Dr. Babasaheb Ambedkar Technological University

(Established a University of Technology in the State of Maharashtra)
(Under Maharashtra Act No. XXIX of 2014)
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POSTGRADUATE PROGRAMME

M.Tech. in Artificial Intelligence and Data Science Syllabus
Aligned with New Education Policy 2020
(With effective from 2025 – 2026 for University Department)

M.Tech. in Artificial Intelligence and Data Science
Course Curriculum Aligned with New Education Policy 2020
(with effective from Academic Year 2025 - 2026)
First Semester

Course Code	Course Name	Weekly Hours			Examination Scheme			Credit
		L	P	T	CA	MSE	ESE	
MTAIPC11	Data Visualisation Techniques	3	-	-	20	20	60	3
MTAIPC12	Quantum Computational Methods	3	-	-	20	20	60	3
MTAIPE13	**Core Elective-I** 1. Cloud Computing 2. Virtual Reality 3. MLOps	3	-	-	20	20	60	3
MTAIPE14	**Core Elective-II** 1. Data Mining and Analysis 2. Time Series Analysis 3. Blockchain	3	-	-	20	20	60	3
MTAIOE15	**Open Elective-I** 1. Natural Language Processing 2. Optimization Techniques 3. Learning Analytics	3	-	-	20	20	60	3
MTCECC16	Research Methodology	3	-	-	20	20	60	3
MTAIPC76L	Software Lab - I (Data Visualisation)	-	4	-	60	-	40	2
MTAIPC18L	Software Lab - II (Elective Courses)	-	4	-	60	-	40	2
MTAICC19	Indian Knowledge System	2	-	-	60	-	40	2
Total		**17**	**8**	**-**	**300**	**120**	**480**	**24**

M.Tech. in Artificial Intelligence and Data Science
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Second Semester

Course Code	Course Name	Weekly Hours			Examination Scheme			Credit
		L	P	T	CA	MSE	ESE	
MTAIPC21	Theoretical Foundations of Machine Learning	3	-	1	20	20	60	4
MTAIPE22	Quantum AI	3	-	-	20	20	60	3
MTAIPE23	**Core Elective-III** A. Computer Vision B. Deep Reinforcement Learning C. Agentic AI	3	-	-	20	20	60	3
MTCEOE24	**Open Elective-II** A. AI Ethics B. Entrepreneurship C. Sustainability Engineering	3	-	-	20	20	60	3
MTAIPE25	**Core Elective-IV** A. Geospatial Data Analysis B. Graph Databases C. Vector Databases	3	-	-	20	20	60	3
MTAIPC26L	Software Lab - III (Machine Learning and Deep Learning Laboratory)	-	4	-	60	-	40	2
MTAIPC27L	Software Lab - IV (Elective Courses)	-	4	-	60	-	40	2
MTAICC28	Seminar	-	4	-	60	-	40	2
	Total	**15**	**12**	**1**	**280**	**100**	**420**	**22**
Exit Requirements to award Certificate in Computer Engineering (Any TWO Courses from the following courses)								
MTEXE1	Research Project leading to ONE Conference paper/book chapter/journal paper	-	8	-	40	-	60	4

M.Tech. in Artificial Intelligence and Data Science
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Third Semester

Course Code	Course Name	Weekly Hours			Examination Scheme			Credit
		L	P	T	CA	MSE	ESE	
MTAIPC21	Research/Industry Internship of TWO months duration	-	16	-	60	-	40	8
MTAICC22	Intellectual Property Rights	3	-	-	20	20	60	3
MTAIPE23	Project Phase - I	-	24	-	60	-	40	12
Total		**3**	**40**	**-**	**140**	**20**	**140**	**23**
Fourth Semester								
MTCEOE24	Project Phase - II	-	24	-	60	-	40	16
Total		**-**	**24**	**-**	**60**	**-**	**40**	**16**

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**Data Visualization Techniques**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Purpose of Data Visualization:** Data, Data Taxonomy: 1D, temporal, 2D, 3D, 4D, ND, Trees, Graphs, Nominal, Ordinal, Quantitative; Visualization, Importance of Data Visualization, Goals of Visualization, Characteristics of Good Visualizations; Exploratory Data Analysis; Time series data and Visualization; Text and Visualization; Tools for Visualization.	06 Hrs
2	**Collecting, pre-processing and Visualizing Data:** Collection: Single source, Multiple sources, Web scraping; Data Cleaning and Aggregation; Mapping data onto aesthetics: Aesthetics and types of data, Scales map data values onto aesthetics; Coordinate systems and axes: Cartesian coordinates, Nonlinear axes, Coordinate systems with curved axes.	06 Hrs
3	**Visualizing Amounts, Distributions, Proportions:** Visualizing many distributions at once: Visualizing distributions along the vertical axis, visualizing distributions along the horizontal axis; Visualizing proportions: pie charts, side-by-side bars, stacked bars and stacked densities, visualizing proportions separately as parts of the total; Visualizing nested proportions; Visualizing associations among two or more quantitative variables: Scatter plots, Correlograms, Dimension reduction, Paired data.	06 Hrs
4	**Advanced Visualization Design:** Visualizing many distributions at once: Visualizing distributions along the vertical axis, visualizing distributions along the horizontal axis; Visualizing proportions: pie charts, side-by-side bars, stacked bars and stacked densities, visualizing proportions separately as parts of the total; Visualizing nested proportions; Visualizing associations among two or more quantitative variables: Scatter plots, Correlograms, Dimension reduction, Paired data.	05 Hrs
5	**Visualizing time series, trends and geospatial data:** Time series: Individual time series, Multiple time series and dose–response curves, Time series of two or more response variables; Trends: Smoothing, Showing trends with a defined functional form, Detrending and time-series decomposition; Geospatial data: Projections, Layers, Choropleth mapping, Cartograms.	05 Hrs

Text/Reference Books:

1. Kieran Healy, “Data Visualization: A Practical Introduction". Princeton University Press, with ISBN-13: 978-0691185064.
2. Claus O. Wilke, “Fundamentals of Data Visualization: A Primer on Making Informative and Compelling Figures”, O'Reilly Media. The ISBN-13: 978-1492031086.
3. Edward R. Tufte, “The Visual Display of Quantitative Information”, Graphics Press, ISBN-13:978-1930824133.
4. lberto Cairo – The Functional Art: An Introduction to Information Graphics and Visualization, New Riders, ISBN-13: 978-0321834737.

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**Quantum Computational Methods**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	Review of Quantum Mechanics and Motivation for Quantum Computation, Qubit: The qubit state - matrix and Bloch sphere representation - computational basis,unitary evolution. Multi-qubit states - No-cloning theorem - Superdense coding - Pure states to Bell states,Bell inequalities.	06 Hrs
2	Protocols with multi-qubits: Swapping - Teleportation - gates: CNOT - Toffoli gate - NAND - FANOUT - Walsh Hadamard, Measurement: Projective operators - General, Projective and POVM measure.	06 Hrs
3	Ensemble: Density operators - pure and mixed ensemble - time evolution - post measurement density operator. Composite systems: Partial trace - Reduced density operator - Schmidt decomposition - Purification- bipartite entanglement.	06 Hrs
4	Quantum computing: Classical computing using qubits - Quantum parallelism - Deutsch's algorithm -Deutsch Josza algorithm. Quantum circuits: Basic gates - ABC decomposition - Gray codes - Universal gates - Principle of deferred and implicit measurements - Quantum Fourier transform - applications: phase estimation, order finding - factoring, discrete logarithm and hidden subgroup problems - Role of prime factoring in classical cryptography - search algorithms.	05 Hrs
5	Distance measures for quantum information - Distance measures for classical information- the closeness of two quantum states –Quantum error-correction- Three qubit bit flip code - Shor code, Theory of quantum error-correction- Constructing quantum codes - Classical linear codes - Stabilizer codes - Stabilizer formalism - Fault-tolerance: the big picture- Fault-tolerant quantum logic- Fault tolerant measurement- Elements of resilient quantum computation	05 Hrs

Text/Reference Books:

1. Nielsen, M., & Chuang, I. In Quantum Computation and Quantum Information: 10th Anniversary Edition, Cambridge: Cambridge University Press, 2010.
2. Rieffel, Eleanor G., and Wolfgang H. Polak. "Quantum computing: A gentle introduction (scientific and engineering computation)." The MIT Press 10 (2014): 1973124.
3. Quantum Theory: Concepts and Methods, Asher Peres, Kluwer Academic Publishers.
4. W.-H. Steeb, Y. Hardy, Problems and Solutions in Quantum Computing and Quantum Information, World Scientific, Singapore 2004.

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**Cloud Computing**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction:** Limitations of the Traditional Computing Approaches, Three Layers of Computing, Three Layers in Traditional Computing, the End of Traditional Computing, Influences behind Cloud Service Adoption. Benefits and challenges: Origin of the Term 'Cloud Computing', Early Initiatives, Utility Computing, Metering and Billing in Cloud, Separation of Data Center Operation, Benefits of Cloud Computing, Challenges of Cloud Computing, How Cloud Computing Addresses Business Challenges, Ethical Issues in Cloud Computing, Cloud Computing: Network as Computer, Role of Web Service, Role of API, Ubiquitous Cloud, Confusion Between Cloud and Internet, Cloud computing services, Resource Virtualization, Resource pooling, sharing and provisioning.	06 Hrs
2	**Scaling in cloud:** Introduction to Scaling, Scaling in Traditional Computing, Scaling in Cloud Computing, Foundation of Cloud Scaling, Scalable Application, Scaling Strategies in Cloud, Auto-Scaling in Cloud, Types of Scaling, Performance and Scalability, the Resource Contention Problem, Cloud Bursting: A Scenario of Flexible Scaling, Scalability is a Business Concern.	06 Hrs
3	**Capacity Planning:** Capacity Planning, Capacity Planning in Computing, Capacity Planning in Cloud Computing, Approaches for Maintaining Sufficient Capacity, Steps for Capacity Planning, **Load Balancing:** Load Balancing , Importance of Load Balancing in Cloud Computing, Load Balancing in Cloud, Goals of Load Balancing, Categories of Load Balancing, Load Balancing Algorithms, Case study on Google cloud and Amazon Elastic Compute Cloud (EC2), File System and Storage.	06 Hrs
4	**Content Delivery Network:** CDN Service Operations, Evolution of CDN, Advantages of CDN, Disadvantages of CDN, CDN Service Provider, Security Reference Model, **Security Issues:** Cloud security, threats to Cloud Security, Infrastructure Security, Information Security, Identity Management and Access Control, Cloud Security Design Principles, Cloud Security Management Frameworks, Security-as-a-Service, Privacy and Compliance Issues.	05 Hrs
5	**Service-Oriented Architecture:** The Pre-SOA Era ,Role of SOA in Cloud Computing, Service-Oriented Architecture, Goal of System Designing, Service Represents Business Functionality, Open Standard Implementation, Benefits of SOA , SOA and Cloud Computing. **Enterprise architecture and SOA:** Enterprise Software, Enterprise Custom Applications, Workflow and Business Processes, Enterprise Analytics and Search, Enterprise Cloud Computing Ecosystem.	05 Hrs

Text/Reference Books:

1. Sandeep Bhowmik, “Cloud Computing”, Cambridge University Press, 2017.
2. Gautam Shroff, “Enterprise Cloud Computing - Technology, Architecture, Applications”, Cambridge University Press, 2016.

Teaching Scheme	Semester I	Examination Scheme
TH 3 PR 0 CR 3	**Virtual Reality**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction:** Course mechanics, Goals and VR definitions, Historical perspective, Birds-eye view(general), Birds-eye view(hardware), Birds-eye view(software), Birds-eye view(sensation and perception).	06 Hrs
2	**Geometry of Virtual Worlds:** Geometric modeling, Transforming models, Matrix algebra and 2D rotations, 3D rotations and yaw, pitch, and roll, Axis-angle representations, Quaternions, Converting and multiplying rotations, Homogeneous transforms, The chain of viewing transforms, Eye transforms, Canonical view transform, Viewport transform.	06 Hrs
3	**Light and Optics:** Three interpretations of light, Refraction, Simple lenses, Diopters, Imaging, properties of lenses, Lens aberrations, Optical system of eyes. **Visual Physiology:** Photoreceptors, Sufficient resolution for VR, Light intensity, Eye movements, Eye movement issues for VR, Neuroscience of vision.	06 Hrs
4	**Visual Perception:** Depth perception, Motion perception, Frame rates and displays. **Tracking Systems:** Overview, Orientation tracking, Tilt drift correction, Yaw drift correction, Tracking with a camera, Perspective n-point problem, Filtering, Lighthouse approach.	05 Hrs
5	**Visual Rendering:** Visual Rendering-Overview, Shading models, Rasterization, Pixel shading, VRspecific problems, Distortion shading, Post-rendering image warp. **Audio:** Physics and physiology, Auditory perception, Auditory localization, Rendering, Spatialization and display, Combining other senses. **Interfaces:** Interfaces overview, Locomotion, Manipulation, System control, Social interaction, Evaluation of VR Systems.	05 Hrs

Text/Reference Books:

1. George Mather, Foundations of Sensation and Perception: Psychology Press; 2nd edition, 2009.
2. Peter Shirley, Michael Ashikhmin, and Steve Marschner, Fundamentals of Computer Graphics, A K Peters/CRC Press; 3 edition, 2009.

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**MLOps**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**MLOps Foundations & Reproducibility:** MLOps motivation vs. model-centric workflows; org roles and interfaces. ML system design: datasets, features, models, services, feedback loops. Reproducibility: environments (conda/poetry), images (Docker), seeds; data & model versioning (DVC, Git-LFS); experiment tracking (MLflow/W&B). Artifact/metadata stores; model registries; basics of governance.	06 Hrs
2	**Pipelines & Orchestration (CI/CD for ML):** CI for ML: unit tests, data/feature tests, model tests; code quality gates. CD for ML: build, validate, and promote models via registries; infra as code (Terraform). Workflow engines: Airflow/Prefect/Kubeflow; feature stores; automated retraining. Data contracts and schema enforcement (Great Expectations).	06 Hrs
3	**Serving & Deployment Patterns:** Packaging models (ONNX, TorchScript), inference servers (FastAPI, BentoML, KFServing/Triton). Deployment targets: VMs, containers, serverless (AWS Lambda/Cloud Run), and Kubernetes/EKS/GKE. Patterns: batch, request/response, streaming; real-time feature pipelines. Rollouts: blue-green, canary, shadow, A/B; traffic shaping; rollback strategies; performance tuning (p95 latency, throughput).	06 Hrs
4	**Observability, Reliability, & Responsible AI:** Monitoring: data quality, data drift, concept drift, performance regression, skew; logging, tracing, metrics. Post-deployment evaluation: slices, confidence, calibration, and continuous evaluation. SRE for ML systems: SLIs/SLOs for accuracy & latency; incident response and playbooks. Responsible AI: bias/fairness checks, privacy (PII handling, DP basics), model cards; security for ML supply chain.	05 Hrs
5	**Scaling, Cost, and LLMOps:** Distributed training & inference (data/model/pipeline parallelism; autoscaling; GPU scheduling). Feature & vector stores; retrieval-augmented generation (RAG) basics for LLMOps. LLMOps specifics: prompt/versioning, offline/online LLM evals, safety filters, guardrails; caching. Cost governance: right-sizing, spot instances, quantization/distillation; green AI considerations.	05 Hrs

Text/Reference Books:

1. Practical MLOps: Operationalizing Machine Learning Models by Noah Gift and Alfredo Deza (latest edition).
2. Machine Learning Production Systems: Engineering Machine Learning Models and Pipelines by Carl Osipov (latest edition).
3. Building Machine Learning Pipelines by Hannes Hapke and Catherine Nelson (latest edition).
4. Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications by Chip Huyen.
5. MLOps Engineering at Scale by Carl Osipov.
6. Introducing MLOps: How to Scale Machine Learning in the Enterprise by Mark Treveil and The Dataiku Team.

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**Data Mining and Analysis**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Data Analysis Foundations:** Data, Matrix, Attributes, Numeric Attributes, Categorical Attributes, Graph Data, Kernel Methods, High-dimensional Data.	06 Hrs
2	**Data Preprocessing:** Cleaning, Integration, Reduction, Transformation, Discretization.	06 Hrs
3	**Frequent Pattern Mining:** Itemset Mining, Summarizing Itemsets, Sequence Mining, Graph Pattern Mining, Pattern and Rule Assessment.	06 Hrs
4	**Clustering:** Representative-based Clustering, Hierarchical Clustering, Density-based Clustering, Spectral and Graph Clustering, Clustering Validation.	05 Hrs

Text/Reference Books:

1. Mohammed J. Zaki and Wagner Meira Jr.. Data Mining and Analytics: Fundamentals Concepts and Algorithms. Cambridge University Press, 2014.
2. Jiawei Han and Micheline Kamber. Data Mining: Concepts and Techniques. Morgan Kaufmann, 2006.
3. Pang-Ning Tan, Michael Steinbach, Vipin Kumar. Data Mining. Pearson Education Limited, 2014.

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**Time Series Analysis**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction:** Definition, components (trend, seasonality, cycle, noise), and types of time series data. Time Series Visualization and Descriptive Statistics, Concept of stationarity, methods for testing stationarity, and transformations to achieve stationarity. White Noise and Random Walks.	06 Hrs
2	**Linear Models for Forecasting:** Autoregressive (AR), Moving Average (MA), and ARMA Models, ARIMA and SARIMA Models, SARIMAX model, model identification using ACF/PACF plots, and model selection, Exponential smoothing, forecast combinations: hierarchical & grouped reconciliation.	08 Hrs
3	**Multivariate & Causal Time Series:** Univariate Time Series Forecasting with Prophet. State-Space Models and Kalman Filtering, Vector Autoregression (VAR) models for multivariate time series, Cointegration and Granger Causality, Hidden Markov Models (HMM) for time series segmentation and classification.	06 Hrs
4	**Volatility, Anomalies & Probabilistic Forecasting:** Conditional heteroscedasticity: ARCH/GARCH variants; volatility forecasting, Anomaly / Change-point detection (residual, density, and Bayesian methods), Evaluation beyond point forecasts: prediction intervals, coverage, Winkler score, CRPS, Probabilistic forecasting & simulation; backtesting and rolling-origin evaluation.	06 Hrs
5	**Machine Learning and Deep Learning for Time Series:** Time Series Forecasting as a Supervised Learning Problem. Feature Engineering for Time Series, Traditional ML Models for Time Series, Deep Learning Models: Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks (CNNs). Temporal Fusion Transformers (TFT) and Informer models.	06 Hrs

Text/Reference Books:

1. Rob J Hyndman and George Athanasopoulos (2021), Forecasting: Principles and Practice (3rd Edition).
2. Manu Joseph (2022), Modern Time Series Forecasting with Python.
3. Jason Brownlee (2018), Deep Learning for Time Series Forecasting: Predict the Future with
4. MLPs, CNNs and LSTMs in Python.
5. Robert H. Shumway and David S. Stoffer (2017), Time Series Analysis and Its Applications: With R Examples (4th Edition).
6. Ben Auffarth (2021), Machine Learning for Time-Series with Python.
7. Brockwell, P.J., & Davis, R.A, Introduction to Time Series and Forecasting, 3rd ed., Springer (latest widely used edition).

Teaching Scheme	Semester I	Examination Scheme
TH 3 PR 0 CR 3	**Blockchain Technology**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit	Topic	Hours
1	**Foundations of Blockchain and Distributed Ledger Technologies:** Evolution of Blockchain: From Bitcoin to Web3, Distributed systems and peer-to-peer networks, Consensus mechanisms: PoW, PoS, DPoS, PBFT, etc.; Types of blockchains: Public, Private, Consortium, Hybrid Forks and scalability challenges; **Cryptography and Security in Blockchain:** Hash functions, Merkle trees, and digital signatures, Public Key Infrastructure (PKI), Zero-knowledge proofs, Homomorphic encryption, Secure key management and wallets, Attacks and defenses: Sybil, 51%, Eclipse, Replay.	06 Hrs
2	**Blockchain Architecture and Protocols:** Bitcoin protocol deep dive, Ethereum architecture and EVM, Hyperledger Fabric architecture, Interoperability and cross-chain communication.	06 Hrs
3	**Smart Contracts and DApp Development:** Lifecycle of smart contracts, Design patterns and security pitfalls, DApp architecture and integration, Decentralized storage: IPFS, Arweave, Filecoin, Frontend integration with blockchain; **Advanced Blockchain Platforms and Ecosystems:** Polkadot, Solana, Cardano, Avalanche, Layer 2 scaling: Lightning Network, Optimistic & ZK Rollups, Interoperability frameworks: Cosmos, Chainlink, IBC, Blockchain oracles and middleware solutions.	06 Hrs
4	**Blockchain in Industry Domains:** Finance & DeFi: Stablecoins, AMMs, Yield Farming, Supply Chain & Logistics: Provenance tracking, traceability, Healthcare: Data sharing, privacy-preserving records, Governance, Voting, and Digital Identity, Tokenization of assets and NFTs.	05 Hrs
5	**Regulations, Ethics, and Economics of Blockchain:** Global blockchain regulations (EU, US, India, etc.), Taxation and compliance (FATF, GDPR, RBI guidelines), Tokenomics and crypto-economics, Ethical and societal implications.	05 Hrs

Text / Reference Books:

1. Melanie Swan, “Blockchain: Blueprint for a New Economy”, O’Reilly, 2015.
2. Andreas Antonopoulos, “Mastering Bitcoin: Unlocking Digital Cryptocurrencies”, O’Reilly, 2014.
3. Iran Bashir “Mastering Blockchain”, Second Edition Paperback, 2018.
4. Daniel Drescher, “Blockchain Basics”, First Edition, Apress, 2017.
5. Ritesh Modi, “Solidity Programming Essentials: A Beginner’s Guide to Build Smart Contracts for Ethereum and Blockchain”, Packt Publishing.

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**Natural Language Processing**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction:** Knowledge of Natural Language Processing, Ambiguity, Models and Algorithms, Text representation in computers, encoding schemes, Regular expressions, Finite State Automata, word recognition, lexicon.	06 Hrs
2	**Grammar and NLP Stages:** NLP grammar, POS and POS schemes, Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, named entities, multiword expressions, lexical analyzer, Parsing, Stemming, Smoothing and Interpolation Names Entity Recognition, Semantics- Meaning representation, semantic analysis, lexical semantics, WordNet, Word Sense Disambiguation- Selectional restriction, machine learning approaches, and dictionary based approaches.	06 Hrs
3	**Pragmatics:** Discourse, Reference Resolution, Reference Phenomena, Syntactic and Semantic Constraints on Coreference, Preferences in Pronoun Interpretation, Text Coherence and Inference Based Resolution Algorithm, Corpora: elements in balanced corpus, Concordance and corpora, characteristics of Gold Standard Corpora.	06 Hrs
4	TreeBank, PropBank, WordNet, VerbNet etc. Resource management with XML, Management of linguistic data with the help of GATE, NLTK. Parallel Corpus, Comparable corpus, Inter-Annotator Agreement Tests, kappa statistics, Corpus annotation tools	05 Hrs
5	**N-GRAMS:** Counting words in Corpora, N-Gram probabilities, Training and Test sets, Evaluating N-Gram Perplexity. Machine Translation and Performance Metrics Machine Translation issues, MT Evaluation, automatic evaluation BLEU, METEOR, ORANGE, Information Retrieval: Vector space model, term weighting, homonymy, polysemy, synonymy, improving user queries.	05 Hrs

Text/Reference Books:

1. Speech and Language Processing by Daniel Jurafsky and James H. Martin, Prentice Hall.
2. Language as a Cognitive Process by T. Winograd, Addison-Wesley.
3. Natural Language Understanding by James Allen, the Benajmins / Cummings.
4. Natural language processing: a Paninian perspective by A. Bharati, R. Sangal, and V. Chaitanya, PHI.

Teaching Scheme						Semester I	Examination Scheme					
TH	3	PR	0	CR	3	**Optimization Techniques**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	Historical Development; Engineering applications of Optimization; Art of Modeling, Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems. Classification of optimization problems, Optimization techniques - classical and advanced techniques, Introduction to Operation Research: Operation Research approach, scientific methods, introduction to models and modeling techniques, general methods for Operation Research models, methodology and advantages of Operation Research, history of Operation Research.	06 Hrs
2	**Linear Programming (LP):** Introduction to LP and formulation of Linear Programming problems, Graphical solution method, alternative or multiple optimal solutions, Unbounded solutions, Infeasible solutions, Maximization – Simplex Algorithm, Minimization – Simplex Algorithm using Big-M method, Two phase method, Duality in linear programming, Integer linear programming.	06 Hrs
3	**Allocation problems and Game Theory:** Introduction to Transportation problems, Transportation problem–Methods of basic feasible solution-Optimal solution MODI Method. Assignment problem-Hungarian method Game theory: Two people-zero sum game-mixed stages -Dominance properties	06 Hrs
4	Sequential optimization; Representation of multi stage decision process, Types of multi stage decision problems; Concept of sub optimization and the principle of optimality. Recursive equations–Forward and backward recursions; Computational procedure in dynamic programming (DP), Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP; Problem formulation and application in Design of continuous beam and optimal geometric layout of atruss.	05 Hrs
5	**Network Analysis:** Network definition and Network diagram, probability in PERT analysis, project time cost trade off, introduction to resource smoothing and allocation Sequencing: Introduction, processing N jobs through two machines, processing N jobs through three machines, processing N jobs through m machines. Inventory Model: Introduction to inventory control, deterministic inventory model, EOQ model with quantity discount	05 Hrs

Text/Reference Books:

1. Hamdy A. Taha, Operations Research, Prentice Hall, Pearso.
2. J. S Arora, Introduction to optimum design, IInd edition, Elsevier India Pvt. Ltd.
3. S. S Rao, Optimization: theory and application, Wiley Eastern Ltd., New Delhi.

4. Wayne L. Winston - Operations Research_ Applications and Algorithms-Duxbury Press (2003).
5. Ravindra K. Ahuja, Thomas L. Magnanti, and James B. Orlin, Network Flows: Theory, Algorithms, and Applications, Pearson.
6. J K Sharma, Operations Research Theory and Applications, MacMillan India Ltd.
7. N D Vohra, Quantitative Techniques in management, Tata McGraw Hill.
8. Payne T A, Quantitative Techniques for Management: A Practical Approach, Reston . Publishing Co. Inc., Virginia.
9. AchilleMessac, Optimization in practice with MATLAB, Cambridge University Press, 2015.

Teaching Scheme	Semester I	Examination Scheme
TH 3 PR 0 CR 3	**Learning Analytics**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction to Learning Analytics:** Definition, importance, and applications, Ethical and Privacy issues Student data in Learning Analytics, Data Collection and Preprocessing, Types of educational data (e.g., clickstream, assessment). Data collection methods and tools. Data preprocessing and cleaning.	06 Hrs
2	**Descriptive Analytics:** Basic statistics and visualisations for educational data, Identifying patterns, trends, and outliers.	06 Hrs
3	**Predictive Analytics:** Regression analysis for educational outcomes, Classification for student performance prediction.	06 Hrs
4	**Personalised Learning Paths:** Adaptive learning systems, Recommender systems for educational content.	05 Hrs
5	**Social Network Analysis in Educational Contexts:** Analyzing collaborative learning patterns, Identifying influential students and groups	05 Hrs

Text / Reference Books:

1. The Handbook of Learning Analytics, 1st edition, Charles Lang, George Siemens, Alyssa Wise, Dragan Gašević Weka – Machine Learning Software.
2. https://onlinecourses.nptel.ac.in/noc19_ge20/preview.

Teaching Scheme	Semester I	Examination Scheme
TH 3 PR 0 CR 3	**Research Methodology**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit	Topic	Hours
1	Research Concepts – concepts – meaning – objectives – motivation. Types of research – descriptive research – conceptual research – theoretical research – applied research – experimental research.	06 Hrs
2	Research process – Criteria for good research – Problems in Indian context. Formulation of Research Task – Literature Review – Importance & Methods – Sources – Quantification of Cause Effect Relations – Discussions– Field Study – Critical Analysis of Facts Generated	06 Hrs
3	Hypothetical proposals for future development and testing, selection of Research tasks.	06 Hrs
4	Mathematical modeling and simulation – Concepts of modeling – Classification of mathematical models – Modeling with – Ordinary differential equations – Difference equations – Partial differential equations – Graphs – Simulation – Process of formulation of model based on simulation.	05 Hrs
5	Interpretation and report writing – Techniques of interpretation – Precautions in interpretation - Significance of report writing – Different steps in report writing – Layout of research report – Mechanics of writing research report – Layout and format – Style of writing – Typing – References – Tables – Figures – Conclusion – Appendices. Applications of statistical methods in research.	05 Hrs

Text/Reference Books:

1. W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
2. Schank Fr., Theories of Engineering Experiments, Tata McGraw Hill Publication.
3. C. R. Kothari, Research Methodology, New Age Publishers.
4. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.

Teaching Scheme	Semester I	Examination Scheme
TH 0 PR 4 CR 2	**Software Lab - I**	CA 60 MSE - ESE 40

List of Experiments:

1. Create a single Python script that generates a scatter plot, a line plot, and a bar chart using Matplotlib for a given dataset, ensuring each plot has proper labels and a title.
2. Using a public dataset (e.g., Titanic), create a pairplot to visualize relationships between numerical features and a heatmap to show feature correlations using Seaborn.
3. Build an interactive scatter plot of the Iris dataset using Plotly, allowing users to hover over points to see details and click to highlight data points.
4. Design and implement a simple dashboard using Dash (a framework for building web apps with Python), displaying at least three linked plots for a chosen dataset.
5. Choose a real-world dataset and create a series of 3-4 plots that tell a clear story, annotating the plots with text to guide the viewer through the narrative.
6. Apply PCA or t-SNE to a high-dimensional dataset (e.g., a handwritten digits dataset) and create a 2D scatter plot of the reduced dimensions to visualize clusters.
7. Use a Python library like NetworkX and Matplotlib to visualize a social network or an airline route network as a graph, with nodes and edges representing entities and their connections.
8. Create a choropleth map of India showing population density by state, using a library like Folium or GeoPandas.
9. Implement a KPI dashboard in Tableau or Power BI: parameterized filters, actions/drill-through, and at least one forecast/explainability visual from an ML model. Provide a short usability test & heuristics report.
10. For a trained model (classification or regression), build explainability views: feature importance, PDP/ICE or SHAP-inspired charts, calibration plot, error analysis. Package as an interactive report (Altair/Plotly or BI).

Teaching Scheme	Semester I	Examination Scheme
TH 0 PR 4 CR 2	**Software Lab - II**	CA 60 MSE - ESE 40

List of Experiments:

1. Implement Gradient Descent from scratch to find the minimum of a simple 1D quadratic function. Visualize the descent path.
2. Extend the Gradient Descent implementation to find the minimum of a 2D function like the Sphere or Beale function. Plot the contour lines and the convergence path.
3. Implement Mini-batch Gradient Descent and compare its convergence speed with full-batch Gradient Descent on a simple linear regression problem.
4. Implement a Newton's Method and compare its convergence rate with Gradient Descent on a convex function. Analyze the number of iterations required for both.
5. Use the scipy.optimize library to solve an unconstrained problem. Compare the results of different built-in solvers (e.g., BFGS, CG, Newton-CG).
6. Use a constrained optimization library (scipy.optimize.minimize) to solve a simple problem with a single equality constraint using the Lagrange Multiplier method.
7. Implement a basic Genetic Algorithm from scratch to solve a simple function optimization problem. Experiment with different crossover and mutation rates.
8. Apply a pre-built meta-heuristic solver (e.g., from pygad) to solve a combinatorial problem like the Traveling Salesperson Problem (TSP) for a small number of cities.
9. Train a simple neural network using different built-in optimizers in TensorFlow or PyTorch (e.g., SGD, Adam, Adagrad). Compare and report the training and validation losses for each.
10. Select an optimization technique from Unit VI (Self-Study) and apply it to a real-world dataset or a Kaggle competition problem. Document the problem formulation, chosen algorithm, and results in a concise report.

Teaching Scheme	Semester I	Examination Scheme
TH 2 PR 0 CR 2	**Indian Knowledge System**	CA 60 MSE - ESE 40

COURSE CONTENT

Unit	Topic	Hours
1	An overview of Indian Knowledge System (IKS): Importance of Ancient Knowledge - Definition of IKS - Classification framework of IKS - Unique aspects of IKS. The vedic corpus: Vedas and Vedangas - Distinctive features of vedic life.	03 Hrs
2	Indian philosophical systems: Different schools of philosophy. Wisdom through the ages: Puranas – Ithihasas - Niti shastras - Subhasitas. Linguistics: Components of a language - Paṇini's work on Sanskrit grammar - Phonetics in Sanskrit and the role of Sanskrit in natural language processing.	04 Hrs
3	The knowledge triangle: Prameya, Pramaṇa, Saṃsaya - Framework for establishing valid knowledge - Potential fallacies in the reasoning process. Salient features of the Indian numeral system - Importance of decimal representation - The discovery of zero and its importance - Unique approaches to represent numbers.	03 Hrs
4	Unique aspects of Indian mathematics - Great mathematicians and their significant contributions in the area of arithmetic, algebra geometry, trigonometry, combinatorial problems in Chandaḥ-sastra of Pingala, binary mathematics and Magic squares in India. Highlights of Indian Astronomy: Historical development of astronomy in India - The Celestial Coordinate System - Astronomical terminologies - Equinotical points, precession of eqinoxes, movable and fixed zodiac - Elements of the Indian Calendar - Panchanga.	03 Hrs
5	Indian science and technology heritage - Metals and metalworking - Mining and ore extraction - Extraction of iron from Biotite by indigenous techniques - Manufacture of steel - Lost wax casting of idols and artefacts - Tools employed for extraction of metallic components. Physical structures in India - Irrigation and water management - Dyes and painting technology - Surgical Techniques - Shipbuilding - Sixty-four art forms (64 Kalas) - Status of indigenous science and technology	03 Hrs

Text/Reference Books:

1. A. K. Bag, History of Technology in India, Vol. I, Indian National Science Academy, New Delhi, 1997.
2. D. N. Bose, S.N. Sen and B. V. Subbarayappa, A Concise History of Science in India, Indian National Science Academy, New Delhi, 2009.
3. B. Datta and A. N. Singh, History of Hindu Mathematics: Parts I and II, Asia Publishing House, Bombay, 1962.

4. M. Hiriyanna, M., Outlines of Indian Philosophy, Motilal Banarsidass, New Delhi, 1994.
5. B. Mahadevan, Vinayak Rajat Bhat, and R.N. Nagendra Pavana, Introduction to Indian Knowledge System: Concepts and Applications, PHI Learning Private Limited, New Delhi, 2022.
6. S. N. Sen and K. S. Shukla, History of Astronomy in India, Indian National Science Academy, 2nd edition, New Delhi, 2000.

Semester - II

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**Theoretical Foundations of Machine Learning**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**PAC Learning:** Agnostic probably approximately correct (PAC) learning model, loss functions, true and empirical risk, uniform convergence, no-free-lunch theorem, growth functions and VC dimension, VC dimension of various classes such as hyperplanes and polynomials, the fundamental theorem of PAC learning, non-uniform PAC learning, principles underlying model selection, validation and k-fold cross validation.	06 Hrs
2	**Convex Learning:** PAC learnability of hyperplanes, linear programming and perceptron algorithms, convex loss functions, mean squared loss, hinge loss and logistic regression functions, surrogate loss functions, regularized loss functions and stability, learnability of Convex Lipschitz bounded and smooth bounded learning problems using the stochastic gradient descent (SGD) algorithm, sample complexity of convex learning problems.	06 Hrs
3	**Applications of SGD:** Support vector machines (SVM): dual formulation, SGD implementation of soft-SVM, implementation of soft SVM with kernels, linear multiclass predictors, multiclass SVM with SGD, linear predictors for bipartite ranking, Feed-forward neural networks, expressive power and sample complexity, SGD and backpropagation.	06 Hrs
4	**Supervised Learning:** Learning a Class, Vapnik-Chervonenkis Dimension, Probably Approximately Correct Learning, Regression, Model Selection and Generalization, Multilayer Perceptrons, Kernel Machines, Markov Models and Hidden Markov Models	05 Hrs

Text/Reference Books:

1. S. S. Schwartz and S. Ben David, Understanding Machine Learning: From Theory To Algorithms, 3rd ed., India: Cambridge University Press, 2015.
2. M. Mohri, A. Rostamizadeh and A. Talwalkar, Foundations of Machine Learning, 3rd ed, India: MIT Press, 2018.
3. C. M Bishop, Pattern Recognition and Machine Learning, 1st ed Springer, 2006.
4. Alpaydin, E., Machine learning, 4th ed., MIT Press, 2021.
5. Margaret M. Fleck, “l”, University of Illinois, Urbana-Champaign, 2013.

Teaching Scheme	Semester II	Examination Scheme
TH 3 PR 0 CR 3	**Quantum AI**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction:** Learning theory and data mining, quantum like classical computers Cantor's diagonal argument, complexity theory, Decision problems, P and NP, Church–Turing Thesis, Von Neumann architecture, Problem Solving, Rules, Logic-based operators, Frames, Categorial representation, Binary vector representation, Production System, Deduction systems, Reaction systems, Conflict resolution, Human problem-solving, Information and measurement, Reversible Computation, Reversible circuits, Toffoli gate.	06 Hrs
2	Introduction to quantum physics, Unitary Evolution, Quantum Mechanics, Hilbert space, Quan- tum Time Evolution, Von Neumann Entropy, Measurement, Heisenberg's uncertainty principle, Randomness, Computation with Qubits, Computation with m Qubit, Matrix Representation of Serial and Parallel Operations, Quantum Boolean Circuits, Periodicity, Quantum Fourier Transform, Unitary Transforms, Search and Quantum Oracle, Grover's Amplification, Circuit Representation, Speeding up the Traveling Salesman Problem, The Generate-and-Test Method, Quantum Problem-Solving, Heuristic Search, Quantum Tree Search, Tarrataca's Quantum Production System.	08 Hrs
3	A General Model of a Quantum Computer, Cognitive architecture, Representation, Quantum Cognition, Decision making, Unpacking Effects, Quantum Walk on a graph, Quantum annealing, Optimization problems, Quantum Neural Computation, Applications on Quantum annealing Computer, Development libraries, Quantum Computer simulation tool kits.	06 Hrs
4	Data-driven models, supervised and unsupervised learning, generalization performance, ensembles, data dependencies, and examples.	06 Hrs
5	Pattern Recognition and Neural Networks, perception, Hopfield Networks, Feedforward networks, Deep learning, computational complexity.	06 Hrs

Text/Reference Books:

1. Isaac Chuang, Michael Nielsen, Quantum Computation and Quantum Information, 10th Anniversary Edition, Cambridge University Press, 2011.
2. Maria Schuld, Ilya Sinayskiy, Francesco Petruccione, An introduction to quantum machine learning, 2014.
3. S. Bhattacharyya, I. Pan, A. Mani, S. De, E. Behrman, S. Chakraborti (Eds.), Quantum Machine Learning, Walter de Gruyter, Berlin, 2020.
4. P. Wittek, Quantum Machine Learning, Elesevier, Amsterdam 2014.

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**Computer Vision**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Digital Image Processing:** Fundamentals, Types of Image Processing, Image Acquisition Methods, Human Perception of Color and Images, Phases of computer Vision and its Applications, Different color Models: RGB, YCbCr, CMYK, HSV, LAB, YIQ and their conversion, Relation Between a pixels: Neighborhood, Adjacency/connectivity, Connected components, Region and Boundaries, Arithmetic logic operations on pixels, Distance Measures.	06 Hrs
2	**Low-level Image Processing:** Image Enhancement in Spatial Domain -Histogram Processing, Contrast Stretching, Log Transformation, Gamma Correction, Smoothing and Sharpening; Logical and Arithmetic Operations, Morphological Image Processing, Image Enhancement in Frequency Domain, Fourier Transform, Convolution and Filtering, Image Restoration.	06 Hrs
3	**Image Feature Extraction:** Edge detection – Canny, Sobel, Prewitt, LOG, DOG, Line detector: Hough Transform; Corner detectors – Harris and Hessian Affine; Orientation Histogram, SIFT, SURF, HOG, GLOH, Gaussian derivative filters, Gabor Filters and DWT, Histogram processing, Histogram Equalization Histogram Specification.	06 Hrs
4	**Image Segmentation:** Edge-based Approaches to Segmentation, Texture Segmentation, Object Detection and Segmentation, Similarity-based: Thresholding, Region growing, Region splitting and merging, Discontinuity-based: Use of point, line and edge for segmentation.	05 Hrs
5	**Motion Analysis:** Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis.	05 Hrs

Text/Reference Books:

1. Computer Vision: A Modern Approach, D. A. Forsyth and J. Ponce, Pearson Education, 2003. (693 pages), ISBN: 9780130851987.
2. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer-Verlag, 2011. (832 pages), ISBN: 978-1848829343.
3. Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, Pearson Education, 2008. (976 pages), ISBN: 9788131726952.

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**Deep Reinforcement Learning**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	Overview of reinforcement learning, Difference between supervised, unsupervised, and reinforcement learning, Components of reinforcement learning (agent, environment, state, action, reward, transaction function, Discount, episode), Bandit problem.	06 Hrs
2	Understanding Markov Decision Processes (MDPs), Policy, State value function, Action value function, Bellman equation, Dynamic Programming—Policy iteration, Policy Improvement, Value iteration, and Limitations of dynamic programming.	06 Hrs
3	Exploration and exploitation strategies- Random, Greedy, Epsilon-Greedy, Softmax, UCB. Monte Carlo Methods: First-Visit Monte Carlo, Every-Visit Monte Carlo, Monte Carlo simulation for policy evaluation.	06 Hrs
4	Temporal Difference Learning (TD), n-step TD, Q-learning, SARSA, bootstrapping.	06 Hrs
5	Function Approximation, linear function approximation, Deep Q-networks (DQN), Double Deep Q-networks (DDQN), Dueling Q-networks (Dueling DQN), Policy gradient methods, and Actor Critic methods.	07 Hrs

Text/Reference Books:

1. Reinforcement Learning: An Introduction, by Richard S. Sutton and Andrew G. Barto.
2. Grokking Deep Reinforcement Learning by Miguel Morales, 2020
3. Alexander Zai, Brandon Brown, Deep Reinforcement Learning in Action, 2020, 1st Edition, Manning Publications.
4. Mohit Sewak, Deep Reinforcement Learning: Frontiers of Artificial Intelligence, 2019, Springer.
5. Sugiyama, Masashi, Statistical reinforcement learning: modern machine learning, 2015, Chapman and Hall.

Teaching Scheme	Semester II	Examination Scheme
TH 3 PR 0 CR 3	**Agentic AI**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction to AI Agents and LLM:** Distinction between traditional AI, Generative AI, and Agentic AI. Core components of an intelligent agent: perception, memory, planning, and tool use. LLM architecture (e.g., Transformers). Pre-training, fine-tuning, and transfer learning. Working with open-source and API-based LLMs.	06 Hrs
2	**Prompt Engineering and Retrieval-Augmented Generation (RAG):** Advanced prompting techniques like Chain-of-Thought (CoT), ReAct (Reasoning + Acting), and reflection. Engineering effective prompts for guiding agent behavior. RAG architecture, vector databases, embeddings, and document loaders. Advanced agentic RAG for intelligent information retrieval.	06 Hrs
3	**AI Agent Frameworks and Multi-Agent Systems (MAS):** In-depth study of popular frameworks like LangChain, LangGraph, AutoGen, and CrewAI. Building custom agents using these frameworks. Designing multi-agent architectures. Patterns for agent collaboration, communication, and task orchestration.	06 Hrs
4	**Agentic Workflows and Design Patterns:** Exploring design patterns such as sequential coordination, parallel execution, and the Evaluator-Optimizer loop.	05 Hrs
5	**Memory and State Management:** Implementing short-term and long-term agent memory. Using vector databases for knowledge retrieval and state management in multi-turn interactions.	06 Hrs

Text/Reference Books:

1. The Elements of Statistical Learning by Trevor Hastie, Robert Tibshirani, and Jerome Friedman.
2. Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville.
3. Neural Networks and Deep Learning: A Textbook by Charu C. Aggarwal.
4. Hands-On Large Language Models: Language Understanding and Generation by Jay Alammar.
5. Generative AI with Python and TensorFlow 2 by Boris Dayma and Daniel D. S. Garcia.
6. Agentic AI Handbook: Design Patterns by Mark Lane.
7. Designing Agentic AI Systems: Patterns, Protocols, and Frameworks for LangGraph, MCP, and AutoGen by Todd Chandler.

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**AI Ethics**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction to AI Ethics:** Understanding the intersection of AI and ethics, Historical perspectives on technology ethics, Key ethical principles and frameworks relevant to AI, Ethical considerations in AI research, development, and deployment, Case studies: Ethical dilemmas in AI applications.	06 Hrs
2	**Bias and Fairness in AI:** Understanding algorithmic bias and its consequences Identifying sources of bias in AI data and algorithms Fairness metrics and techniques for bias mitigation Ensuring equitable representation in training data Case studies: Real-world examples of bias in AI systems.	06 Hrs
3	**Transparency and Accountability:** Importance of transparency in AI decision-making, Interpretable machine learning and explainable AI, Ethical considerations in black-box AI systems, Algorithmic accountability and responsibility, Case studies: Exploring transparency challenges in AI applications.	06 Hrs
4	**Privacy and Data Ethics:** Privacy implications of AI technologies, Data collection, consent, and anonymization, Privacy-preserving AI techniques, Ethical considerations in data sharing and aggregation, Case studies: Privacy breaches and ethical implications.	05 Hrs
5	**Societal Impact and Future Directions:** Ethical considerations in AI's impact on employment and economy: AI and social inequality: Digital divide, job displacement, and more, Global perspectives on AI ethics and regulation, Ethical design for AI-driven automation, Future challenges and ethical considerations in advanced AI technologies.	06 Hrs

Text/Reference Books:

1. Ethics of Artificial Intelligence and Robotics by Vincent C. Müller.
2. Artificial Intelligence Safety and Ethics by Roman V. Yampolskiy.
3. Data and Goliath: The Hidden Battles to Collect Your Data and Control Your World" by Bruce Schneier.
4. Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy by Cathy O'Neil.
5. The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power by Shoshana Zuboff.
6. Algorithms of Oppression: How Search Engines Reinforce Racism by Safiya Umoja Noble
7. Automating Inequality: How High-Tech Tools Profile, Police, and Punish the Poor by Virginia Eubanks.
8. The Ethical Algorithm: The Science of Socially Aware Algorithm Design by Michael Kearns and Aaron Roth.

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**Entrepreneurship**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction to Entrepreneurship:** Understanding the entrepreneurial mindset, Overview of the startup ecosystem, Role of innovation in entrepreneurship, Identifying and evaluating entrepreneurial opportunities, Case studies: Successful tech startup stories	06 Hrs
2	**Ideation and Innovation:** Techniques for generating innovative ideas, Problem-solving and design thinking for startups, Prototyping and MVP (Minimum Viable Product) development, Intellectual property rights and technology innovation, Case studies: Turning ideas into marketable solutions	06 Hrs
3	**Business Strategy and Planning:** Developing a viable business model canvas, Market analysis and customer segmentation, Value proposition and competitive positioning, Revenue models and pricing strategies, Case studies: Building a solid business strategy	06 Hrs
4	**Funding and Financial Management:** Sources of funding: Bootstrapping, angel investors, venture capital, etc., Pitching and presenting to investors, Financial planning and projections for startups, Managing finances and tracking key metrics, Case studies: Fundraising and financial challenges	05 Hrs
5	**Launch, Growth, and Scaling:** Building a strong startup team and company culture, Product launch strategies and marketing for startups, Customer acquisition and retention in a tech startup, Scaling challenges and expansion strategies, Case studies: Scaling up successful technology startups	06 Hrs

Text/Reference Books:

1. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries.
2. Zero to One: Notes on Startups, or How to Build the Future by Peter Thiel.
3. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail by Clayton M. Christensen.
4. Founders at Work: Stories of Startups' Early Days by Jessica Livingston.
5. Hooked: How to Build Habit-Forming Products by Nir Eyal.
6. Disciplined Entrepreneurship: 24 Steps to a Successful Startup by Bill Aulet.
7. Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist by Brad Feld and Jason Mendelson.
8. The Art of Startup Fundraising by Alejandro Cremades.
9. The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company" by Steve Blank and Bob Dorf.

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**Sustainability Engineering**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction to Sustainability Engineering:** Understanding the concept of sustainability in engineering,Triple bottom line: Environmental, social, and economic aspects, Role of computer engineers in sustainable technology development,Ethical considerations in sustainable engineering, Case studies: Success stories in sustainable technology innovation	06 Hrs
2	**Sustainable Design and Development:** Principles of sustainable design in computer engineering, Life cycle assessment (LCA) of technology products, Design for energy efficiency and resource conservation, Eco-friendly materials and manufacturing processes, Case studies: Sustainable design practices in electronic products	06 Hrs
3	**Energy Efficiency and Renewable Technologies:** Energy consumption and environmental impact of computing systems, Green computing strategies and energy-efficient algorithms, Renewable energy sources for powering technology, Smart energy management and energy-aware computing, Case studies: Energy-efficient data centers and computing devices	06 Hrs
4	**E-Waste Management and Circular Economy:** The problem of electronic waste (e-waste) and its environmental impact, Recycling and responsible disposal of electronic products, Circular economy principles and their relevance to technology, Design for disassembly, repair, and reusabilit, Case studies: E-waste management initiatives and circular design examples	05 Hrs
5	**Social Impact and Global Perspectives:** Social implications of technology: Digital divide, accessibility, and equity, Sustainable technology adoption in developing countries, Global efforts towards sustainable development goals (SDGs), Technological solutions for environmental monitoring and conservation, Case studies: Technology for social good and sustainable development	06 Hrs

Text/Reference Books:

1. Sustainable Engineering: Concepts, Design, and Case Studies by David T. Allen and David R. Shonnard.
2. Design for Sustainability: A Sourcebook of Integrated, Eco-logical Solutions by Janis Birkeland.
3. Green IT: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line by Toby Velte, Anthony Velte, and Robert Elsenpeter.
4. E-Waste Management: From Waste to Resource edited by Florin-Constantin Mihai.
5. Cradle to Cradle: Remaking the Way We Make Things by William McDonough and Michael Braungart.
6. The Upcycle: Beyond Sustainability—Designing for Abundance by William McDonough and Michael Braungart.

7. The Responsible Company: What We've Learned From Patagonia's First 40 Years by Yvon Chouinard and Vincent Stanley.
8. Sustainable IT Architecture: The Progressive Way of Overhauling Information Systems with Sustainability by Guenther Ruhe and Janusz Górski.

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**Geospatial Data Analysis**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction to Geospatial Data:** Overview of Geospatial Science and its applications in engineering and environmental systems; Components of GIS, GPS, and Remote Sensing; Types of geospatial data: spatial, non-spatial, raster, and vector; Coordinate systems, map projections, and georeferencing; Data acquisition techniques: satellite imagery, LiDAR, UAV, and field surveys.	06 Hrs
2	**Spatial Data Models and Management:** Vector and raster data models: structure, storage, and operations; Attribute data management using relational databases; Spatial data quality, accuracy, and metadata; Introduction to spatial databases (PostGIS, SpatiaLite); Data preprocessing and integration for analysis.	06 Hrs
3	**Spatial Analysis and Geoprocessing:** Spatial operations: buffering, overlay, intersection, and proximity analysis; Digital terrain analysis: slope, aspect, and watershed delineation; Spatial interpolation and surface analysis; Hotspot and cluster analysis; Network analysis and spatial accessibility modeling.	06 Hrs
4	**Remote Sensing and Image Analysis:** Fundamentals of remote sensing and electromagnetic spectrum; Image preprocessing: radiometric, geometric, and atmospheric corrections; Image classification: supervised and unsupervised techniques; Change detection and land cover mapping; Integration of remote sensing data with GIS.	05 Hrs
5	Advanced Topics and Applications: Geospatial data visualization and web mapping (ArcGIS Online, QGIS Web, Leaflet); Machine learning and AI applications in geospatial analysis; Spatial statistics and modeling; Case studies: urban planning, environmental monitoring, disaster management, transportation, and agriculture; Open data sources and ethical use of geospatial data.	06 Hrs

Text/Reference Books:

1. Burrough, P.A., McDonnell, R.A., and Lloyd, C.D., Principles of Geographical Information Systems, Oxford University Press.
2. Heywood, I., Cornelius, S., and Carver, S., An Introduction to Geographical Information Systems, Pearson Education.
3. Jensen, J.R., Introductory Digital Image Processing: A Remote Sensing Perspective, Pearson.
4. Longley, P.A. et al., Geographical Information Systems and Science, Wiley.
5. Tomlinson, R., Thinking About GIS: Geographic Information System Planning for Managers, Esri Press.

Teaching Scheme	Semester II	Examination Scheme
TH 3 PR 0 CR 3	**Graph Databases**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit	Topic	Hours
1	**Introduction:** What Is a Graph? A High-Level View of the Graph Space Graph Databases Graph Compute Engines The Power of Graph Databases Performance Flexibility Agility Options for Storing Connected Data. Relational Databases Lack Relationships NOSQL Databases Also Lack Relationships Graph Databases Embrace Relationships	06 Hrs
2	**Data Modeling with Graphs**: Models and Goals The Labeled Property Graph Model Querying Graphs: An Introduction to Cypher, A Comparison of Relational and Graph Modeling, Cross-Domain Models, Common Modeling Pitfalls, Identifying Nodes and Relationships Avoiding Anti-Patterns	06 Hrs
3	**Building a Graph Database Application:** Data Modeling Application Architecture Testing Capacity Planning, Importing and Bulk loading data. Graphs in the real world: Why Organization choose graph data bases Common use cases real world examples	06 Hrs
4	**Graph Database Internals**. Native Graph Processing Native Graph Storage Programmatic APIs Kernel API Core API Traversal Framework Nonfunctional Characteristics Transactions Recoverability Availability Scale	05 Hrs
5	Predictive Analysis with Graph Theory. Depth- and Breadth-First Search Path-Finding with Dijkstra's Algorithm The A* Algorithm Graph Theory and Predictive Modeling Triadic Closures Structural Balance Local Bridges	06 Hrs

Text/Reference Books:

1. Ian Robinson, Graph Databases, New Opportunities for Connected Data, Oreilly

Teaching Scheme						Semester II	Examination Scheme					
TH	3	PR	0	CR	3	**Vector Databases**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	**Multidimensional Point Data:** Range trees, priority search trees,Quad trees, K-d trees, one-dimensional ordering bucket methods, PK trees,	06 Hrs
2	**Object-based and Image-based Representations:** Interior based representation, boundary-based representations, Difference-based compaction methods.	06 Hrs
3	**Intervals and Small Rectangles:** Plane sweep methods and rectangle intersection problems. Plane sweep methods and measure problems. Point-based methods. Area-based methods.	06 Hrs
4	**High Dimensional data:** Best first nearest neighbour finding, depth-first k-nearest neighbour finding, Approximate nearest neighbour finding. Multi-dimensional indexing methods, distance-based indexing methods, dimension reduction methods Embedding methods.	05 Hrs

Text/Reference Books:

1. Hanan Samet, Foundations of Multidimensional and Metric Data Structures, The Morgan Kaufmann Series in Data Management Systems.
2. Borwankar, Nitin. *Vector Databases: A Practical Introduction*. Sebastopol, CA: O'Reilly Media, Inc., 2026

Teaching Scheme	Semester II	Examination Scheme
TH 0 PR 4 CR 2	**Software Lab - III**	CA 60 MSE - ESE 40

List of Experiments:

1. Data preprocessing: Clean, visualize and perform EDA on a tabular dataset (e.g., UCI Heart Disease / Titanic). Tasks: missing value handling, feature encoding, scaling, EDA plots, correlation, train/test split.
2. Implement Linear Regression on a Boston Housing dataset, including model training, evaluation (MSE, R-squared), and visualization of fitted lines.
3. Implementation of Logistic Regression for binary classification on a Breast Cancer dataset. Analyze performance using a confusion matrix, accuracy, precision, and recall.
4. Building a Decision Tree Classifier for the Iris dataset. Visualize the tree and analyze the impact of pruning.
5. Predicting heart disease using a Random Forest or Gradient Boosting Classifier (e.g., XGBoost/LightGBM). Compare the performance with a single Decision Tree. Demonstrate feature importances and effect of depth/regularization.
6. Implementing a multi-class classification model using a Support Vector Machine (SVM) with different kernels on a digit recognition dataset. visualize decision boundaries and perform hyperparameter tuning (C, gamma).
7. Performing clustering on a customer segmentation dataset using K-Means and Hierarchical Clustering. Visualize the clusters and interpret the results.
8. Applying Principal Component Analysis (PCA) for dimensionality reduction on a high-dimensional dataset (e.g., face recognition).
9. Applying a Naive Bayes classifier for spam detection on an email dataset.
10. End-to-end pipeline: data ingestion, model training, evaluation, model versioning, export and a simple deployment demo (e.g., Flask or TensorFlow SavedModel + REST endpoint). Dataset: Choose a classification/regression dataset of interest (e.g., Bike Sharing, House prices). Deliverable: reproducible pipeline, Dockerfile or deployment notes, final report and project presentation.

Teaching Scheme	Semester II	Examination Scheme
TH 0 PR 4 CR 2	**Software Lab - IV**	CA 60 MSE - ESE 40

List of Experiments:

1. Use Neo4j to understand how graph data is stored, connected, and queried in a graph database.
2. Compare relational and graph databases to observe how connected data is handled differently in each system.
3. Design a graph data model for a real-world case by identifying nodes, relationships, and their properties.
4. Use Cypher for querying on graphs such as finding nodes and relationships, filtering data, aggregating results, and finding patterns that connect multiple entities.
5. Implement graph algorithms such as depth-first search, breadth-first search, Dijkstra's, and A* to find paths and analyze connectivity.
6. Apply graph theory concepts such as triadic closures, local bridges, and structural balance to perform predictive analysis.
7. Build a small graph-based application using real-world data and visualize the results using suitable tools.
8. Implement multidimensional data structures such as k-d trees, range trees, and quad trees to perform range and nearest neighbor searches.
9. Perform high-dimensional searches using exact and approximate nearest neighbor methods to analyze performance and accuracy.
10. Integrate and visualize graph and spatial data using visualization tools like Gephi or QGIS to explore relationships and patterns.
11. Implement data import and bulk loading techniques in Neo4j to efficiently add large datasets into a graph database.
12. Analyze graph performance by measuring query execution time, indexing impact, and scalability with increasing data size.
13. Develop a simple recommendation system using graph relationships to suggest connections or items based on user data.
14. Use graph traversal techniques to explore multi-level relationships and understand hierarchical or network structures.
15. Integrate graph databases with Python or Java applications using APIs to perform programmatic querying and analysis.

Semester - III

Teaching Scheme						Semester III	Examination Scheme					
TH	3	PR	0	CR	3	**Intellectual Property Rights**	CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit	Topic	Hours
1	Introduction to IPR: Meaning of property, Origin, Nature, Meaning of Intellectual Property Rights, Introduction to TRIPS and WTO, Kinds of Intellectual property rights—CopyRight, Patent, Trade Mark, Trade; Secret and trade dress, Design, Layout Design, Geographical Indication, Plant. Varieties and Traditional Knowledge.	06 Hrs
2	Patent Rights And Copy Rights— Origin, Meaning of Patent, Types, Inventions which are not patentable, Registration Procedure, Rights and Duties of Patentee, Assignment and license, Restoration of lapsed Patents, Surrender and Revocation of Patents, Infringement, Remedies & Penalties.	06 Hrs
3	Copyright—Origin, Definition & Types of Copyright, Registration procedure, Assignment & license, Terms of Copyright, Piracy, Infringement, Remedies, Copy rights with special reference to software.	06 Hrs
4	Trade Marks: Origin, Meaning & Nature of Trade Marks, Types, Registration of TradeMarks, Infringement & Remedies, Offenses relating to Trade Marks, Passing Off, Penalties. Domain Names on cyberspace.	05 Hrs
5	Design- Meaning, Definition, Object, Registration of Design, Cancellation of Registration, International convention on design, functions of Design. Semiconductor Integrated circuits and layout design Act-2000.	06 Hrs

Text/Reference Books:

1. Prabuddha Ganguli, IPR: Unleashing the Knowledge Economy, published by Tata McGraw Hill 2001.
2. Intellectual Property Rights and the Law, Gogia Law Agency, by Dr. G.B. Reddy.
3. Law relating to Intellectual Property, Universal Law Publishing Co, by Dr. B.L.Wadehra.
4. IPR by P. Narayanan.
5. Law of Intellectual Property, Asian Law House, Dr.S.R. Myneni.