B. Tech. (Artificial Intelligence and Data Science / Artificial Intelligence and Machine Learning and Allied) Syllabus Aligned with the New Education Policy 2020 Effective from 2025 - 2026 (All Years)

(Affiliated Colleges)

Note: Refer to this syllabus for the Second, Third year in Artificial Intelligence and Data Science, Artificial Intelligence and Machine Learning, Computer Engineering and Data Science, Data Science with Program Codes (11263, 11911, 11912, 11913, 11917, 11921, 11925, 11995, 11997)

Department of Computer Engineering

Dr. Babasaheb Ambedkar Technological University, Lonere - 402103

www.cse.dbatu.ac.in

B.Tech in Computer Engineering and Allied Programs
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2024 - 2025)
First Semester

Course Category	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
BSC	24AF1000BS101	Engineering Mathematics - I	3	-	20	20	60	3
BSC	24AF1CHEBS102	Engineering Chemistry	3	-	20	20	60	3
BSC	24AF1CHEBS103L	Engineering Chemistry Lab	-	2	60	-	40*	1
ESC	24AF1EMES104	Engineering Mechanics	3	-	20	20	60	3
ESC	24AF1EMES105L	Engineering Mechanics Lab	-	2	60	-	40*	1
ESC	24AF1000ES106	Programming for Problem Solving	2	-	20	20	60	2
ESC	24AF1000ES107L	Programming for Problem Solving Lab	-	2	60	-	40*	1
VSEC	24AF1000VS108L	Workshop Practices	-	4	60	-	40*	2
AEC-01	24AF1000VS109	Communication Skills	2	-	20	20	60	2
AEC-01	24AF1000VS110L	Communication Skills Lab	-	2	60	-	40*	1
CC	24AF1000CC111	A. Yoga Education B. NSS-I C. NCC	1	2	60	-	40†	2
		Total	**14**	**14**	**460**	**100**	**540**	**21**

***Practical/Oral evaluation of 40 marks at the end of the semester.**
†Presentation/Oral evaluation of 40 marks at the end of the semester.

B.Tech in Computer Engineering and Allied Programs
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2024 - 2025)
Second Semester

Course Category	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
BSC	24AF1000BS201	Engineering Mathematics - II	3	-	20	20	60	3
BSC	24AF2PHYBS202	Engineering Physics	3	-	20	20	60	3
BSC	24AF2PHYBS203L	Engineering Physics Lab	-	2	60	-	40*	1
ESC	24AF2EGRES204	Engineering Graphics	2	-	20	20	60	2
ESC	24AF2EGRES205L	Engineering Graphics Lab	-	2	60	-	40*	1
ESC	24AF1000ES206	Basic Electrical and Electronics Engineering	3	-	20	20	60	3
ESC	24AF1000ES207L	Basic Electrical and Electronics Engineering Lab	-	2	60	-	40*	1
ESC	24AF2CMEES208	Basic Civil and Mechanical Engineering	3	-	20	20	60	3
BSC	24AF1EEEES209	Energy and Environmental Engineering	2	-	20	20	60	AU
IKS	24AF1000IK210	IKS Bucket#	2	-	20	20	60	2
VSEC	24AF1000VS211	Design Thinking	2	-	20	20	60	2
CC	24AF1000CC212	A. Integrated Personality Development B. NSS-II C. Health and Wellness	1	2	60	-	40†	2
		Total	**21**	**08**	**510**	**100**	**540**	**23**

***Practical/Oral evaluation of 40 marks at the end of the semester**
†Presentation/Oral evaluation of 40 marks at the end of the semester
 # Refer to the University website for the subjects under IKS bucket

Note: Students can complete online courses of 40% of total credits through online platform NPTEL/SWAYAM/Sector Skill council of India and other online platforms identified by the University time to time. At least 80% contents of the NPTEL/SWAYAM/Sector Skill council of India course should match with syllabus contents of the subject prescribed by the university.

Exit Option I: After completion of first year in engineering
Qualifier for One Year UG Certificate: Students opting for this option, should undergo the well-defined training/internship of 4-6 weeks which is equivalent to 4 Credits (120hrs) in the appropriate /relevant industry or organization.

B.Tech in Artificial Intelligence and Allied
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2025 - 2026)
Third Semester

Course Category	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
BSC	25AF1000BS301	Engineering Mathematics-III	3	-	20	20	60	3
PCC1	25AF1245PC302	Data Structures	3	-	20	20	60	3
PCC2	25AF1245PC303	Discrete Mathematics	3	-	20	20	60	3
PCC3	25AFAIPC304	Artificial Intelligence	2	-	20	20	60	2
OE-I	25AF1XXXOEM305X	Any Course from the Open Elective Bucket	2	-	20	20	60	2
MDM	25AFAIMD306	Multi-Disciplinary Minor Course* **(For Examination Refer MDM Bucket)**	-	-	20	20	60	-
PCC4	25AFAIPC307	Prompt Engineering	2	-	20	20	60	2
VEC	25AF1000VE308A	Life of Chhatrapati Shivaji Maharaj	1	-	50	-	-	1
PCC Lab	25AFAIPCL309	Data Structures Laboratory with Python	1	4	60	-	40	3
VEC	25AF1000VE310	Universal Human Values-II	3	-	20	20	60	3
VEC	25AFAIPCL311	Artificial Intelligence Laboratory	-	2	60	-	40	1
		Total	**20**	**6**	**330**	**160**	**560**	**23**

Course Type and Acronyms used

Basic Science Course (BSC)
Engineering Science Course (ESC)
Program Core Course (PCC)
Vocational Skill Enhancement Course (VSEC)
Co-curricular Course (CC)
Ability Enhancement Course (AEC)
Indian Knowledge System (IKS)

L - Lecture,
P / PR - Practical,
CA - Continuous Assessment,
TH - Theory,
MSE - Mid Semester Examination,
ESE - End Semester Examination,
CR - Credit

B.Tech in Artificial Intelligence and Allied
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2025 - 2026)
Fourth Semester

Course Categories	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
PCC1	25AFAIPC401	Introduction to Operating Systems	3	-	20	20	60	3
PCC2	25AFAIPC402	Data Analytics	3	-	20	20	60	3
PCC3	25AF1245PC403	Probability and Statistics	3	-	20	20	60	3
PCC Lab	25AFAIPCL404	Full Stack Development	1	2	60	-	40	2
OE-II	25AF1XXXOEM405X	Any Course from the Open Elective Bucket	2	-	20	20	60	2
MDM	25AFAIMD406	Multi-Disciplinary Minor Course* **(For Examination Refer MDM Bucket)**	-	-	20	20	60	-
VSEC	25AFCOIAE407	Constitution of India	2	-	50	-	-	Audit
VSEC	25AF1000VE308B	Life of Bharat Ratna Dr. Babasaheb Ambedkar	1	-	50	-	-	1
PCC Lab	25AFAIPCL409	Introduction to Operating Systems Laboratory	-	2	60	-	40	1
AEC	25AF1000VE410	Modern Indian Languages A) Marathi B) Hindi C) Sanskrit	2	-	20	20	60	2
Total			**17**	**4**	**340**	**120**	**380**	**17**
	Exit Requirements for Certificate Program							
VSEC	23AFAIVE411	LLM Course with Programming	-	16	60	-	40	8

B.Tech in Artificial Intelligence and Allied
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2026 - 2027)
Fifth Semester

Course Categories	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
PCC1	26AF1245PC501	Machine Learning	3	-	20	20	60	3
PCC2	26AFAIPC502	Object Oriented Programming in Java	3	-	20	20	60	3
PCC3	26AFAIPC503	Cloud and Distributed AI Systems	3	-	20	20	60	3
PCC4	26AFAIPC504	Data Engineering and Big Data Systems	3	-	20	20	60	3
OE-III	26AF1XXXOEM505X	**Open Elective Bucket**	2	-	20	20	60	2
MDM	26AFAIMD506	**MDM Bucket**	-	-	20	20	60	-
PEC	26AFAIPE507	**Program Elective:** A. Vector Databases B. Human Computer Interaction C. AI for Cybersecurity	2	-	20	20	60	2
PCC LAb	26AF1245PCL508	Machine Learning Laboratory	-	2	20	20	60	1
PCC Lab	26AFAIPCL509	MLOps Laboratory	1	2	60	-	40	2
CEP/FP	25AFAIAE510	Seminar and Mini Project	-	2	60	-	40	1
Total			**17**	**6**	**220**	**160**	**540**	**20**

B.Tech in Artificial Intelligence and Allied
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2026 - 2027)
Sixth Semester

Course Categories	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
PCC1	26AFAIPC601	Deep Learning	3	-	20	20	60	3
PCC2	26AFAIPC602	Natural Language Processing	3	-	20	20	60	3
PCC3	26AFAIPC603	Fundamental Edge AI	3	-	20	20	60	3
PEC	26AFAIPC604	**Program Elective:** A. Information Security and Privacy B. Cyber Physical Systems C. Optimization Techniques	3	-	20	20	60	3
OE-IV	26AF1XXXOEM605X	**Open Elective Basket**	2	-	20	20	60	2
MDM	26AFAIMD606	**MDM Bucket**	-	-	20	20	60	-
PCCLab	26AFAIPCL607	Deep Learning Laboratory	-	4	60	-	40	2
PCC Lab	26AFAIPCL608	Natural Language Processing Laboratory	-	2	60	-	40	1
AEC	26AFAIAE609	Modern AI Web Application based Project	1	2	60	-	40	2
Total			**15**	**8**	**300**	**120**	**480**	**19**
Exit Requirements for Certificate Program								
VSEC	23AFAIVE610	Project based on MLops, LLM or Deep learning	-	16	60	-	40	8

B.Tech in Artificial Intelligence and Allied
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2027 - 2028)
Seventh Semester

Course Categories	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
PCC	27AFXXXXPC701	AI Ethics	3	-	20	20	60	3
PEC	27AFXXXXPC702	**Program Elective:** A. Graphical Neural Networks B. Quantum AI C. AI governance	2	-	20	20	60	2
PCC Lab	27AFXXXXMD703	Computer Vision	-	2	60	-	40	1
Project	27AFXXXXP704	Project-Phase	-	4	60	-	40	2
MDM	27AFXXXXPC705	MDM Bucket	-	-	20	20	60	-
Internship	27AFXXXXO706	Internship	-	24	60	-	40	12
PCC Lab	27AFXXXXPCL707	Mobile Application Development	1	2	40	-	60	2
		Total	**22**	**10**	**490**	**140**	**620**	**22**

Fourth Year in B.Tech in Artificial Intelligence and Allied
Course Curriculum Aligned with New Education Policy 2020
(Effective from Academic Year 2026 - 2027)

Eigth Semester

Course Categories	Course Code	Course Name	Weekly Hours		Examination Scheme			Credit
			L	P	CA	MSE	ESE	
PCC	27AXXXXPC801	AI Governance	3	-	20	20	60	3
PCC	27AFXXXXPE802	**Program Elective** A. Generative AI B. Graphical Neural Networks C. AI for Social Good	3	-	20	20	60	2
PEC	27AXXXXPE803	**Program Elective** A. Quantum Machine Learning B. Business Analytics C. Learning Analytics	3	-	20	20	60	2
MDM	27AFXXXXMD804	**MDM Bucket**	2	-	40	-	60	2
RM	27AFXXXXRM805	Research Methodology	3	2	40	-	60	4
PCC Lab	27AFXXXXPL806	Project Phase - II	-	4	40	-	60	2
		Total	**22**	**10**	**490**	**140**	**620**	**20**

List of Open Electives (OE)

In the vertical of Multidisciplinary courses, students need to cover Open Elective Courses (OE) of 08 credits. These 08 credits over semesters III to V are included in the basic minimum of 160-max.176 Credits. It is offered in the Second and/or Third year. Refer to the wise credit distribution table given below. Faculty-wise baskets of OE are prepared by the university. They are chosen from faculty other than that of the Major Faculty, i.e., in this case, the Major Faculty is the Faculty of Engineering. Other Faculties considered are as follows:

1. Faculty of Management and Commerce
2. Faculty of Law
3. Faculty of Humanities and Arts
4. Faculty of Architecture and Planning
5. Faculty of Health Sciences
6. Faculty of Science

Students must take up three courses of 08 credits over semesters III to V.

List of Open Electives for Faculty of Management and Commerce

Sr. No.	Course Name	Teaching Scheme	Duration (Weeks)	Credits	Institute Offering Course	Name of Professor/ Resource Person	Link
1	Advanced Algorithmic Trading and Portfolio Management	4 Hrs / Week	8	2	IIT, Kanpur	Prof. Abhinava Tripathi	https://nptel.ac.in/courses/110104169
2	Business Analytics & Text Mining Modeling using Python	4 Hrs / Week	8	2	IIT, Roorkee	Prof. Gaurav Dixit	https://nptel.ac.in/courses/110107129
3	Commodity Derivative & Risk Management	4 Hrs / Week	12	3	IIT, Kharagpur	Prof. Prabina Rajib	https://nptel.ac.in/courses/110105168
4	E-Business	4 Hrs / Week	12	3	IIT, Kharagpur	Prof. Mamata Jenamani	https://nptel.ac.in/courses/110105083
5	Econometric Modelling	4 Hrs / Week	8	2	IIT, Roorkee	Prof. Sujata Kar	https://nptel.ac.in/courses/110107153
6	Introduction to Marketing Essentials	4 Hrs / Week	12	3	IIT, Roorkee	Prof. Zillur Rahman	https://nptel.ac.in/courses/110107147
7	Security Analysis & Portfolio Management	4 Hrs / Week	12	3	IIT, Roorkee	Prof. J. P. Singh	https://nptel.ac.in/courses/110107154
8	Equity Stock Market		6	3	Indian Institute of Management, Bangalore (IIB)	P. C. Narayan	https://onlinecourses.swayam2.ac.in/imb23_mg59/preview

List of Open Electives for Faculty of Law

Sr. No.	Course Name	Teaching Scheme	Duration (Weeks)	Credits	Institute Offering Course	Name of Professor / Resource Person	Link
1	Introduction to Law on Electricity	4 Hrs / Week	8	2	IIT, Kharagpur	Prof. Uday Shankar	https://nptel.ac.in/courses/129105004
2	New Labour Codes of India	4 Hrs / Week	12	3	IIT, Kharagpur	Prof. K. D. Raju	https://nptel.ac.in/courses/129105006
3	Right to Information and Good Governance	4 Hrs / Week	12	3	National Law School of India University	Prof. Sairam Bhat	https://nptel.ac.in/courses/129106001
4	Conflict Management through Mediation	4 Hrs / Week	8	2	Vice-Chancellor, National University of Study and Research in Law, Ranchi (NUSRL)	Prof. (Dr.) Ashok R. Patil	https://nptel.ac.in/courses/129106008
5	Biodiversity Protection, Farmers and Breeders Rights	4 Hrs / Week	8	2	IIT, Kharagpur	Prof. Padmavati Manchikanti Prof. Narendran Thiruthy	https://nptel.ac.in/courses/129105008

List of Open Electives for Faculty of Humanities and Arts

Sr. No.	Course Name	Teaching Scheme	Duration (Weeks)	Credits	Institute Offering Course	Name of Professor / Resource person	Link
1	Developing Soft Skills and Personality	4 Hrs / Week	8	2	IIT, Kanpur	Prof. T. Ravichandran	https://nptel.ac.in/courses/109104107
2	Folk and Minor Art in India	4 Hrs / Week	8	2	IIT, Kanpur	Prof. Shatarupa Thakurta Roy	https://nptel.ac.in/courses/109104106
3	Sustainable Happiness	4 Hrs / Week	8	2	IIT, Kharagpur	Prof. Atasi Mohanty	https://nptel.ac.in/courses/109105493
4	Soft Skill Development	4 Hrs / Week	8	2	IIT, Kharagpur	Prof. Priyadarshi Patnaik, Prof. V. N. Giri, Prof. D. Suar	https://nptel.ac.in/courses/109105110
5	Introduction to Market Structures	4 Hrs / Week	12	3	IIT, Guwahati	Prof. Amarjyoti Mahanta	https://nptel.ac.in/courses/109103187
6	Human Resource Development	4 Hrs / Week	12	3	IIT, Kharagpur	Prof. KBL Srivastava	https://nptel.ac.in/courses/109105121
7	Educational Leadership	4 Hrs / Week	12	3	IIT, Kharagpur	Prof. Atasi Mohanty	https://nptel.ac.in/courses/109105122

List of Open Electives for Faculty of Architecture and Planning

Sr. No.	Course Name	Teaching Scheme	Duration (Weeks)	Credits	Institute Offering Course	Name of Professor / Resource person	Link
1	Architectural Approaches to Decarbonization of Buildings	4 Hrs / Week	12	3	School of Planning and Architecture, Vijayawada, An Institute of National Importance under the Ministry of Education Govt. of India	Prof. Iyer Vijayalaxmi Kasinath	https://nptel.ac.in/courses/124106454
2	Building Materials and Composites	4 Hrs / Week	8	2	IIT, Kharagpur	Prof. Sumana Gupta	https://nptel.ac.in/courses/124105013
3	Building Materials as a Cornerstone to Sustainability	4 Hrs / Week	12	3	School of Planning and Architecture, Vijayawada, An Institute of National Importance under the Ministry of Education Govt. of India	Prof. Iyer Vijayalaxmi Kasinath	https://nptel.ac.in/courses/124106455
4	Modern Indian Architecture	4 Hrs / Week	8	2	IIT, Roorkee	Prof. P. S. Chani	https://nptel.ac.in/courses/124107161

List of Open Electives for Faculty of Science

Sr. No.	Course Name	Teaching Scheme	Duration (Weeks)	Credits	Institute Offering Course	Name of Professor / Resource Person	Link
1	Quantum Computing	4 Hrs / Week	12	3	IIT, Kanpur	Prof. Debabrata Goswami	https://onlinecourses.nptel.ac.in/noc19_cy31/preview#:~:text=Building%20up%20on%20the%20digital,the%20laws%20of%20quantum%20mechanics.
2	Introduction to Quantum Computing: Quantum Algorithms and Qiskit	4 Hrs / Week	4	1	IIT Madras, IBM Research, IBM Systems	Prof. Prabha Mandayam, Prof. Anupama Ray, Prof. Sheshashayee Raghunathan	https://onlinecourses.nptel.ac.in/noc24_cs67/preview
3	Quantum Information and Computing	4 Hrs / Week	8	2	IIT, Bombay	Prof. Dipan Ghosh Department of Physics	https://archive.nptel.ac.in/courses/115/101/115101092/
4	Dynamics of Classical and Quantum Fields	4 Hrs / Week	12	3	IIT, Guwahati	Prof. Girish S. Setlur	https://onlinecourses.nptel.ac.in/noc22_ph29/preview

Teaching Scheme		Semester III Engineering Mathematics - III	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Able to comprehend the fundamental knowledge of the Laplace and inverse Laplace transforms and their derivatives for elementary functions	MSE	20
CR	3	2. Able to apply the properties of Laplace and inverse Laplace transforms to solve simultaneous linear and linear differential equations with constant coefficients.	ESE	60
		3. Able to conceptualize the definitions and properties of Fourier transforms and to solve boundary value problems using Fourier transforms.		
		4. Able to find the solutions of partial differential equations governing real-world problems.		
		5. Able to conceptualize limit, continuity, derivative and integration of complex functions, complex integrals useful in real-world problems.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Laplace Transform:** Definition – conditions for existence; Transforms of elementary functions; Properties of Laplace transforms - Linearity property, first shifting property, second shifting property, transforms of functions multiplied by t^n, scale change property, transforms of functions divided by t, transforms of integral of functions, transforms of derivatives; Evaluation of integrals by using Laplace transform; Transforms of some special functions- periodic function, Heaviside-unit step function, Dirac delta function.	07 Hrs
2	**Inverse Laplace Transform:** Introductory remarks; Inverse transforms of some elementary functions; General methods of finding inverse transforms; Partial fraction method and Convolution Theorem for finding inverse Laplace transforms; Applications to find the solutions of linear differential equations and simultaneous linear differential equations with constant coefficients.	07 Hrs
3	**Fourier Transform:** Definitions – integral transforms; Fourier integral theorem (without proof); Fourier sine and cosine integrals; Complex form of Fourier integrals; Fourier sine and cosine transforms; Properties of Fourier transforms; Parseval's identity for Fourier Transforms.	07 Hrs
4	**Partial Differential Equations and Their Applications:** Formation of Partial differential equations by eliminating arbitrary constants and functions; heat Equations solvable by direct integration; Linear equations of first order (Lagrange's linear equations); Method of separation of variables – applications to find solutions of one-dimensional flow equation ($ie.\ \frac{\partial u}{\partial t} = C^2 \frac{\partial^2 u}{\partial t^2}$), and one-dimensional wave equation ($ie.\ \frac{\partial^2 y}{\partial t^2} = C^2 \frac{\partial^2 y}{\partial x^2}$).	07 Hrs

5 **Functions of Complex Variables:** Analytic functions; Cauchy-Riemann equations in Cartesian and polar forms; Harmonic functions in Cartesian form; Cauchy's integral theorem; Cauchy's integral formula; Residues; Cauchy's residue theorem (All theorems without proofs). 07 Hrs

Text Books:

1. Higher Engineering Mathematics by B. S. Grewal, Khanna Publishers, New Delhi.
2. Higher Engineering Mathematics by H. K. Das and Er. Rajnish Verma, S. Chand & Co. Pvt. Ltd., New Delhi.
3. Higher Engineering Mathematics by B. V. Ramana, Tata McGraw-Hill Publications, New Delhi.

Reference Books:

1. Advanced Engineering Mathematics by Erwin Kreyszig, John Wiley & Sons, New York.
2. A Text Book of Engineering Mathematics by Peter O' Neil, Thomson Asia Pte Ltd., Singapore.
3. Advanced Engineering Mathematics by C. R. Wylie & L. C. Barrett, McGraw-Hill Publishing Company Ltd., New Delhi.
4. Integral Transforms by I. N. Sneddon, Tata McGraw-Hill , New York.

Teaching Scheme		Semester III Discrete Mathematics	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Apply principles of propositional and predicate logic to model, analyze, and validate logical arguments using truth tables, standard forms, rules of inference, and quantifiers.	MSE	20
CR	3	2. Use set theory, functions, and relations to represent, manipulate, and reason about mathematical structures and their properties.	ESE	60
		3. Solve combinatorial problems using counting principles, recurrence relations, and graph theory concepts, including paths, connectivity, colouring, and spanning trees.		
		4. Implement algorithms for graph and tree problems such as shortest paths, minimal spanning trees, Huffman coding, and topological sorting.		
		5. Analyse and apply algebraic structures, including groups, rings, fields, and Boolean algebras, to formulate and solve problems in computer science and related domains.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to Propositional Logic:** Propositions, truth values, Truth tables for operators, Truth Tables of Compound Propositions, Precedence of Logical Operators. **Propositional Equivalences:** Logical Equivalences, Constructing New Logical Equivalences, Normal Forms. **Predicates and Quantifiers:** Predicates, Quantifiers: Universal and Existential, Quantifiers with Restricted Domains, Precedence of Quantifiers, Binding Variables, Logical Equivalences Involving Quantifiers, Negating Quantified Expressions, Translating from English into Logical Expressions, Examples from Lewis Carroll, Nested Quantifiers: Understanding Statements Involving Nested Quantifiers, The Order of Quantifiers, Negating Nested Quantifiers. **Rules of Inference:** Valid Arguments in Propositional Logic, Rules of Inference for Propositional Logic, Using Rules of Inference to Build Arguments, Resolution, Fallacies.	09 Hrs
2	**Basic notions in set Theory:** Sets, Venn Diagrams, Subsets, The Size of a Set, Power Sets, Cartesian Products, Set operations, Set Identities, Generalized Unions and Intersections, Cardinality of Sets. **Functions:** Introduction, Subjective, Injective, Bijective, inverse functions, Composition of functions. **Relations:** Relations and Their Properties, n-ary Relations and Their Applications, Representing Relations, Closures of Relations, Equivalence Relations, Equivalence classes and partitions, Partial Ordering, Hasse Diagram, Topological Sort.	09 Hrs
3	**Combinatorics:** Applications of Recurrence Relations, Solving Linear Recurrence Relations.	07 Hrs

4	**Graph:** Some Special Simple Graphs, Bipartite Graphs, New Graphs from Old, Shortest path problems, Euler and Hamiltonian paths, Isomorphic graphs, Planar graphs, Connectivity, Matching Coloring. **Trees:** Prefix Codes, Huffman coding, Spanning trees and cut sets, Minimal spanning trees, Kruskal's and Prim's algorithms for minimal spanning trees.	07 Hrs
5	**Algebraic Structures and Morphism:** Algebraic Structures with one Binary Operation, Semi Groups, Monoids, Groups, Congruence Relation and Quotient Structures, Free and Cyclic Monoids and Groups, Permutation Groups, Substructures, Normal Subgroups, Algebraic Structures with two Binary Operation, Rings, Integral Domain and Fields, Boolean Algebra and Boolean Ring.	05 Hrs

Text Books:

1. C. L. Liu, Elements of Discrete Mathematics, McGraw-Hill Publication, 3rd Edition, 2008.

Reference Books:

1. Lipschutz, Discrete Mathematics, McGraw-Hill Publication, 3rd Edition, 2009.
2. V. K. Balakrishnan, Schaum's Outline of Graph Theory, McGraw-Hill Publication, 1st Edition, 1997.
3. Eric Gossett, Discrete Mathematics with Proof, Wiley Publication, 2nd Edition, 2009.
4. Kenneth H. Rosen, Discrete Mathematics and its Applications, McGraw-Hill Publication, 6th Edition, 2010.
5. Y. N. Singh, Discrete Mathematical Structures, Wiley Publication, 1st Edition, 2010.
6. Dr. Sukhendu Dey, Graph Theory with Applications, SPD Publication, 1st Edition, 2012.

Teaching Scheme		Semester III Data Structures	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Explain fundamental concepts of data, data types, data structures, and Abstract Data Types (ADT), and analyse algorithms in terms of time and space complexity.	MSE	20
CR	3	2. Solve computational problems by applying appropriate data structures such as arrays, hash tables, stacks, queues, and linked lists.	ESE	60
		3. Implement tree and graph data structures, including binary trees, binary search trees, heaps, and adjacency matrix representations, and perform related operations and traversals.		
		4. Demonstrate proficiency in searching and sorting algorithms, including sequential, binary search, skip lists, insertion sort, selection sort, and radix sort, along with file handling techniques.		
		5. Select and implement suitable data structures and algorithms to develop efficient, maintainable, scalable software solutions.		

COURSE CONTENT

Unit No.	Topic	Hours
1	Data, Data types, Data structure, Abstract Data Type (ADT), representation of Information, characteristics of algorithm, program, analyzing programs. **Arrays and Hash Tables:** Concept of sequential organization, linear and non-linear data structures, storage representation, array processing, sparse matrices, transpose of sparse matrices, Hash Tables, Direct address tables, Hash tables, Hash functions, Open addressing, Perfect hashing.	06 Hrs
2	**Stacks and Queues:** Introduction, stack and queue as ADT, representation and implementation of stack and queue using sequential and linked allocation, Circular queue and its implementation, Application of stack for expression evaluation and expression conversion, recursion, priority queue.	06 Hrs
3	**Linked Lists:** Concept of linked organization, singly and doubly linked list, and dynamic storage management, circular linked list, operations such as insertion, deletion, concatenation, traversal of linked list, dynamic memory management, garbage collection.	06 Hrs
4	**Trees and Graphs:** Basic terminology, binary trees and their representation, insertion and deletion of nodes in binary trees, binary search tree and its traversal, threaded binary tree, Heap, Balanced Trees, Terminology and representation of graphs using adjacency matrix, Warshall's algorithm.	06 Hrs
5	**Searching and Sorting:** Sequential, binary searching, skip lists – dictionaries, linear list representation, skip list representation, operations – insertion, deletion, and searching. Insertion sort, selection sort, radix sort, and File handling.	06 Hrs

Reference Books:

1. Horowitz and Sahani, Fundamentals of Data Structures, Universities Press, 2nd Edition, 2008.
2. Thomas Cormen, Introduction to Algorithms, PHI Publication, 2nd Edition, 2002.
3. Venkatesan & Rose, Data Structures, Wiley Publication, 1st Edition, 2015.
4. Goodrich & Tamassia, Data Structures & Algorithms in C++, Wiley Publication, 2nd Edition, 2011.
5. R. G. Dromey, How to Solve it by Computer, 2nd Impression, Pearson Education.
6. Kyle Loudon, Mastering Algorithms with C: Useful Techniques from Sorting to Encryption, O'Reilly Media, 1st Edition, 1999.

Text Books:

1. Mark Allen Weiss, Data structures and algorithms analysis in C++, Pearson Education, 4th Edition, 2013.
2. S. Lipschutz, Data Structures, McGraw-Hill Publication, Revised 1st Edition, 2014.
3. Y. Langsm, M. Augenstin, A. Tanenbaum, Data Structures using C and C++, Prentice Hall India Learning Private Limited, 2nd Edition, 1998.
4. Trembley and Sorenson, Introduction to Data Structures, PHI Publication, 2nd Revised Edition, 1983.
5. Vishal Goyal, Lalit Goyal, A Simplified Approach To Data Structure, SPD Publication, 1st Edition, 2014.

Teaching Scheme		Semester III Artificial Intelligence	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-	1. Explain the foundations, history, and scope of artificial intelligence, and describe the structure and behavior of intelligent agents in various environments.	MSE	20
CR	2	2. Apply problem-solving techniques, including uninformed, informed, and adversarial search strategies, to develop optimal solutions for well-defined problems.	ESE	60
		3. Represent and reason with knowledge using predicate logic, rules, and inference methods, and apply these to solve reasoning problems.		
		4. Implement probabilistic reasoning, planning techniques, and natural language processing methods to handle uncertainty and language-based tasks.		
		5. Apply machine learning approaches, including decision trees, neural networks, genetic algorithms, and expert system design, to develop intelligent applications.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction:** What Is AI? The Foundations of Artificial Intelligence, the History of Artificial Intelligence, the State of the Art. Intelligent Agents: Agents and Environments Good Behavior: The Concept of Rationality, The Nature of Environments, The Structure of Agents.	04 Hrs
2	**Problem-solving**: Solving Problems by Searching, Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Heuristic Functions, Defining Constraint Satisfaction Problems, Constraint Propagation: Inference in CSPs, Backtracking Search for CSPs, Local Search for CSPs, The Structure of Problems. Adversarial Search, Games, Optimal Decisions in Games, Alpha–Beta Pruning.	07 Hrs
3	**Knowledge & Reasoning:** Knowledge representation issues, Representation & mapping, Approaches to knowledge representation, Issues in knowledge representation. Using predicate logic: Representing simple facts in logic, Representing instant & ISA relationship, Computable functions & predicates, Resolution, Natural deduction. Representing knowledge using rules: Procedural verses declarative knowledge, Logic programming, Forward verses backward reasoning, Matching, Control knowledge.	07 Hrs
4	**Probabilistic Reasoning:** Representing knowledge in an uncertain domain, The semantics of Bayesian networks, Dempster-Shafer theory, Fuzzy sets &	04 Hrs

fuzzy logics, Planning: Overview, Components of a planning system, Goal stack planning, Hierarchical planning and other planning techniques.

Text / Reference Books:

1. Rich, E. and Knight K.: Artificial Intelligence, Tata McGraw- Hill
2. Peter Norvig, Artificial Intelligence: A Modern Approach, Third Edition.
3. Ivan Bratko, Prolog Programming for Artificial Intelligence, Addison-Wesley.

Teaching Scheme		Semester III Prompt Engineering	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-	1. Explain the evolution of NLP to large language models, their architecture, and the role of prompt engineering in AI/ML applications.	MSE	20
CR	2	2. Design and evaluate effective prompts using various prompting types, patterns, and debugging techniques.	ESE	60
		3. Apply advanced prompting methods, including Chain-of-Thought, ReAct, and multimodal prompting, using tools such as LangChain and OpenAI SDK.		
		4. Develop domain-specific prompts for tasks such as coding assistance, conversational agents, and data analysis, including low-resource language applications.		
		5. Assess prompt safety, bias, and ethical considerations, and implement best practices for secure and responsible LLM usage.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to Prompt Engineering & LLMs:** Evolution of NLP to Large Language Models, Anatomy of LLMs: Tokens, embeddings, context windows, Why prompt engineering matters, Prompt engineering applications in AI/ML systems, Introduction to GPT, Claude, PaLM, Mistral, etc., Prompting vs fine-tuning.	04 Hrs
2	**Foundations of Prompt Design:** Types of prompting: Zero-shot, One-shot, Few-shot, Prompt patterns: Instructional, Delimiting, Role-based, Socratic, Prompt evaluation metrics: accuracy, relevance, hallucination, safety, Prompt debugging techniques. **Advanced Prompting Techniques:** Chain-of-Thought Prompting, Self-Ask Prompting, ReAct (Reason + Act) prompting, Multimodal prompting (text + image), Prompt templates using Python APIs (LangChain, OpenAI SDK).	04 Hrs
3	**Prompt Engineering for Domain-Specific Tasks:** Coding assistance and code generation prompts, Conversational agents and dialogue design, Legal, educational, medical prompts, Data wrangling and analysis via prompting, Prompting in low-resource languages.	04 Hrs
4	**Prompt Safety, Bias, and Ethics:** Bias, toxicity, misinformation in model outputs, Adversarial prompting and jailbreak attempts, Safety best practices in prompt design, Evaluation frameworks (BLEU, ROUGE, BERTScore, human evals), Future directions: function calling, tool use, retrieval-augmented generation (RAG)	04 Hrs

Text/Reference Books:

1. "The Art of Prompt Engineering with OpenAI APIs" by Nathan Hunter.
2. "Prompt Engineering for Everyone" by Isa Fulford & Andrew Ng (DeepLearning.AI short course).
3. "Building AI Applications with OpenAI API" by Yash Sheth.

Teaching Scheme		Semester III Introduction to Python	Examination Scheme	
TH	-	**Course Objectives:** 1. Demonstrate the ability to set up a Python programming environment and execute basic programs using the Python interpreter. 2. Apply variables, operators, control structures, and functions to implement program logic and modular solutions. 3. Manipulate strings, handle exceptions, perform basic input/output operations, and work with files in Python. 4. Implement object-oriented programming concepts and use Python data structures such as lists, tuples, sets, and dictionaries for problem solving. 5. Integrate Python programs with databases using SQL, including creating, querying, and joining tables to manage structured data.	CA	-
PR	-		MSE	-
CR	-		ESE	-

COURSE CONTENT

Unit No.	Topic	Hours
1	Informal introduction to programming, algorithms and data structures, downloading and installing Python, run a simple program on Python interpreter.	02 Hrs
2	Variables, operations, control flow – assignments, conditionals, loops, functions: optional arguments, default values, passing functions as arguments.	02 Hrs
3	Statements, Expressions, Strings: String processing. Exception handling, Basic input/output, handling files.	02 Hrs
4	Class and Object, Data Structure: List, Tuple and Sequences, Set, Dictionaries.	04 Hrs
5	Using Database and Structured Query Languages (SQL): SQLite manager, Spidering Twitter using a Database, Programming with multiple tables, JOIN to retrieve data.	04 Hrs

Text/Reference Books:

1. Michael Urban and Joel Murach, Murach‘s Python Programming, Murach's Publication, 2016
2. Charles Severance, Python for Informatics: Exploring Information, University of Michigan, Version 2.7.0, 2014.
3. Dr. R. Nageswara Rao, Core Python Programming, Dreamtech Press, 1st Edition, 2016.
4. Mark Lutz, Learning Python, O'Reilly Media, 5th Edition, 2013.
5. Mark Pilgrim, Dive into Python 3, A press Publication, 2nd Edition, 2009.
6. Allen B. Downey, Think Python, O'Reilly Media, 2nd Edition, 2012.
7. Jon Kleinberg and Eva Tardos, Algorithm Design, Pearson Education, 1st Edition, 2006.

Teaching Scheme		Semester III Life of Chhatrapati Shivaji Maharaj	Examination Scheme	
TH	1	**Course Objectives:** 1. Analyse Shivaji Maharaj's military strategies, including guerrilla warfare, fortress defence, naval power, and intelligence networks, in historical and tactical contexts. 2. Evaluate Shivaji Maharaj's leadership, management practices, and innovations in logistics, fortifications, and military technology. 3. Interpret Shivaji Maharaj's views on women's rights, religious tolerance, democracy, and nationalism, and relate them to contemporary socio-political values.	CA	50
PR	-		MSE	-
CR	1		ESE	-

COURSE CONTENT

Unit No.	Topic	Hours
1	Shivaji Maharaj as a Great Conqueror, Master Strategist and innovator in Military Tactics Guerrilla Warfare (Ganimi Kava), Fortress Strategy, Avoidance of Direct Confrontation, Diplomacy and Alliances, Naval Power.	05 Hrs
2	Shivaji Maharaj's Management and leadership strategies, Architecture and metallurgy of Raigad Fort, Use of Light Cavalry, Intelligence Network, Asymmetric Warfare, Logistics and Supply Chains, Fortifications and Military Architecture	05 Hrs
3	Shivaji Maharaj's views about Women's rights, their dignity and religious views. His views on Democracy & Nationalism	05 Hrs

Teaching Scheme		Semester III Data Structure and Python Programming Laboratory	Examination Scheme	
TH	1		CA	60
PR	4		MSE	–
CR	3		ESE	40

List of Experiments (Data Structures):

1. Write a program to implement a stack using arrays.
2. Write a program to implement a circular queue using arrays.
3. Write programs to implement the following data structures: (a) Single linked list, (b) Double linked list, (c) Circular linked list
4. Write a program to implement a stack using a linked list such that the push and pop operations of the stack still take O (1) time.
5. Write a program to create a binary search tree (BST) by considering the keys in given order and perform the following operations on it. (a) Minimum key (b), Maximum key, (c) Search for a given key, (d) Find predecessor of a node, (e) Find successor of a node, (f) Delete a node with given key.
6. Write a program to implement hashing with (a) Separate Chaining and (b) Open addressing methods.
7. Implement the following sorting algorithms: (a) Insertion sort, (b) Merge sort, (c) Quick sort, (d) Heap sort.

List of Experiments (Python Programming):

1. Program to calculate the area of triangle, rectangle, circle.
2. Program to find the union of two lists.
3. Program to find the intersection of two lists.
4. Program to remove the —i‖ th occurrence of the given word in a list where words repeat.
5. Program to count the occurrences of each word in a given string sentence.
6. Program to check if a substring is present in a given string.
7. Program to map two lists into a dictionary.
8. Program to count the frequency of words appearing in a string using a dictionary.
9. Program to create a dictionary with key as first character and value as words starting with that character.
10. Program to find the length of a list using recursion.
11. Write a Program to compute the diameter, circumference, and volume of a sphere using class.
12. Program to read a file and capitalize the first letter of every word in the file.

Teaching Scheme		Semester III Universal Human Values - II	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Explain the concept of value education, self-exploration, and the relationship between happiness, prosperity, and basic human aspirations.	MSE	20
CR	3	2. Distinguish between the needs of the self and the body, and apply methods to achieve harmony within the individual and between the self and the body.	ESE	60
		3. Demonstrate understanding of harmony in the family and society by applying foundational values such as trust and respect in human relationships.		
		4. Analyse the interconnectedness and mutual fulfilment among the four orders of nature and relate it to sustainable living and coexistence.		
		5. Apply a holistic understanding of human values to professional ethics, decision-making, and strategies for value-based life and profession.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to Value Education:** Understanding Value Education, Self-exploration as the Process for Value Education, Continuous Happiness and Prosperity, the Basic Human Aspirations, Right Understanding, Relationship and Physical Facility, Happiness and Prosperity, Current Scenario, Method to Fulfill the Basic Human Aspirations.	05 Hrs
2	**Harmony in the Human Being:** Understanding Human being as the Co-existence of the Self and the Body, Distinguishing between the Needs of the Self and the Body, The Body as an Instrument of the Self, Understanding Harmony in the Self, Harmony of the Self with the Body, Programme to Ensure self-regulation and Health.	05 Hrs
3	**Harmony in the Family and Society:** Harmony in the Family, the Basic Unit of Human Interaction, Values in Human-to-Human Relationship, 'Trust' – the Foundational Value in Relationship, 'Respect' – as the Right Evaluation, Understanding Harmony in the Society, Vision for the Universal Human Order	04 Hrs
4	**Harmony in the Nature (Existence):** Understanding Harmony in the Nature, Interconnectedness, self-regulation and Mutual Fulfillment among the Four Orders of Nature, Realizing Existence as Co-existence at All Levels, The Holistic Perception of Harmony in Existence.	05 Hrs
5	Implications of the Holistic Understanding – a Look at Professional Ethics: Natural Acceptance of Human Values, Definitiveness of (Ethical) Human Conduct, A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order, Competence in Professional Ethics- Holistic Technologies, Production Systems and Management Models-Typical Case Studies, Strategies for Transition towards Value-based Life and Profession	05 Hrs

Text Books:

1. 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.

Reference Books:

1. Jeevan Vidya: Ek Parichaya, 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 Karamchand Gandhi
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - Pandit Sunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

Teaching Scheme		Semester III Artificial Intelligence Laboratory	Examination Scheme	
TH	-		CA	60
PR	2		MSE	–
CR	1		ESE	40

List of Experiments:

1. Study of Lisp/ PROLOG.
2. Existing AI Application (e.g. Recommendation system, Carpooling, OTT channels etc.)
3. Solve any problem using depth first search.
4. Solve any problem using breadth first search.
5. Solve an 8-puzzle problem using the best first search.
6. Write a program to solve Tic-Tac-Toe using Min-Max search.
7. Solve traveling salesman problems.
8. Write a program for Alpha–Beta Pruning.
9. Write a program to solve 8 queens problems.
10. Write a program to solve map coloring problems using CSP.

Semester - IV

Teaching Scheme		Semester IV Introduction to Operating Systems	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Explain the structure, components, and types of operating systems, including process, memory, file, and I/O management.	MSE	20
CR	3	2. Apply CPU scheduling algorithms and multithreading models to improve process performance and system throughput.	ESE	60
		3. Implement process synchronization techniques, and analyze deadlock conditions with appropriate prevention, avoidance, and recovery strategies.		
		4. Evaluate memory management schemes, including paging, segmentation, and virtual memory, using various page replacement algorithms.		
		5. Analyze file system organization, storage allocation methods, and disk scheduling techniques for efficiency and reliability.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction and Operating System Structures:** Definition, Types of Operating system, Real-Time Operating Systems, System Components: System Services, Systems Calls, System Programs, System Structure, Virtual Machines, System Design and Implementation, System Generations.	06 Hrs
2	**Processes and CPU Scheduling:** Process Concept, Process Scheduling, Operation on process, Inter-process Communication, Cooperating processes, Threads, Multithreading model, Scheduling criteria, Scheduling Algorithms, Thread Scheduling, Multiple-Processor Scheduling, Scheduling Algorithms evaluation.	06 Hrs
3	**Process Synchronization:** The critical-section problem, Critical regions, Peterson‘s Solution, Synchronization Hardware, Semaphores, Classical Problems of synchronization, and Monitors Deadlocks: Systems Model, Deadlock characterization, Methods for handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Recovery from Deadlock, Combined approach to deadlock Handling.	06 Hrs
4	**Memory Management:** Basic concept, Logical and Physical address map, Memory allocation: Continuous Memory Allocation, Fixed and variable partition, Internal and external fragmentation and compaction, Paging: Principle of operation, Page allocation – Hardware support for paging, Protection and sharing, Disadvantages of paging; Segmentation. Virtual Memory: Basics of Virtual Memory – Hardware and control structures – Locality of reference, Page fault, Working Set, Dirty page / Dirty bit – Demand paging, Page Replacement algorithms: Optimal, First in First Out (FIFO), Second Chance (SC), Not recently used (NRU) and Least Recently used (LRU).	10 Hrs

5	**File Management:** File Concept, Access methods, File types, File operation, Directory and disk structure, File System Structure, File System Implementation, Allocation methods (contiguous, linked, indexed), Free-space management (bit vector, linked list, grouping), directory implementation (linear list, hash table), efficiency and performance. Mass-Storage Structure: Disk Structure, Disk attachment, Disk scheduling, Disk management, Swap Space Management.	08 Hrs

Text/Reference Books:

1. Abraham Silberschatz, Peter B. Galvin and Greg Gagne, Operating System Concepts, Wiley Publication, 8th Edition, 2008.
2. Andrew S. Tanenbaum, Modern Operating System, PHI Publication, 4th Edition, 2015.
3. D. M. Dhamdhere, Systems Programming and Operating Systems, McGraw-Hill, 2nd Edition, 1996.
4. Garry Nutt, Operating Systems Concepts, Pearson Publication, 3rd Edition, 2003.
5. Harvey M. Deitel, An Introduction to Operating Systems, Addison Wesley Publication, 2nd Edition, 1990.
6. Thomas W. Doeppner, Operating System in Depth: Design and Programming, Wiley Publication, 2011.

Teaching Scheme		Semester IV Data Analytics	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Apply statistical concepts and methods for data collection, preparation, cleaning, and exploratory data analysis, addressing bias and errors.	MSE	20
CR	3	2. Compute and interpret descriptive statistics, measures of central tendency, spread, and distribution shape to summarize datasets.	ESE	60
		3. Perform data transformation and standardization techniques to prepare data for statistical modeling and hypothesis testing.		
		4. Conduct classical statistical tests, including Z-tests, t-tests, ANOVA, and non-parametric tests, to analyze and compare datasets.		
		5. Interpret the results of statistical analyses, assess significance, and evaluate model robustness and validity for data-driven decision-making.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Statistical Data and Concepts:** The statistical Methods, Misuse, Misinterpretation, and bias, Sampling and sampling size, Data preparation and cleaning, Missing data and data errors, Exploratory Data Analysis, Statistical error, Statistical Modeling, Computational Statistics, Inference, Bias, Cofounding, Hypothesis testing, Types of error, Statistical significance, Confidence Interval, Power and robustness, Degrees of freedom, Non parametric analysis.	07 Hrs
2	**Descriptive Statistics:** Counts and specific values, Measure of central tendency, Measure of spread, Measure of distribution shape, Statistical indices, Moments, Key functions, Measures of complexity and model selection.	05Hrs
3	**Data Transformation and Standardization:** Box-Cox and power transforms, Freeman-Tukey (square root and arcsine) transforms, Log and Exponential transforms, Logit transforms, Normal transform.	05 Hrs
4	**Classical Tests and Contingency Tables:** Goodness of fit tests: Anderson-Darling, Chi-square test, Kolmogorov-Smirnov, Ryan-Joiner, Shapiro-Wilk, Jarque-Bera, Lilliefors. **Z-test:** Test of single mean, standard deviation known, Test of the difference between two means, standard deviation known, test for proportions. **T-tests:** Test of single mean, standard deviation not known, Test of the difference between two means, standard deviation not known, Test of regression coefficients	07 Hrs

5 **Analysis of Variance and Covariance** 07 Hrs

Variance test: Chi square test of single variable, F-test of two variables, test of homogeneity; Wilcoxon rank-sum/Mann-Whitney U test; Sign test.

Contingency Tables: Chi-square contingency table test, G contingency table test, Fisher's exact test, Measures of association, McNemar's test.

ANOVA: Single factor or one way ANOVA, Two factor or two-way and higher-way ANOVA, MANOVA, ANCOVA; Non Parametric ANOVA: Kruskal Wallis ANOVA, Friedam ANOVA test, Mood's median.

Text/Reference Books:

1. Dr. Michael J de Smith, Statistical Analysis Handbook: A Comprehensive Guide to Statistical Concepts, Methods and Tools, The Winchelsea Press, Drumlin Security Ltd, Edinburgh, 2018 edition. https://www.statsref.com/HTML/index.html
2. Douglas C. Montgomery, George C. Runger, Applied Statistics and Probability for Engineers, Sixth Edition, Wiley, 2013.
3. Dr.J.Ravichandran, Probability And Statistics For Engineers, First Edition, Wiley, 2010.
4. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. V2.1, Cambridge University Press. 2014. (free online)
5. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective. ISBN 0262018020, 2013.
6. Foster Provost and Tom Fawcett. Data Science for Business: What You Need to Know about Data Mining and Data-analytic Thinking. ISBN 1449361323. 2013.
7. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline, O'Reilly. 2014.

Teaching Scheme		Semester IV Probability and Statistics	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. To explain basic concepts in statistics and probability. 2. To describe various probabilistic distributions.	MSE	20
CR	3	3. To apply regression and correlation techniques.	ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**Probability Theory** Definition of probability: classical, empirical, and axiomatic approach of probability, Addition theorem of probability, Multiplication theorem of probability, Bayes' theorem of inverse probability, Properties of probabilities with proofs, Examples.	10 Hrs
2	**Random Variable and Mathematical Expectation:** Random variables, Probability distributions, Probability mass function, Probability density function, Mathematical expectation, Join and marginal probability distributions, Properties of expectation and variance with proofs.	06 Hrs
3	**Theoretical Probability Distributions:** Binomial distribution, Poisson distribution, Normal distribution, Fitting of binomial distributions, Properties of binomial, Poisson, and normal distributions, Relation between binomial and normal distributions, Relation between Poisson and normal distributions, Importance of normal distribution, Examples.	10 Hrs
4	**Correlation:** Introduction, Types of correlation, Correlation and causation, Methods of studying correlation, Karl Pearson's correlation coefficient, Spearman's rank correlation, Coefficient, Properties of Karl Pearson's correlation coefficient and Spearman's rank correlation coefficient, Probable errors.	06 Hrs
5	**Linear Regression Analysis:** Introduction, Linear and non-linear regression, Lines of regression, Derivation of regression lines of y on x and x on y, Angle between the regression lines, Coefficients of regression, Theorems on regression coefficient, Properties of regression coefficient.	06 Hrs

Text Books:

1. S. C. Gupta, Fundamentals of Statistics, Himalaya Publishing House, 7th Revised and Enlarged Edition, 2016.
2. G. V. Kumbhojkar; Probability and Random Processes, C. Jamnadas and Co., 14th Edition, 2010.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

4. Veerarajan T., Engineering Mathematics, Tata McGraw-Hill, New Delhi, 2010.
5. G. Haribaskaran; Probability, Queuing Theory and Reliability Engineering, Laxmi Publications, 2nd Edition, 2009.
6. Murray Spiegel, John Schiller, R. ALU Srinivasan, Probability And Statistics, Schaum's Outlines, 4th Edition, 2013.

Teaching Scheme		Semester IV Constitution of India	Examination Scheme	
TH	2	**Course Objectives:**	CA	60
PR	-	1. Explain the historical background, sources, features, and key provisions of the Indian Constitution, including citizenship, fundamental rights, duties, and directive principles.	MSE	-
CR	AU	2. Describe the structure, roles, and functions of the Union and State governments, and analyze the relationship between the Centre and States.	ESE	40
		3. Interpret the organization and functioning of local self-government institutions and evaluate their role in strengthening grassroots democracy.		
		4. Analyze the functions of the Election Commission and other constitutional bodies related to the welfare of marginalized communities and women.		

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction:** Constitution' meaning of the term, Indian Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive, Principles of State Policy.	05 Hrs
2	**Union Government and its Administration:** Structure of the Indian Union: Federalism, Centre- State, relationship, President: Role, power and position, PM and Council of ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha.	05 Hrs
3	**State Government and its Administration** Governor: Role and Position, CM and Council of Ministers, State Secretariat: Organisation, Structure and Functions.	04 Hrs
4	**Local Administration:** District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation, Pachayati Raj: Introduction, PRI: Zila Pachayat, Elected officials and their roles, CEO Zila Pachayat: Position and role, Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.	05 Hrs
5	**Election Commission:** Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners, State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.	05 Hrs

Text/Reference Books:

1. Sastry, T. S. N., (2005). India and Human Rights: Reflections, Concept Publishing Company India (P Ltd.).
2. Nirmal, C.J., (1999). Human Rights in India: Historical, Social and Political Perspectives (Law in India), Oxford India.

Teaching Scheme		Semester IV Life of Bharat Ratna Dr. Babasaheb Ambedkar	Examination Scheme	
TH	1	**Course Objectives:**	CA	50
PR	-	1. Analyze the socio-political context of Dr. Ambedkar's era and his role in the Indian freedom struggle and social reform movements.	MSE	-
CR	1	2. Evaluate Dr. Ambedkar's contributions to the framing of the Indian Constitution and his vision for social justice and empowerment.	ESE	-
		3. Interpret Dr. Ambedkar's views on Marxism, class struggle, and caste, and assess their relevance to contemporary Indian society and economic policy.		

COURSE CONTENT

Unit No.	Topic	Hours
1	Introduction to the socio-political context of Ambedkar's era, British Colonialism, Indian National Movement, Caste Hierarchy, Untouchability, Social Reform Movements, Role in the Indian freedom struggle.	05 Hrs
2	Contributions to the Constitution of India, Vision for social justice and empowerment.	05 Hrs
3	Dr. Ambedkar and Marxism: An Exploration of His Thoughts on Marxism, Common ground with Marxism, Focus on class struggle, Caste vs. Caste, Primacy of Caste in Indian Society, Economic ideas and policies	05 Hrs

Teaching Scheme		Semester V Introduction to Operating System Laboratory	Examination Scheme	
TH	-		CA	40
PR	2		MSE	–
CR	1		ESE	60

List of Experiments:

1. Hands on Unix Commands
2. Shell programming for file handling.
3. Shell Script programming using the commands grep, awk, and sed.
4. Implementation of various CPU scheduling algorithms (FCFS, SJF, Priority).
5. Implementation of various page replacement algorithms (FIFO, Optimal, LRU).
6. Concurrent programming; use of threads and processes, system calls (fork and v-fork).
7. Study pthreads and implement the following: Write a program which shows the performance.
8. Improvement in using threads as compared with process.(Examples like Matrix Multiplication.
9. Hyper Quick Sort, Merge sort, Traveling Sales Person problem).
10. Implementation of Synchronization primitives – Semaphore, Locks and Conditional Variables.
11. Implementation of Producer-Consumer problem, Bankers algorithm.
12. Implementation of various memory allocation algorithms, (First fit, Best fit and Worst fit), Disk.
13. Scheduling algorithms (FCFS, SCAN, SSTF, C-SCAN).
14. Kernel reconfiguration, device drivers and systems administration of different operating systems.
15. Writing utilities and OS performance tuning.

Teaching Scheme		Semester IV Modern Indian Languages (A) Marathi	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	2		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**मराठीचा उगम आणि विकास:** मराठीचा उगम आणि विकास, मराठी भाषेवर संत परंपरेचा प्रभाव- ज्ञानेश्वर, तुकाराम, नामदेव आणि एकनाथ यांच्या रचनांचा अभ्यास, मराठीत बखरी लेखन व इतिहास दर्शन, आधुनिक मराठी आणि सुधारणा चळवळी- टिळक, फुले, आणि आगरकर यांचे योगदान.	02 Hrs
2	**स्वातंत्र्यानंतरची मराठी भाषा:** महाराष्ट्र राज्य निर्मिती व मराठीचा अधिकृत दर्जा, डिजिटल युगातील मराठी भाषा : ब्लॉग, सोशल मीडिया आणि ई-साहित्य, मराठी भाषा संरक्षणासाठी उपाययोजना, शिक्षण व्यवस्थेतील मराठीचा वापर, जागतिक स्तरावर मराठी भाषेचा प्रभाव.	02 Hrs
3	**मराठी लेखनाचे नियम आवण व्याकरण:** संधि, वाक्यप्रकार (विधानार्थी वाक्य, प्रश्नार्थी वाक्य, आज्ञार्थी वाक्य इ.), विरामचिन्हे आणि त्यांचे उपयोग, शुद्धलेखन, समानाथी शब्द (पर्यायवाची शब्द), विरुद्धाथी शब्द.	02 Hrs
4	**लेखन कौशल्य:** लेखन कौशल्याचा परिचय, लेखन कौशल्याचे महत्त्व आणि आवश्यकता ▪ पत्रलेखन ▪ निबंध लेखन ▪ वृत्तलेखन (वृत्तपत्रीय लेखन) ▪ इतिवृत्त लेखन ▪ सारांश लेखन	02 Hrs
5	**भाषांतर (मराठीतून इंग्रजी आणि इंग्रजीतून मराठी):** भाषांतराचा मूलभूत परिचय- भाषांतराची व्याख्या आणि स्वरूप, महत्त्व आणि उपयोग, भाषांतराचे प्रकार इ. ▪ पारिभातषक शब्दावली, मराठीतून इंग्रजी आणि इंग्रजीतून मराठी भाषांतर.	02 Hrs

Text / Reference Books:

1. प्रशासनिक लेखन, भाषा संचालनालय , महाराष्ट्र शासन, मुंबई १९६६
2. सुगम मराठी व्याकरण व लेखन - मो.रा. वाळंबे
3. "अनुवाद तसद्धांत आणि प्रयोग" – डॉ. भालचंद्र नेमाडे (लोकवाङ्मय गृह प्रकाशन)
4. मराठी भाषा आणि साहित्याचा इतिहास – वि.का. राजवाडे प्रकाशक : राजवाडे संशोधन मंडळ, धुळे
5. भाषांतर : सिद्धांत आणि प्रयोग – डॉ. अशोक केळकर प्रकाशक : लोकवाङ्मय गृह, मुंबई

Teaching Scheme		Semester IV Modern Indian Languages (B) Hindi	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	2		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**हिंदी भाषा का उद्भि और स्रोत:** ▪ हिंदी भाषा की उत्पत्ति और स्वरूप ▪ संस्कृत, प्राकृत और अपभ्रंश से हिंदी का विकास ▪ हिंदी की प्रमुख बोलियाँ (ब्रज, अवधी, खडी बोली, भोजपुरी, राजस्थानी आदी) ▪ हिंदी पर फारसी, अरबी और अंग्रेजी भाषा का प्रभाव.	02 Hrs
2	**स्वातंतंत्र्योत्तर काल में हिंदी भाषा** ▪ प्रशासन, शिक्षा और संचार माध्यमों में हिंदी की भूमिका ▪ राजभाषा के रूप में हिंदी – संवैधानिक स्थिति और व्यावहारिक उपयोग ▪ हिंदी का वैश्विक विस्तार और डिजिटल माध्यमों में हिंदी की उपस्थिति ▪ प्रशासन और संचार माध्यमों में हिंदी	02 Hrs
3	**हिंदी भाषा लेखन के नियम और व्याकरण** ▪ वणिमाला ▪ शब्द-भेद ▪ संधि ▪ वाक्य रचना ▪ वर्तनी ▪ उपसर्ग, प्रत्यय और शब्द निर्माण की प्रक्रिया ▪ विराम चिन्हों का प्रयोग ▪ पर्यायवाची शब्द ▪ विलोम शब्द.	02 Hrs
4	**लेखन कौशल** ▪ पत्र लेखन ▪ प्रतिवेदन (रिपोटि) लेखन ▪ विज्ञप्ति, नोटिस और परिपत्र लेखन निबंध लेखन ▪ सार लेखन.	02 Hrs
5	**अनुवाद (अंग्रेजी से हिंदी और हिंदी से अंग्रेजी)** अनुवाद : सिद्धांत और परंपरा, अनुवाद : क्षेत्र, प्रकार, पारिभाषीक शब्दावली, अंग्रेजी से हिंदी और हिंदी से अंग्रेजी अनुवाद	02 Hrs

Text / Reference Books:

1. "हिंदी भाषा का उद्भव और विकास" – डॉ. हरीशचंद्र वर्मा (लोकभारती प्रकाशन)
2. "हिंदी भाषा का इतिहास" – डॉ. रामविलास शर्मा (राजकमल प्रकाशन)
3. "भारत में राजभाषा हिंदी" – डॉ. विश्वनाथ प्रसाद (भारतीय राजभाषा पररषद)
4. "हिंदी व्याकरण और रचना" – डॉ. हरीशचंद्र वर्मा (लोकभारती प्रकाशन)
5. "हिंदी लेखन कौशल" – डॉ. रमेश गुप्ता (सातहत्य भवन)
6. "अनुवाद विज्ञान और सिद्धांत" – डॉ. ओमप्रकाश (राजकमल प्रकाशन)

Teaching Scheme		Semester IV Modern Indian Languages (C) Sanskrit	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	2		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to Sanskrit:** Importance and history of Sanskrit, Sanskrit alphabets (Varnamala), Swaras (Vowels), Vyanjanas (Consonants), Pronunciation and script (Devanagari).	02 Hrs
2	**Basic Grammar:** Nouns, pronouns, Grammatical numbers, Grammatical genders, Grammatical person, Verbs, Tenses, Sandhi (Combination of letters), Karaka (Case system) – Nominative, Accusative, Instrumental, etc., Vibhakti (Declensions of nouns and pronouns), Linga (Gender: Masculine, Feminine, Neuter), Vakya Rachana (Sentence construction).	02 Hrs
3	**Simple Vocabulary and Sentence Formation:** Basic words and their meanings (nature, family, animals, objects, etc.), Greetings and basic conversational phrases, Formation of simple sentences	02 Hrs
4	**Selected Sanskrit Shlokas and Subhashitas:** Recitation and meaning of simple verses from Bhagavad Gita, Hitopadesha, or Panchatantra, Common proverbs (Subhashitas)	02 Hrs
5	**Reading and Writing Practice:** Reading simple Sanskrit texts, Writing small paragraphs in Sanskrit	02 Hrs

Teaching Scheme		Semester IV Full Stack Development	Examination Scheme	
TH	1	**Course Objectives:**	CA	60
PR	2	1. Apply Bootstrap components, grid systems, and themes to design responsive and mobile-first web interfaces.	MSE	-
CR	2	2. Use JavaScript for DOM manipulation, event handling, string processing, and form validation to enhance user interaction.	ESE	40
		3. Implement interactive features using jQuery for effects, traversal, and AJAX-based asynchronous operations.		
		4. Develop server-side applications using PHP and MySQL for dynamic content generation, form handling, and database management.		
		5. Build and deploy complete full-stack applications using the Laravel MVC framework, integrating front-end, back-end, and database functionalities.		

COURSE CONTENT

Unit No.	Topic	Hours
1	Bootstrap: Introduction to Bootstrap, Bootstrap Basics, Bootstrap Grids, Bootstrap Themes, Bootstrap CSS, Bootstrap JS.	02 Hrs
2	Javascripts: Introduction to JavaScript, JavaScript Language Basics, JavaScript Events, JavaScript Strings, JavaScript Type Conversion, JavaScript RegExp, JavaScript Error, JavaScript Hoisting,	02 Hrs
3	jQuery: jQuery Events, jQuery Effects, jQuery HTML, jQuery Traversing, jQuery AJAX & Misc.	02 Hrs
4	PHP & Mysql: Embedding PHP in HTML, Adding Dynamic Content, Accessing Form Variables, Storing and retrieving data, Using Arrays perform different operations, String Manipulation and Regular Expressions.	02 Hrs
5	MVC with Laravel: Laravel Installation, Working with Forms, Working with Controller, Laravel Blade Template with Bootstrap, Responses with Html, Laravel Migration, Laravel Requests, Models; Laravel Eloquent ORM, Build a Complete App in Laravel.	02 Hrs

Text / Reference Books:

1. Learning PHP, MySQL, JavaScript, CSS & HTML5: A Step-by-Step Guide to Creating Dynamic Websites by Robin Nixon.
2. Full-Stack JavaScript Development by Eric Bush.
3. Web Design with HTML, CSS, JavaScript, and JQuery Set Book by Jon Duckett Professional JavaScript for Web Developers Book by Nicholas C. Zakas.
4. “Laravel: Up and Running" by Matt Stauffer.
5. Title: Head First jQuery by Ryan Benedetti, Ronan Cranley, September 2011, O'Reilly Media, Inc.

Lab Assignments:

1. Create a responsive webpage using Bootstrap classes for typography, buttons, alerts, and tables. Apply proper layout and spacing.
2. Design a multi-column layout using Bootstrap's grid system. Include responsive breakpoints for mobile, tablet, and desktop views.
3. Develop a login/registration page using Bootstrap form controls and implement form validation using Bootstrap's built-in utilities and JavaScript.
4. Write a script to perform simple DOM manipulations like hiding/showing content, changing text, and style on button click using JavaScript events.
5. Create a form where input strings are validated, formatted, and manipulated using string methods and type conversion.
6. Demonstrate function and variable hoisting using examples. Show the difference between `var`, `let`, and `const` with scope illustrations.
7. Create a dynamic webpage that responds to user actions like clicks, hover, and form input using jQuery event listeners and animation effects.
8. Develop a web page that fetches data asynchronously using jQuery AJAX (e.g., weather API or random user data API). Display results dynamically.
9. Write PHP scripts that perform sorting, searching, and merging operations on arrays. Validate input using regular expressions and manipulate strings (e.g., format names or extract domains from emails).
10. Develop a complete Laravel-based CRUD application (e.g., blog, task manager, or product inventory) using routes, controllers, models, migrations, and Blade templates. Include user-friendly error messages and Bootstrap styling.

Semester - V

Teaching Scheme		Semester V Machine Learning	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Understand core concepts and types of machine learning. 2. Apply supervised learning algorithms and handle overfitting.	MSE	20
CR	3	3. Implement neural networks and basic deep learning models. 4. Explore probabilistic models and learning theory. 5. Use clustering and recommendation techniques for data analysis.	ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	Basic definitions, types of learning, hypothesis space and inductive bias, evaluation, cross-validation, Linear regression, Decision trees, over fitting, Instance based learning, Feature reduction, Collaborative filtering based recommendation.	05 Hrs
2	Probability and Bayes learning, Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM.	05 Hrs
3	Perceptron, multilayer network, back propagation, introduction to deep neural network.	04 Hrs
4	Computational learning theory, PAC learning model, Sample complexity, VC Dimension, Ensemble learning.	05 Hrs
5	Clustering k-means, adaptive hierarchical clustering, Gaussian mixture model.	05 Hrs

Text / Reference Books:

1. Tom Mitchell, Machine Learning, First Edition, McGraw Hill, 1997.
2. Ethem Alpaydin, Introduction to Machine Learning, Prentice Hall India Learning Private Limited; 2nd edition, 2010.

Teaching Scheme		Semester V Object Oriented Programming in Java	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	2		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	Introduction to Object Technology: Methods and Classes, Objects and Instantiation, Reuse, Encapsulation and Information Hiding, Inheritance, Interfaces, Programming Languages, Java, Typical Java Development Environment. Introduction to Java Applications, Printing Output, Input Using Scanner, Variables and Data Types, Memory Concepts, Arithmetic Operators, Equality and Relational Operators, Algorithms, Pseudocode, Control Structures, if Statement, if-else Statement, Nested if-else Statement, while Loop, Counter-Controlled Iteration, Sentinel-Controlled Iteration, Compound Assignment Operators, Increment and Decrement Operators.	05 Hrs
2	**Methods, Arrays and Strings:** Methods, static Methods, Method Parameters, Method-Call Stack, Scope of Declarations, Method Overloading, Random Number Generation, Arrays, Array Initialization, Enhanced for Loop, Passing Arrays to Methods, Multidimensional Arrays, Variable-Length Argument Lists, ArrayList, Fundamentals of Characters and Strings, String Class, StringBuilder Class, Character Class, Tokenizing Strings, Regular Expressions.	05 Hrs
3	**Classes, Objects and Object-Oriented Programming:** Instance Variables, set and get Methods, Constructors, Primitive Types and Reference Types, Access Control, this Reference, Composition, enum Types, Garbage Collection, static Members, final Variables, Inheritance, Superclasses and Subclasses, Constructors in Subclasses, Polymorphism, Abstract Classes and Methods, Interfaces, Functional Interfaces, Program to an Interface.	04 Hrs
4	**Exception Handling, Collections and File Processing:** Exception Handling, Exception Hierarchy, finally Block, Chained Exceptions, Assertions, try-with-Resources, Collections Framework, Wrapper Classes, Autoboxing and Auto-Unboxing, Lists, Linked Lists, Sets, Maps, PriorityQueue, Iterators, Files and Streams, NIO Basics, Sequential Text Files, XML Serialization, File and Directory Operations.	05 Hrs
5	**Advanced Java Concepts:** Lambda Expressions, Functional Interfaces, Stream Processing, Filtering and Mapping, Method References, Generic Methods, Generic Classes, Wildcards, Linked Lists, Stacks, Queues, Trees, Recursion, Fibonacci Series, Towers of Hanoi, Searching Algorithms, Sorting Algorithms, Big O Notation, Introduction to JDBC, Database Connectivity, Prepared Statements, Transaction Processing, Introduction to JShell.	05 Hrs

Text/Reference Books:

1. Deitel, P. J., & Deitel, H. M. (2018). *Java: How to program* (11th ed.). Pearson Education.
2. Schildt, H. (2021). *Java: The complete reference* (12th ed.). McGraw-Hill Education.
3. Horstmann, C. S. (2019). *Core Java Volume I—Fundamentals* (11th ed.). Pearson.
4. Horstmann, C. S. (2020). *Core Java Volume II—Advanced Features* (11th ed.). Pearson.
5. Bloch, J. (2018). *Effective Java* (3rd ed.). Addison-Wesley Professional.
6. Sierra, K., & Bates, B. (2022). *Head first Java* (3rd ed.). O'Reilly Media.

Teaching Scheme		Semester V Cloud and Distributed AI Systems	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to Cloud:** Cloud Computing at a Glance, the Vision of Cloud Computing, Defining a Cloud, a Closer Look, Cloud Computing Reference Model. Characteristics and Benefits, Challenges Ahead, Historical Developments. **Virtualization:** Introduction, Characteristics of Virtualized Environment, Taxonomy of Virtualization Techniques, Virtualization and Cloud computing, Pros and Cons of Virtualization, Technology Examples- VMware and Microsoft Hyper-V.	05 Hrs
2	**Cloud Computing Architecture:** Introduction, Cloud Reference Model, Architecture, Infrastructure / Hardware as a Service, Platform as a Service, Software as a Service, Types of Clouds, Public Clouds, Private Clouds, Hybrid Clouds, Community Clouds, Economics of the Cloud, Open Challenges, Cloud Interoperability and Standards, Scalability and Fault Tolerance. **Defining the Clouds for Enterprise:** Storage as a service, Database as a service, Process as a service, Information as a service, Integration an s a service and Testing as a service. Scaling a cloud infrastructure -Capacity Planning, Cloud Scale.	08 Hrs
3	**Aneka:** Cloud Application Platform Framework Overview, Anatomy of the Aneka Container, From the Ground Up: Platform Abstraction Layer, Fabric Services, Foundation Services, Application Services, Building Aneka Clouds, Infrastructure Organization, Logical Organization, Private Cloud Deployment Mode, Public Cloud Deployment Mode, Hybrid Cloud Deployment de, Cloud Programming and Management, Aneka SDK, Management Tools.	06 Hrs
4	Introduction to Distributed AI Systems, Evolution of AI Systems: Traditional Machine Learning Systems, Deep Learning Systems, Large Language Models, Need for Distributed AI, Overview of Distributed AI Architecture: Compute Resources, Storage Systems, Networking Components, AI Workflows, GPU Fundamentals: CPU versus GPU, GPU Architecture Basics, CUDA Overview, Role of GPUs in AI Training and Inference, Communication Between Multiple GPUs, Parallel Computing Concepts: Data Parallelism, Model Parallelism, Pipeline Parallelism, Challenges in Distributed AI Systems: Scalability, Communication Overhead, Resource Utilization, Fault Tolerance.	05 Hrs
5	**Distributed Training of AI Models:** Introduction to Distributed Training, Need for Distributed Training: Large Datasets, Large Models, Faster Training, PyTorch Distributed Training Overview: Distributed Processing Concepts,	05 Hrs

Multi-GPU Training Environment, Distributed Data Parallel (DDP): Concept, Architecture, Training Workflow, Gradient Synchronization, Training Data Management: Dataset Partitioning, Distributed Sampling, Batch Processing, Memory Management in Large-Scale Training: GPU Memory Constraints, Mixed Precision Training, Introduction to Fully Sharded Data Parallel (FSDP): Parameter Sharding, Memory Optimization, Benefits of FSDP, Comparison of DDP and FSDP: Performance, Scalability, Resource Requirements.

Text/Reference Books:

1. Mastering Cloud Computing by Raj Kumar Buyya, Christian Vecchiola, and S.Thamarai Selvi from TMH 2013.
2. Wu, F. (2025). Distributed AI systems: A practical guide to building scalable training, inference, and serving systems for production AI. Packt Publishing.
3. Stevens, E., Antiga, L., & Viehmann, T. (2024). Deep Learning with PyTorch (2nd ed.). Manning Publications.
4. Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems (3rd ed.). O'Reilly Media.

Teaching Scheme		Semester V Data Engineering and Big Data Systems	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**Fundamentals of Data Engineering and Big Data:** Introduction, Evolution of Data Processing Systems, Data Engineering Lifecycle, Characteristics of Big Data: Volume, Velocity, Variety, Veracity and Value, Types of Data Sources, Batch Processing and Stream Processing Concepts, Big Data Architecture, Data Engineering Roles and Responsibilities, Modern Data Engineering Ecosystem, Introduction to Distributed File Systems.	05 Hrs
2	**Distributed Storage and Big Data Processing Frameworks:** Distributed File Systems: Hadoop Distributed File System (HDFS) Architecture, NameNode and DataNode, Data Replication and Fault Tolerance, Distributed Storage Concepts, Hadoop Ecosystem Overview, MapReduce Programming Model, Mapper, Reducer and Combiner, Data Partitioning, Introduction to Apache Spark, Resilient Distributed Datasets (RDDs), Spark DataFrames, Spark SQL Fundamentals, Performance Comparison of MapReduce and Spark.	06 Hrs
3	**Data Warehousing and Data Integration:** Introduction, Operational Database versus Data Warehouse, Data Warehouse Architecture, Fact Tables and Dimension Tables, Star Schema and Snowflake Schema, Data Marts, Online Analytical Processing (OLAP), Extract, Transform and Load (ETL), Extract, Load and Transform (ELT), Data Integration Techniques, Data Quality Assessment, Metadata Management, Introduction to Data Lake and Lakehouse Architecture.	06 Hrs
4	**Real-Time Data Engineering:** Introduction, Streaming Data Fundamentals, Event-Driven Architecture, Publish–Subscribe Communication Model, Message Brokers, Apache Kafka Architecture, Producers, Consumers and Topics, Stream Processing Concepts, Window-Based Processing, Data Pipelines for Streaming Applications, Log Processing, Event Streaming Applications, Monitoring and Performance Metrics for Data Pipelines.	05 Hrs
5	Data Governance, Security and Industrial Applications: Data Governance Fundamentals, Data Ownership and Stewardship, Data Privacy and Compliance, Data Security Techniques, Data Backup and Recovery, Data Lineage, Data Catalogs, Workflow Scheduling Concepts, Introduction to Apache Airflow, Workflow Orchestration, Industrial Applications of Data Engineering in Finance, Healthcare, E-Commerce, Manufacturing and Smart Cities, Emerging Trends in Data Engineering, Serverless Data Engineering, Data Mesh and Data Fabric Concepts.	05 Hrs

Text/Reference Books:

1. Akidau, T., Chernyak, S., & Lax, R. (2018). Streaming systems: The what, where, when, and how of large-scale data processing. O'Reilly Media.
2. Kleppmann, M. (2017). Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems. O'Reilly Media.
3. Karau, H., Warren, R., Konwinski, A., Wendell, P., & Zaharia, M. (2015). Learning Spark: Lightning-fast big data analysis. O'Reilly Media.
4. Reis, J., & Housley, M. (2022). Fundamentals of data engineering: Plan and build robust data systems. O'Reilly Media.
5. Marz, N., & Warren, J. (2015). Big data: Principles and best practices of scalable real-time data systems. Manning Publications.

Teaching Scheme		Semester V Vector Databases	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	2		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**Fundamentals of Vector Databases and Embeddings:** Introduction to Data Management, Traditional Databases versus Vector Databases, Structured and Unstructured Data, Overview of Artificial Intelligence and Machine Learning Applications, Introduction to Vector Representations, Feature Vectors, Embeddings, Similarity Search Concepts, Distance Metrics: Euclidean Distance, Cosine Similarity, Manhattan Distance, Applications of Vector Databases in Recommendation Systems, Semantic Search, Image Retrieval, and Natural Language Processing.	05 Hrs
2	**Vector Embeddings and Data Preparation:** Introduction to Embedding Models, Text Embeddings, Image Embeddings, Sentence Embeddings, Word Embeddings, Feature Extraction Techniques, Data Preprocessing for Vector Databases, Dimensionality Reduction Concepts, Metadata Management, Vector Storage Fundamentals, Embedding Generation Using Pre-trained Models, Introduction to Transformer-Based Embeddings, Practical Applications of Embedding Generation.	05 Hrs
3	**Vector Indexing and Similarity Search:** Introduction to Vector Indexing, Exact Search and Approximate Nearest Neighbor (ANN) Search, Indexing Techniques, Brute Force Search, Hierarchical Navigable Small World (HNSW), Inverted File Index (IVF), Product Quantization (PQ), Search Performance Metrics, Recall and Precision, Query Processing, Filtering and Hybrid Search, Performance Optimization Techniques, Scalability Considerations.	04 Hrs
4	**Vector Database Systems and Applications:** Architecture of Vector Databases, Data Ingestion and Storage, Query Processing Pipeline, Introduction to Popular Vector Databases, Similarity Search Workflows, Metadata Filtering, Real-Time Search Applications, Recommendation Systems, Semantic Search Systems, Image and Multimedia Retrieval, Fraud Detection Applications, AI-Powered Knowledge Retrieval Systems, Integration with Machine Learning Applications.	05 Hrs
5	**Retrieval-Augmented Generation (RAG) and Emerging Trends:** Introduction to Retrieval-Augmented Generation (RAG), Knowledge Retrieval Concepts, Large Language Models and Vector Databases, Building a Simple RAG Pipeline, Document Chunking Strategies, Embedding-Based Retrieval, Context Generation, Evaluation of Retrieval Systems, Challenges in Vector Search, Security and Privacy Considerations, Scalability Issues, Future Trends in Vector Databases and AI Applications.	05 Hrs

Text/Reference Books:

1. Mehta, A., & Agrawal, A. (2024). Vector databases for beginners: A practical guide to embeddings, similarity search, and AI applications. BPB Publications.
2. Manning, C. D., Raghavan, P., & Schütze, H. (2008). Introduction to information retrieval. Cambridge University Press.
3. Aggarwal, C. C. (2018). Neural networks and deep learning. Springer.
4. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press.
5. Turnbull, D., & Berryman, J. (2024). Relevant search: With applications for vector search and retrieval systems (2nd ed.). Manning Publications.
6. Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow (3rd ed.). O'Reilly Media.

Teaching Scheme		Semester V Human Computer Interaction	Examination Scheme	
TH	2	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	2		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**HCI Foundations:** Input–output channels - Human memory - Thinking: reasoning and problem solving - Emotion - Individual differences - Psychology and the design of interactive systems - Text entry devices - Positioning - pointing and drawing - Display devices - Devices for virtual reality and 3D interaction - Physical controls - sensors and special devices - Paper: printing and scanning.	05 Hrs
2	Designing - Programming Interactive systems - Models of interaction - Frameworks and HCI - Ergonomics - Interaction styles - Elements of the WIMP interface - The context of the interaction - Experience - engagement and fun - Paradigms for interaction. Cantered Design and testing - Interaction design basics - The process of design - User focus - Scenarios - Navigation design - Screen design and layout, Iteration and prototyping.	05 Hrs
3	HCI in the software process - Iterative design and prototyping - Design rules - Principles to support usability - Standards and Guidelines - Golden rules and heuristics - HCI patterns. Implementation support - Elements of windowing systems - Programming the application - Using toolkits - User interface management systems.	04 Hrs
4	Evaluation techniques - Evaluation through expert analysis - Evaluation through user participation - Universal design - User support. Models and Theories - Cognitive models - Goal and task hierarchies - Linguistic models - The challenge of display-based systems - Physical and device models - Cognitive architectures.	05 Hrs
5	Collaboration and communication - Face-to-face communication - Conversation - Text-based communication - Group working - Dialog design notations - Diagrammatic notations - Textual dialog notations - Dialog semantics - Dialog analysis and design Human factors and security - Groupware - Meeting and decision support systems - Shared applications and artifacts - Frameworks for groupware - Implementing synchronous groupware - Mixed - Augmented and Virtual Reality.	05 Hrs

Text/Reference Books:

1. A Dix, Janet Finlay, G D Abowd, R Beale, “Human - Computer Interaction”, Pearson Publishers, Third Edition, 2008.

2. Shneiderman, Plaisant, Cohen, Jacobs, “Designing the User Interface: Strategies for Effective Human Computer Interaction”, Pearson Publishers, Fifth Edition, 2018.
3. Jonathan Lazar, “Research Methods in Human–Computer Interaction”, John Wiley & Sons (2017)

Teaching Scheme		Semester V AI for Cybersecurity	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	Overview on Machine Learning with use cases from cybersecurity, classification of threats, attacks, vulnerabilities, malware, trojans etc.	05 Hrs
2	Classification of malware using supervised/unsupervised learning based on signatures and profiling. Decision Tree and context based malicious event detection	06 Hrs
3	Time Series Analysis and Ensemble modelling to detect deviation from normal behaviour, case studies in Reconnaissance detection	05 Hrs
4	Efficient Network Anomaly detection; familiarize with various stages of network attack and address using deep neural networks, develop intrusion detection systems	06 Hrs
5	Adversarial attacks on ML systems, model poisoning, black box attacks, white box attacks, state-of-art research paper reading on deep learning systems	05 Hrs

Text/Reference Books:

1. A. Hands-on Machine Learning for Cyber Security by Soma Halder, ISBN139781788992282
2. Machine Learning and Security by David Freeman, Clarence Chio Publisher: O'Reilly Media, Inc. Release Date: February 2018 ISBN: 9781491979891.
3. Malware Data Science by Joshua Saxe with Hillary Sanders, ISBN-10: 1-59327-859-4 ISBN-13: 978-1-59327-859-5 Publisher: William Pollock.

Teaching Scheme		Semester V Machine Learning Laboratory	Examination Scheme	
TH	-		CA	60
PR	2		MSE	-
CR	1		ESE	40

List of Experiments:

1. Implement a toy classification problem using decision boundaries (manual coding). Apply train/test split and k-fold cross-validation to a dataset (e.g., Iris). Compare accuracy, precision, recall, F1-score.
2. Implement simple and multiple linear regression using NumPy and using scikit-learn. Plot regression lines and residuals. Compute RMSE and R^2 values.
3. Train a decision tree classifier and visualize the tree. Analyze performance with/without pruning and depth control. Demonstrate overfitting using synthetic data.
4. Implement and visualize k-Nearest Neighbors classification. Tune k and compare accuracy. Demonstrate curse of dimensionality.
5. Apply PCA and t-SNE for dimensionality reduction. Visualize high-dimensional data in 2D. Measure accuracy before and after feature reduction.
6. Implement a simple user-based and item-based collaborative filter. Use cosine similarity or Pearson correlation. Recommend top-N items for a user.
7. Implement Gaussian Naive Bayes manually and using scikit-learn. Classify spam/ham email or sentiment analysis.
8. Train logistic regression for binary classification. Visualize the sigmoid function and decision boundary. Analyze ROC curve and AUC.
9. Train a linear and kernel (RBF, polynomial) SVM. Visualize margins and support vectors. Tune C and gamma hyperparameters.
10. Implement a single-layer perceptron from scratch. Train a multilayer perceptron using scikit-learn / Keras. Compare performance with different activation functions.
11. Visualize layers, activations, and loss using Keras. Build a 2–3 layer DNN for digit classification.
12. Simulate sample complexity: How performance improves with increasing training size. Discuss PAC model using toy examples. Conceptual lab: VC Dimension estimation for linear classifiers.
13. Compare Bagging (Random Forest) vs Boosting (AdaBoost/XGBoost). Visualize feature importance.
14. Apply K-Means and visualize clusters. Use silhouette score and elbow method to tune K.
15. Fit a Gaussian Mixture Model (GMM) and visualize decision boundaries. Perform Agglomerative Clustering and plot dendrograms.

Teaching Scheme		Semester V MLOps Laboratory	Examination Scheme	
TH	1	**Course Objectives:**	CA	60
PR	2		MSE	-
CR	2		ESE	40

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to MLOps:** Overview of MLOps and its significance: Key challenges in deploying and managing ML models in production, Comparison of traditional software development, DevOps and MLOps, Key components of MLOps, MLOps workflow, Landscape of MLOps tools and technologies.	02 Hrs
2	**ML Pipelines & Data Management:** Overview of data engineering tools and practices, Data management for ML models, ML pipeline automation. DVC overview. Feature Stores. Motivation, role in ML and Generative AI applications, benefits for MLOps. Feast overview.	02 Hrs
3	**CI/CD for ML Models:** Use of version control systems like Git for model development, automated testing & validation, model delivery strategies	02 Hrs
4	**Machine Learning Model Development:** Comparison of development of small models vs large models including LLMs, tracking model training & experimentation using MLFlow, hyperparameter tuning and optimization.	02 Hrs
5	**Model Deployment and Serving:** Overview of containerization and orchestration technologies and various other cloud-based deployment options, Deployment strategies for different environments (cloud, edge, on-premises), Model serving options	02 Hrs

Text/Reference Books:

1. *Building Mac*hine Learning Powered Applications: Going from Idea to Product - Emmanuel Ameisen - O'Reilly publication
2. Reliable Machine Learning: Applying SRE Principles to ML in Production - Chen, Murphy, Parisa - O'Reilly publication
3. Machine Learning Engineering in Action - Ben Wilson - O'Reilly publication
4. Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems - Martin Kleppmann - O'Reilly publication

List of Experiments:

1. Introduction to MLOps, Comparison of Software Development, DevOps and MLOps, MLOps Lifecycle, Key Components of MLOps, Challenges in Production Machine Learning Systems, Survey of MLOps Tools and Technologies, Preparation of MLOps Workflow Diagram and Report.

2. Git Installation and Configuration, Repository Creation, Branching and Merging, Managing ML Project Source Code, Collaboration Using GitHub or GitLab, Maintaining Version History, Resolving Merge Conflicts, Documentation of Version Control Workflow.
3. Installation and Configuration of DVC, Dataset Tracking, Dataset Version Management, Storage of Data Artifacts, Comparison of Dataset Versions, Integration of DVC with Git, Reproducibility of Machine Learning Experiments.
4. Data Collection, Data Preprocessing, Feature Engineering, Data Validation, Pipeline Design, Automation of Data Processing Workflow, Execution of End-to-End Data Pipeline, Documentation of Pipeline Stages.
5. Introduction to Feature Stores, Feature Repository Creation, Feature Definition and Registration, Data Ingestion into Feature Store, Retrieval of Online and Offline Features, Feature Reusability for Multiple Models, Analysis of Benefits of Feature Stores in MLOps.
6. Installation and Configuration of MLflow, Training of Machine Learning Models, Logging Parameters and Metrics, Artifact Tracking, Experiment Comparison, Model Registration, Selection of Best Model Based on Experimental Results.
7. Development of Baseline Machine Learning Model, Hyperparameter Selection, Grid Search and Random Search Techniques, Performance Evaluation, Experiment Tracking with MLflow, Comparative Analysis of Model Performance.
8. Unit Testing of Data Processing Functions, Testing of Training Pipelines, Validation of Model Outputs, Creation of Automated Test Cases, Execution of Tests Using CI Tools, Analysis of Test Results.
9. Setup of GitHub Actions or GitLab CI, Automated Build Process, Automated Testing Workflow, Validation of Model Training Scripts, Generation of Build Reports, Continuous Integration Pipeline Documentation.
10. Introduction to Docker, Creation of Dockerfile, Packaging Machine Learning Application, Building Docker Images, Running Containers, Testing Containerized Applications, Documentation of Container Deployment Process.
11. Development of REST API Using Flask or FastAPI, Integration of Trained Machine Learning Model, Creation of Prediction Endpoints, Testing Using Postman, Analysis of Response Time and Prediction Accuracy, Documentation of Deployment Workflow.
12. Dataset Versioning Using DVC, Feature Management Using Feast, Experiment Tracking Using MLflow, Pipeline Automation, Automated Testing and CI Integration, Containerization Using Docker, Model Deployment and Serving, Preparation of Project Report and Demonstration of Complete MLOps Workflow.

Teaching Scheme		Semester V Seminar and Mini Project	Examination Scheme	
TH	-		CA	60
PR	2		MSE	-
CR	1		ESE	40

Guidelines

The students shall study in group of two members (or individual) on some special topic beyond the scope of the syllabus under the subjects of Computer Science Engineering, Artificial Intelligence, Data Science, or inter discipline branch from current literature, by referring the current technical journal or reference books, under the guidance of the teacher. The students shall prepare his report and deliver talk on the topic for other students of his class in the presence of his guide and internal examiner. The student is permitted to use audio-visual aids or any other such teaching aids.

Continues Assessment: The Continues Assessment for this head will consists of the report written in a technical reporting manner and presentation of the talk on the subject and will be assessed by the internal examiner appointed by the Head of concern department of the institution.

Semester - VI

Teaching Scheme		Semester VI Deep Learning	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	Traditional Machine Learning Basics: Linear Regression, Logistic, Regression, k Nearest Neighbors, Classifier with Probability Theory, Decision Trees, Random Forest, Support Vector Machine, Artificial Neural Network: Artificial Neuron, Perceptron, Stochastic Gradien Descent, and Back Propagation Neural Network, Neural Network Architecture, NN with One Hidden Layer, NN with One Hidden Layer and Multiple Outputs, Neura Network Hyper-parameters	05 Hrs
2	Deep Architecture: need, applications, Hyper-parameters in Deep Neural Networks (Encoding, Layers, Loss function, Learning Rate, Momentum and Optimization Regularization and dropout, Batch Norms) , vanishing gradient problem, and way to mitigate it. Convolution Neural Network: from Dense Layers to Convolutions, pooling layers CNN Architectures (AlexNet, VGG, NiN, GoogLeNet, ResNet, DensNet), Application in Image segmentation, Automated Object Detection models.	05 Hrs
3	Deep Sequence Models: Sequence Modeling Problems, Motivation and Applications, Traditional Models: Recurrent Neural Networks, Back-propagation through time; Modern Recurrent Neural Networks: Gated Recurrent Units, Lon Short Term Memory (LSTM), Deep Recurrent Neural Networks, automatic imag captioning, video to text with LSTM models.	04 Hrs
4	Deep Unsupervised Learning: Latent variable models, Autoencoders, Deep Generative Modeling: Variational Autoencoders, Generative Adversarial Networks (GANs), Recent Advance, Image generation with Generative adversarial networks, Advance Topic in Deep Learning: Transfer Learning: Need and motivation, Transfer Learning Process, Data Augmentation, Applications	05 Hrs
5	Responsible AI, MLOps and Industrial Applications: Explainable AI (XAI), Fairness and Bias in AI Systems, Responsible and Ethical AI, Model Evaluation Metrics, Model Deployment Strategies, MLOps Fundamentals, Cloud-Based AI Deployment, Monitoring and Maintenance of AI Systems, AI Agents and Tool Usage, Case Studies in Healthcare, Finance, Manufacturing, Smart Cities, and Autonomous Systems.	05 Hrs

Text / Reference Books:

1. Deep Learning, Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.

2. Machine Learning: An Algorithmic Perspective, Second Edition, Stephen Marsland, Chapman and Hall/CRC.
3. Dive into Deep Learning, Zhang, A., Lipton, Z. C., Li, M., & Smola, A. J. (2023). *Dive into deep learning*. Cambridge University Press.
4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow Géron, A. (2022). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow* (3rd ed.). O'Reilly Media.
5. Pattern Recognition and Machine Learning, Bishop, C. M. (2006). *Pattern recognition and machine learning*. Springer.
6. Machine Learning, Mitchell, T. M. (1997). *Machine learning*. McGraw-Hill.
7. Neural Networks and Deep Learning, Aggarwal, C. C. (2018). *Neural networks and deep learning: A textbook*. Springer.
8. Deep Learning with Python, Chollet, F. (2021). *Deep learning with Python* (2nd ed.). Manning Publications.

Teaching Scheme		Semester VI Natural Language Processing	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	Lexical Analysis: Lexical Analysis - Regular expression and Automata for string matching - Words and Word Forms - Morphology fundamentals - Morphological Diversity of Indian Languages - Morphology Paradigms - Finite State Machine / Transducers Based Morphology - Automatic Morphology Learning - Parts of Speech - N-gram Models - Hidden Markov Models.	05 Hrs
2	Speech Processing: Biology of Speech Processing - Place and Manner of Articulation - Word Boundary Detection - Argmax based computations - HMM and Speech Recognition - Text to Speech Synthesis - Rule Based-Concatenative based approach.	05 Hrs
3	Parsing: Theories of Parsing - Parsing Algorithms – Earley Parser - CYK Parser - Probabilistic Parsing - CYK - Resolving attachment and structural ambiguity - Shallow Parsing - Dependency Parsing - Named Entity Recognition - Maximum Entropy Models - Conditional Random Fields.	04 Hrs
4	Lexical Knowledge Networks: Meaning: Lexical Knowledge Networks - Wordnet Theory - Indian Language Wordnets and Multilingual Dictionaries - Semantic Roles - Word Sense Disambiguation - WSD and Multilingualism - Metaphors - Coreference and Anaphora Resolution.	05 Hrs
5	Applications: Applications: Sentiment Analysis - Text Entailment - Machine Translation - Question Answering System - Information Retrieval - Information Extraction - Cross Lingual Information Retrieval (CLIR).	05 Hrs

Text/Reference Books:

1. Jurafsky Daniel, Martin James, “Speech and Language Processing”, Second Edition, Tenth Impression, Pearson Education, 2018.
2. Christopher Manning, Schutze Heinrich, “Foundations of Statistical Natural Language Processing”, MIT Press, 1999.
3. Allen James, “Natural Language Understanding”, Second Edition, Benjamin Cumming, 1995.
4. Charniack Eugene, “Statistical Language Learning”, MIT Press, 1993.
5. Foundations of Statistical Natural Language Processing, The MIT Press Cambridge, Massachusetts London, England,1999.
6. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, “Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems”, O'REILLY, 2020.

Teaching Scheme		Semester VI Fundamental Edge AI	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-	1. Analyze heterogeneous architectures and implement communication bridges between high-level OS environments and real-time hardware peripherals.	MSE	20
CR	3	2. Design efficient vision processing pipelines using hardware-accelerated interfaces and zero-copy memory principles for real-time edge applications.	ESE	60
		3. Apply model optimization techniques including quantization and pruning to adapt standard neural networks for resource-constrained edge hardware.		
		4. Evaluate system performance using empirical benchmarking to justify trade-offs between computational speed, energy consumption, and model accuracy.		
		5. Synthesize an end-to-end Edge AI solution on the Arduino UNO Q platform, demonstrating a complete workflow from model optimization to physical deployment.		

COURSE CONTENT

Unit No.	Topic	Hours
1	Fundamentals of Heterogeneous Systems; Introduction to SoC (System-on-Chip) architecture combining Application Processors and Microcontrollers. Inter-Processor Communication (IPC); Bridge protocols, Shared Memory mechanisms, and Remote Procedure Calls (RPC).	05 Hrs
2	Hardware Abstraction Layers (HAL); Memory-mapped I/O (MMIO), and peripheral multiplexing. Power Domain Management; Introduction to Sleep States, Wake-on-Interrupt logic, and basic Power-Aware scheduling. Comparison of General Purpose vs. Task-Specific compute units.	05 Hrs
3	Basics of Neural Hardware Acceleration; Parallelism via SIMD (Single Instruction, Multiple Data) and Vectorization logic. The Vision Processing Chain; MIPI-CSI interface fundamentals, Image Signal Processor (ISP) basics, and Zero-copy data paths for frame buffers.	04 Hrs
4	Introduction to Specialized Accelerators; Understanding the role of DSPs (Digital Signal Processors) and NPUs (Neural Processing Units) in ofloading CPU tasks. Computational Complexity in Vision; Reducing overhead in real-time image preprocessing.	05 Hrs
5	Fundamentals of Model Compression; The transition from Floating-point (FP32) to Fixed-point (INT8) arithmetic. Quantization Principles;	05 Hrs

Understanding scale and zero-point mapping, and the impact of precision loss on model accuracy.

Text/Reference Books:

1. Eliasmith, C., & Stewart, T. C. (2024). Edge AI engineering: Applications, hardware, and deployment for intelligent systems. CRC Press.
2. Plunkett, T., & Venkatesan, R. (2023). Practical edge AI: Deploying machine learning on embedded and IoT devices. Packt Publishing.
3. Johnston, A., & Carnevale, M. (2023). TinyML cookbook: Practical recipes for embedded machine learning and edge AI. Packt Publishing.

Teaching Scheme		Semester VI Information Security and Privacy	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	Information Security Introduction -- Defining and Understanding security through security models, Confidentiality, Integrity and Availability, formal description of security, Attacks and Defences, Threats, Vulnerabilities and Risk, Assurance, Prevention, Detection, Security Controls, Identification and Authentication. Authorization and Access Control, Access Control Models & Mechanisms and Multilevel Security, Auditing and Accountability.	05 Hrs
2	Computational Number Theory & Cryptography - Fermat's theorem, Euler's theorem, Euclid's algorithm, manually and computationally encrypt/decrypt, sign/verify signatures for small messages using RSA, Deffie-Hellman and DSA algorithms. Applied cryptography viz. Symmetric key Cryptography, asymmetric Cryptography and Digital Signatures, message authentication codes, hash functions and modes of cryptographic operations, Physical Security.	05 Hrs
3	Network Security – Network threats: eavesdropping, spoofing, modification, denial of service attacks o Introduction to network security techniques: firewalls, virtual private networks, intrusion detection. Different Network Security Protocols.	04 Hrs
4	Operating System Security & Trusted OS-- Memory, time, file, object protection requirements and techniques, Protection in contemporary operating systems, ACLs, DAC, MAC, RBAC, Identification and authentication, Identification goals, Authentication requirements, Human authentication, Machine authentication, OS Forensics. Assurance & Trust, Design principles, Evaluation criteria, Evaluation process.	05 Hrs
5	Application & Program Security– Flaws, Malicious code: viruses, Trojan horses, worms, Program flaws: buffer overflows, time-of-check to time-of-use flaws, incomplete mediation o Defenses, Software development controls, Testing techniques, Secure Coding, Distributed Systems Security.	05 Hrs

Text/Reference Books:

1. The Basics of Information Security by Jason Andress, Syngress Publication.
2. Security in Computing (3rd Edition) 3rd Edition by Charles P. Pfleeger (Author), Shari Lawrence Pfleeger (Author), PHI.
3. B. Tjaden Fundamentals of Secure Computer Systems Franklin Beedle & Associates 2003.

4. D. Russell & G.T. Gangemi, Sr, Computer Security Basics.
5. W. Stallings, Network Security Essentials. Prentice Hall, 2003.

Teaching Scheme		Semester VI Cyber Physical Systems	Examination Scheme	
TH	3	**Course Objectives:**	CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	**Fundamentals of Cyber Physical Systems:** Cyber-Physical Systems (CPS) in the real world; Basic principles of design and validation of CPS, Industry 4.0; AutoSAR, IIOT implications, Building Automation, Medical CPS	05 Hrs
2	**Platform Components for Cyber Physical Systems:** CPS HW platforms - Processors, Sensors, Actuators; CPS Network - WirelessHart, CAN, Automotive Ethernet; Scheduling Real Time CPS tasks: Table-driven and Event driven schedulers Hybrid schedulers.	07 Hrs
3	**Principles of Dynmical Systems:** Dynamical Systems and Stability; Controller Design Techniques; Performance under Packet drop and Noise.	05 Hrs
4	**CPS implementation issues:** From features to automotive software components Mapping software components to ECUs; CPS Performance Analysis: Effect of scheduling, bus latency, sense and actuation faults on control performance, network congestion; Building real-time networks for CPS	07 Hrs
5	**Intelligent CPS:** Safe Reinforcement Learning: Robot motion control, Autonomous Vehicle control; Gaussian Process Learning: Smart Grid Demand Response, Building Automation.	07 Hrs

Text/Reference Books:

1. Suh, Sang C., U. John Tanik, John N. Carbone, and Abdullah Eroglu, eds. Applied cyber-physical systems. Springer New York, 2014.
2. Alur, Rajeev. Principles of cyber-physical systems. MIT Press, 2015.
3. Colombo, Armando W., Thomas Bangemann, Statmatis Karnouskos, Jerker Delsing, Petr Stluka, Robert Harrison, Francois Jammes, and Jose L. Lastra. "Industrial cloud-based cyber-physical systems." The Imc-aesop Approach 22 (2014): 4-5.

Teaching Scheme		Semester VI Optimization Techniques	Examination Scheme	
TH	3		CA	20
PR	-		MSE	20
CR	3		ESE	60

COURSE CONTENT

Unit No.	Topic	Hours
1	Preliminaries: Proofs, Vector Spaces and Matrices, Linear Transformations, Eigenvalues and Eigenvectors, Orthogonal Projections, Quadratic Forms, Matrix Norms, Concepts from Geometry, Elements of Calculus.	06 Hrs
2	Unconstrained Optimization: Basics of Set Constrained and Unconstrained Optimization, One Dimensional Search Methods, Golden Section Search, Fibonacci Search, Newton's Method, Secant Method, Solving Ax = b	06 Hrs
3	Linear Programming: Introduction to Linear Programming, Simplex Method, Duality	06 Hrs
4	Nonlinear Constrained Optimization: Problems with Equality Constraints, Problems with Inequality Constraints, Karush Kuhn Tucker Condition, Convex Optimization Problems,	06 Hrs
5	Algorithms for Constrained Optimization: Projections, Project gradient methods, Penalty methods.	06 Hrs

Text / Reference Books:

1. An Introduction to Optimization, Edwin K.P. Chong, Stanislaw H. Zak, Wiley, 2017.
2. Convex Optimization, Stephen Boyd, LievenVandenberghe, 2004.
3. Modern Optimization with R (Use R), Paulo Cortez, Springer, 2014.

Teaching Scheme		Semester VI Deep Learning Laboratory	Examination Scheme	
TH	-		CA	60
PR	4		MSE	-
CR	2		ESE	40

List of Experiments:

1. Implement perceptron learning algorithm and attempt to solve two input i) AND gate ii) Or Gate iii) EXOR gate problems.
2. Design and implement a perceptron learning algorithm and attempt to solve XOR problem
3. Implement a Multilayer Feed Backward Neural network algorithm on MNIT digits dataset.
4. Build your own Recurrent networks and Long short-term memory networks on IMDB movie reviews classification data.
5. Design and implement a BiLSTM and BERT on given a product review dataset to classify the review rating from 1 to 5 classes
6. Design and implement Autoencoders for credit card fraud detection.
7. Design and implement a Convolutional Neural Network for image classification on the Fashion-MNIST dataset.
8. Implement a VGG19 model for image classification with and without Transfer Learning on a dataset.
9. Implement a U-Net convolutional neural network model on segmentation of electron microscopic (EM) images of the brain dataset.
10. Implement a FRCNN algorithm for object detection on small object dataset.

Teaching Scheme		Semester VI Natural Language Processing Laboratory	Examination Scheme	
TH	-		CA	60
PR	2		MSE	-
CR	1		ESE	40

List of Experiments:

1. Implement the Text Representation Techniques
   a. One-hot encoding b. TF-IDF c. Bag-of-Words
2. Implement the Text Pre-processing Techniques
   a. Tokenization b. Lemmatization c. Normalization
3. Implement the Porters Stemming algorithm
4. Implement the Spellchecker
5. Implement Hidden Markov model (HMM) for POS tagging
6. Implement the probabilistic language model
7. Write a program to perform the Text Summarization
   a. Abstractive b. Extractive
8. Write a program to perform the Text Classification
   a. PoS Tagging b. Sentiment Classification
9. Write a program to perform the Named Entity Recognition (NER)
10. Download and Install the LangChain and use LangChain to perform different NLP tasks.

Teaching Scheme		Semester VI Modern Web Application based Project	Examination Scheme	
TH	1		CA	60
PR	2		MSE	-
CR	2		ESE	40

Guidelines for Students

The students shall undertake a major web application project individually or in a group of two to three members under the supervision of a faculty guide. The project shall emphasize the design, development, testing, deployment, and documentation of a modern full-stack web application that addresses a real-world problem. Students are encouraged to select interdisciplinary, socially relevant, or industry-oriented problem statements. The project should follow the complete Software Development Life Cycle (SDLC), including requirement analysis, system design, implementation, testing, deployment, and maintenance planning. Students should apply modern web development frameworks, database technologies, RESTful APIs, authentication mechanisms, and cloud deployment practices wherever applicable.

Each project shall include the following phases:

- Problem identification and literature survey.
- Requirement specification and feasibility analysis.
- System architecture and database design.
- User Interface/User Experience (UI/UX) design.
- Frontend and backend application development.
- Database integration and API development.
- User authentication and authorization.
- Testing, debugging, and performance optimization.
- Deployment on a cloud or web hosting platform.
- Preparation of technical documentation and user manual.
- Final demonstration and presentation.

The project should employ suitable technologies such as **HTML5, CSS3, JavaScript, React.js / Angular / Vue.js, Node.js, Express.js, Django, Laravel, Spring Boot, ASP.NET Core**, relational or NoSQL databases, Git-based version control, and cloud deployment platforms according to project requirements.

Each team shall maintain the following documents throughout the semester:

- Software Requirement Specification (SRS)
- System Design Document (UML diagrams, ER diagrams, database schema)
- Project plan with milestones
- Source code repository using Git
- Test cases and testing report
- Deployment report
- Final project report

Students shall demonstrate the project at different milestones through periodic reviews conducted by the faculty guide.