmail.com <paramartha.dutta@gmail.com>;acakcs@caluniv.ac.in <acakcs@caluniv.ac.in>;achakra12@yahoo.com <achakra12@yahoo.com>;hrishav.barua@tcs.com <hrishav.barua@tcs.com>;Dr. Kalpana Sharma, (Professor, CSE & Director DoR) <kalpana.s@smit.smu.edu.in>;Biswaraj Sen,SMIT <biswaraj.s@smit.smu.edu.in>;Udit Kr Chakraborty,SMIT <udit.c@smit.smu.edu.in>;SWARUP SARKAR, SMIT <swarup.s@smit.smu.edu.in>; HIMANGSHU PAL, SMIT <himangshu.p@smit.smu.edu.in>;Om Prakash Singh,SMIT <om.s@smit.smu.edu.in>;rbera50@gmail.com <rbera50@gmail.com>

Cc:HOD, AI & DS <hod.ai@smit.smu.edu.in>

1 attachments (464 KB)

B.TECH CSE(DS) Syallabus-28-05-2024.pdf;

Dear Esteemed BOS Members,

We cordially invite you to a Board of Studies (BOS) meeting to discuss the new syllabus for the B.Tech CSE (Data Science) program. The syllabus will be effective from July 2024 onwards, covering both the Admitted Batch of 2024 (from 1st semester) and the Admitted Batch of 2023 (from the 3rd semester). The meeting will be held online on **June 01, 2024 from 4:00pm onwards**.

Please join the meeting with MS Team Link:

https://teams.microsoft.com/l/meetup-join/19%3a4dAzdAo44Iu0NTkkjpQscPVaRomSxTQ-r0JS5Jbk2nY1%40thread.tacv2/1716906930069?context=%7b%22Tid%22%3a%2281a40298-9b95-4446-81c0-a0311fccfdf2%22%2c%22Oid%22%3a%227d5a7148-05cc-4c56-bf21-3daca6b17fb1%22%7d

Your presence and insights are highly valued as we strive to enhance the curriculum. We have attached the draft copy of the syllabus for your perusal. Kindly review it and provide your valuable feedback.

Thank you for your continued support in shaping our program.

Dr. Om Prakash Singh

Associate Professor and Head,

Department of Artificial Intelligence and Data Science

Sikkim Manipal Institute of Technology

Majitar, Sikkim-737136, INDIA

Mob:9800408668

SMIT SIKKIM MANIPAL UNIVERSITY
SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY
Majhitar, Rangpo-737136, Sikkim, India
Ph.: +91-3592-246353, 246220
Fax: +91-3592-246112
Email: smit@smu.edu.in,
Web: http://smu.edu.in

Date: 28/09/2023

BOS MEETING

Agenda: Interaction with Shri Bhanu Murthy Modali (Industry BOS member) to discuss and frame the syllabus of B.Tech in Computer Science and Engineering (Data Science) Program.

A meeting was held at DRDO Lab C-402, to facilitate an interaction between Shri Bhanu Murthy Modali an industry BOS member from Dell International Services India Pvt Ltd. and the internal BOS members of SMIT. The primary agenda was to discuss and frame the syllabus of B.Tech in Computer Science and Engineering (Data Science) Program.

The meeting proceeded successfully with productive discussions and insights shared by Shri Bhanu Murthy Modali and other BOS members. The BOS members engaged in fruitful dialogues regarding syllabus framing.

The meeting took place on two consecutive days i.e 28th & 29th Sept 2023 in the presence of an internal BOS members and Shri Bhanu Murthy Modali (Industry BOS member).

It concluded successfully with the gesture of offering khadas and a memento to the external member as a token of appreciation for their valuable contribution and participation.

Faculty members will further work on the syllabus framing discussed during the meeting. Future actions and implementation of proposed changes will be done accordingly.

Date: 28/09/2023
Location: DRDO Lab C-402

ARTIFICIAL INTELIGENCE & DATA SCIENCE
SMIT
Majitar - Rangpo
East Sikkim
Pin -737136

Shri Bhanu Murthy Modali
Industry BOS Member
Dell International Services India Pvt Ltd.

Dr. Om Prakash Singh
Internal BOS Member, SMIT
Dept. of CSE(Data Science)

Dr Swarup Sarkar
Internal BOS Member,SMIT
Dept of CSE(Data Science)

Dr. Himangshu Pal
Internal BOS Member,SMIT
Dept of CSE(Data Science)

Prof.(Dr.) Kalpana Sharma
Internal BOS Member,SMIT
Dept of CSE

Prof.(Dr.) Biswaraj Sen
Internal BOS Member,SMIT
Dept of IT

Prof.(Dr.) R. N Bera
Internal BOS Member,SMIT
Dept of CSE(Data Science)

Prof.(Dr.) Sourav Dhar
Internal BOS Member, SMIT
Dept of ECE

"Global Leadership in Human Development, Excellence in Education and Healthcare"

Points discussed in the BOS Meeting Held on 28/09/23 and 29/09/23

The following points were discussed on BOS meeting:

1. Updation of the proposed syllabus schema for B.Tech in CSE(Data Science) program.
2. Discussion regards minor specialization subjects and the credit hours.
3. Advice was given to emphasis on practical hands on.
4. Software security methods and test cases, related subject may be introduced in program electives,
5. Discussion were made regarding Deep Learning domain, generative AI and AI prompt engineering, and same may be considered and introduced.
6. Discussion were made on recent trends in computer science from the corporate point of view (Use of LLM, AI Prompt etc.).
7. Considering the GATE, syllabus to be framed accordingly.
8. Discussion were made on various STACKS (MERN, MEAN etc.) used in the corporate and also discussion was made for Dockers used for AI.
9. Use of Git and GitHub were also discussed.
10. Discussion were also made on AI production.
11. Trends in use of libraries, and its challenges in handling soft corners of the problem or its inability to handle niche problem in computer science.
12. Syllabus for Core AI / ML subjects to be reconsidered taking into the consideration of the time allotted for the particular subject.
13. Discussion and appreciation were made on project based learning.
14. Panel members suggested the implementation of MOOC courses.
15. Business analytics to be introduced, where two option were given viz. Business/ financial analytics for minor specialization in data science.
16. Appreciation were made for one-year student industry internship.
17. Probability and statistics to be introduced for students of data science.

Om Prakash Singh 29/09/2023
(Dr. O. P. Singh)

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SMIT
Majitar - Rangpo
East Sikkim
Pin -737136

SMIT SIKKIM MANIPAL UNIVERSITY
SIKKIM MANIPAL INSTITUTE OF TECHNOLOGY

Majhitar, Rangpo-737136, Sikkim, India
Ph.: +91-3592-246353, 246220
Fax: +91-3592-246112
Email : smit@smu.edu.in
Web: http://smu.edu.in

Minutes of Meeting: B. Tech CSE (Data Science) Syllabus Approval

Date: 01-06-2024

Agenda: Review and approval of the B. Tech CSE (Data Science) syllabus.

A. The Department of Artificial Intelligence and Data Science convened a Board of Studies (BOS) meeting on June 1, 2024, to review and approve the B.Tech CSE (Data Science) syllabus. The revised syllabus will take effect from **July 2024** for third-semester students. Dr. Om Prakash Singh, Associate Professor and Head of the Department of AI&DS at SMIT, chaired the meeting.

B. The following distinguished members participated in the BOS meeting, which was conducted in hybrid mode:

- **Mr. Bhanu Murty Modali** – Director, IT Architecture, Dell Technologies
- **Mr. Hrishav Bakul Barua** – Scientist, TCS Research Lab, Kolkata
- **Dr. Rohit Sinha** – Professor, Department of EEE, IIT Guwahati
- **Dr. Amlan Chakraborty** – Professor & Director, A.K. Choudhury School of IT, University of Calcutta
- **Dr. Hiren Kumar Deva Sharma** – Professor, Department of IT, Guwahati University
- **Dr. Swastika Chakraborty** – Professor, Department of ECE, Narula Institute of Technology, Kolkata
- **Dr. Rabindranath Bera** – Ex-Professor and Head of Department, AI&DS, SMIT
- **Dr. Kalpana Sharma** –Professor, Dept. of CSE and Director, DOR, SMU
- **Dr. Biswaraj Sen** – Professor and Head, Department of IT, SMIT
- **Dr. Udit Chakraborty** – Professor and Head, Department of CSE, SMIT & Head, Quality Cell
- **Dr. Swarup Sarkar** – Associate Professor, Department of AI&DS, SMIT
- **Dr. Himangshu Pal** – Assistant Professor, Department of AI&DS, SMIT

C. The BOS chairman welcomed all the esteemed BOS members and introduced each one of them to the members The syllabus, aligned with the National Education Policy 2020 (NEP2020) and SMU guidelines, was presented, emphasizing its key features.

Syllabus Highlights:

1. **Total Credits:** 180
2. **Minor Specializations/Options for Open Electives:**
   - Data Science (available to students from other departments)
   - Computer Vision and Speech Technology
   - Biomedical Technology
3. **Provision of One-Year Internship**
4. **Program Electives/Open Electives from 3rd Semester Onwards**
5. **Choice Based Electives**

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Om Prakash Singh 01/06/24
(Dr. O.P. Singh)

D. Following the BOS meeting and considering feasibility, the syllabus has been updated as follows:

1. Introduction to Data Science: The subject previously known as "Data Science" has been renamed to "Introduction to Data Science." The content has been expanded and reorganized to provide a comprehensive overview of data science concepts, techniques, and applications.
2. Program Electives V (6th Semester): Two important subjects have been added:
   - AI in Healthcare
   - Software Engineering
3. ASR Syllabus Update: The syllabus for Automatic Speech Recognition (ASR) has been modified to align with current advancements in speech processing.

E. The meeting concluded with gratitude to all BOS members for their valuable input.

Signature of Internal BOS Members:

Dr. Kalpana Sharma,
Professor, Dept. of CSE,
and Director, Directorate of
Research(DOR), SMU

Dr. Udit Chakraborty
Professor and Head,
Department of CSE, SMIT
& Head, Quality Cell

Dr. Biswaraj Sen Professor
and Head, Department of
IT, SMIT

Dr. Himangshu Pal
Assistant Professor,
Department of AI&DS,
SMIT

Dr. Swarup Sarkar
Associate Professor,
Department of AI&DS,
SMIT

External Board of Studies (BOS) members have provided their approval for the B. Tech in Computer Science and Engineering (Data Science) syllabus via email and the same is attached herewith.

BOS Chairman: Dr. Om Prakash Singh,
Associate Professor and Head,
Dept. of AI&DS, SMIT

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East Sikkim
Pin -737136

Consent from BOS Members:

Re: Invitation to BOS Meeting for B.Tech CSE (Data Science) Syllabus for discussion and approval

Swastika Chakraborty <swastika.chakraborty@nit.ac.in>

Sat 6/1/2024 5:55 PM

To:HOD, AI & DS <hod.ai@smit.smu.edu.in>
Cc:bhanu.murthy.modali@dell.com <Bhanu.Murthy.Modali@dell.com>;Rohit Sinha <rsinha@iitg.ac.in>;Sumantra Dutta Roy <sumantra@ee.iitd.ac.in>;hirenkdsarma@gauhati.ac.in <hirenkdsarma@gauhati.ac.in>;Paramartha Dutta <paramartha.dutta@gmail.com>;acakcs@caluniv.ac.in <acakcs@caluniv.ac.in>;achakra12@yahoo.com <achakra12@yahoo.com>;hrishav.barua@tcs.com <hrishav.barua@tcs.com>;Dr. Kalpana Sharma, (Professor, CSE & Director DoR) <kalpana.s@smit.smu.edu.in>;Biswaraj Sen,SMIT <biswaraj.s@smit.smu.edu.in>;Udit Kr Chakraborty,SMIT <udit.c@smit.smu.edu.in>;SWARUP SARKAR, SMIT <swarup.s@smit.smu.edu.in>;HIMANGSHU PAL, SMIT <himangshu.p@smit.smu.edu.in>;Om Prakash Singh,SMIT <om.s@smit.smu.edu.in>;rbera50@gmail.com <rbera50@gmail.com>

1 attachments (3 KB)

Outlook-bmwbqlbc.png;

Accepted. Please go ahead with the syllabus framed.

Thanks
Dr. Swastika Chakraborty
Professor, Narula Institute of Technology
Kolkata

HB

HRISHAV BARUA<hrishav.barua@tcs.com>

To: Swastika Chakraborty <swastika.chakraborty@nit.ac.in>; HOD, AI & DS

Sat 6/1/2024 6:11 PM

Cc: Rohit Sinha <rsinha@iitg.ac.in>; **+13 others**

TCS Confidential

Dear Sir,

The discussed syllabus is very comprehensive and diverse. It will be a good starting point for this course. Hence please go ahead with this syllabus.

Thanks,
Hrishav Bakul Barua,
Scientist , TCS Research

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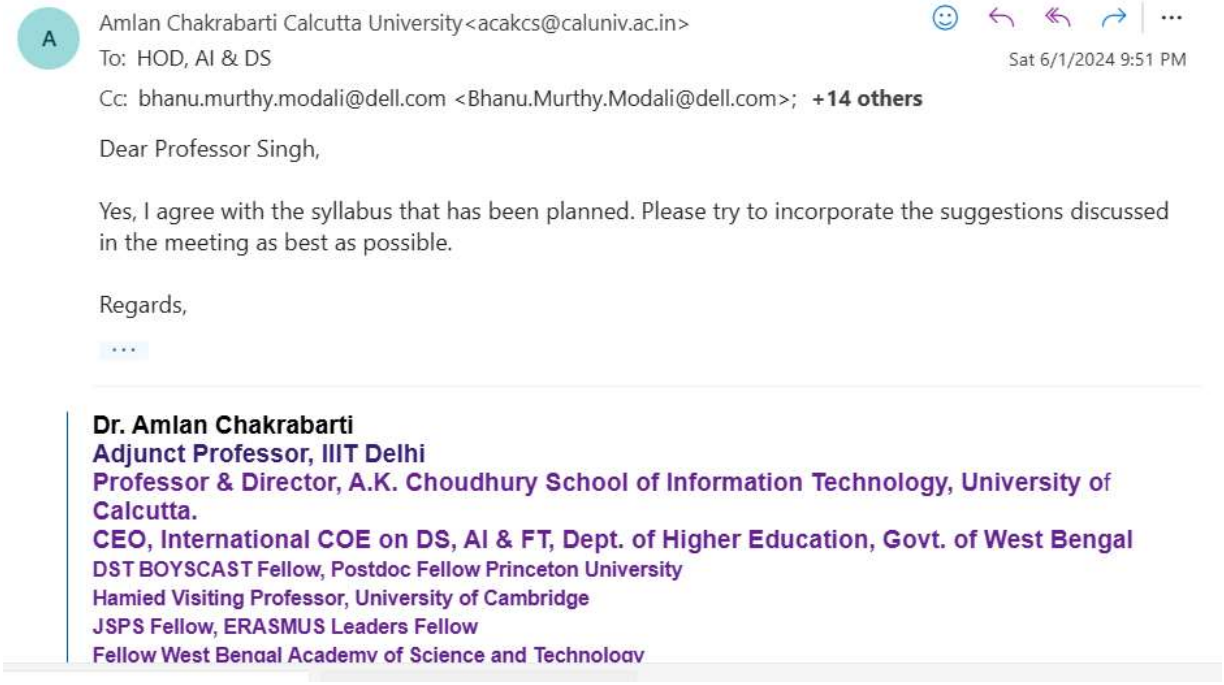


A

Amlan Chakrabarti Calcutta University<acakcs@caluniv.ac.in>

To: HOD, AI & DS

Sat 6/1/2024 9:51 PM

Cc: bhanu.murthy.modali@dell.com <Bhanu.Murthy.Modali@dell.com>; **+14 others**

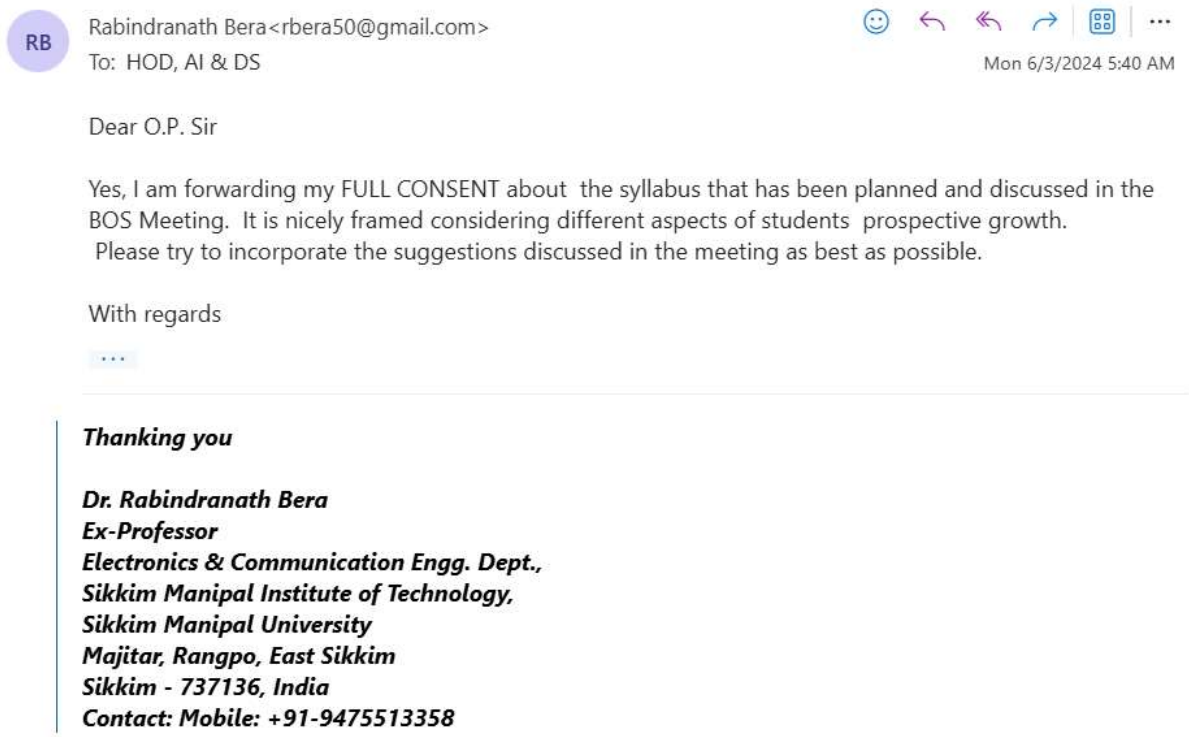
Dear Professor Singh,

Yes, I agree with the syllabus that has been planned. Please try to incorporate the suggestions discussed in the meeting as best as possible.

Regards,

...

Dr. Amlan Chakrabarti
Adjunct Professor, IIIT Delhi
Professor & Director, A.K. Choudhury School of Information Technology, University of Calcutta.
CEO, International COE on DS, AI & FT, Dept. of Higher Education, Govt. of West Bengal
DST BOYSCAST Fellow, Postdoc Fellow Princeton University
Hamied Visiting Professor, University of Cambridge
JSPS Fellow, ERASMUS Leaders Fellow
Fellow West Bengal Academy of Science and Technology



RB

Rabindranath Bera<rbera50@gmail.com>
To: HOD, AI & DS

Mon 6/3/2024 5:40 AM

Dear O.P. Sir

Yes, I am forwarding my FULL CONSENT about the syllabus that has been planned and discussed in the BOS Meeting. It is nicely framed considering different aspects of students prospective growth.
Please try to incorporate the suggestions discussed in the meeting as best as possible.

With regards

...

Thanking you

Dr. Rabindranath Bera
Ex-Professor
Electronics & Communication Engg. Dept.,
Sikkim Manipal Institute of Technology,
Sikkim Manipal University
Majitar, Rangpo, East Sikkim
Sikkim - 737136, India
Contact: Mobile: +91-9475513358

Re: Invitation to BOS Meeting for B.Tech CSE (Data Science) Syllabus for discussion and approval

Hiren Kumar Deva Sarma <hirenkdsarma@gauhati.ac.in>
Tue 6/4/2024 8:51 AM

To: Amlan Chakrabarti Calcutta University <acakcs@caluniv.ac.in>
Cc: HOD, AI & DS <hod.ai@smit.smu.edu.in>; bhanu.murthy.modali@dell.com <Bhanu.Murthy.Modali@dell.com>; Rohit Sinha <rsinha@iitg.ac.in>; Sumantra Dutta Roy <sumantra@ee.iitd.ac.in>; swastika.chakraborty@nit.ac.in <swastika.chakraborty@nit.ac.in>; paramartha.dutta@gmail.com <paramartha.dutta@gmail.com>; achakra12@yahoo.com <achakra12@yahoo.com>; hrishav.barua@tcs.com <hrishav.barua@tcs.com>; Dr. Kalpana Sharma, (Professor, CSE & Director DoR) <kalpana.s@smit.smu.edu.in>; Biswaraj Sen,SMIT <biswaraj.s@smit.smu.edu.in>; Udit Kr Chakraborty,SMIT <udit.c@smit.smu.edu.in>; SWARUP SARKAR, SMIT <swarup.s@smit.smu.edu.in>; HIMANGSHU PAL, SMIT <himangshu.p@smit.smu.edu.in>; Om Prakash Singh,SMIT <om.s@smit.smu.edu.in>; rbera50@gmail.com <rbera50@gmail.com>

Dear Sir,
Agreed. Hope this revised curriculum will benefit the students significantly.
Best wishes-
Hiren KD Sarma.

On Sat, 1 Jun 2024 at 21:34, Amlan Chakrabarti Calcutta University <acakcs@caluniv.ac.in> wrote:

> Dear Professor Singh,
>
> Yes, I agree with the syllabus that has been planned. Please try to incorporate the suggestions discussed in the meeting as best as possible.
>
> Regards,
>
> On Sat, Jun 1, 2024 at 5:20 PM HOD, AI & DS <hod.ai@smit.smu.edu.in> wrote:
>
> > Dear Sir/Madam,
> >
> > Based on the Online BOS meeting held on the 1st of June 2024, request your acceptance note with comments.
> >
> > Thank you, all esteemed BOS members, for your valuable input for enhancing the curriculam.
> >
> > With Regards.
> >
> > Dr. Om Prakash Singh
> > Associate Professor and Head,
> > Department of Artificial Intelligence and Data Science
> > Sikkim Manipal Institute of Technology