First Year in M.Tech. (Computer Engineering) Syllabus
Aligned with New Education Policy 2020
With effective from 2023 - 2024

(University Department only)

Department of Computer Engineering

Dr. Babasaheb Ambedkar Technological University, Lonere - 402103

www.cse.dbatu.ac.in

First Year in M.Tech. in Computer Engineering
Course Curriculum Aligned with New Education Policy 2020
(with effective from Academic Year 2023 - 2024)
First Semester

Course Code	Course Name	Weekly Hours			Examination Scheme			Credit
		L	P	T	CA	MTE	ESE	
23UD2245PC101	Advanced Machine Learning Techniques	3	-	1	20	20	60	4
23UD2245PE102	**Core Elective-I** A. Software Architecture B. Natural Language Processing C. Model Checking	3	-	-	20	20	60	3
23UD2245PE103	**Core Elective-II** A. Social Network Analysis B. Distributed Computing C. Quantum Computation	3	-	-	20	20	60	3
23UD224OE104	**Open Elective-I** A. Learning Analytics B. VLSI and CAD C. Cybersecurity	3	-	-	20	20	60	3
23UD2245PE105	Research Methodology	3	-	-	20	20	60	3
23UD2245PC106	Software Lab - I (Advanced Machine Learning)	-	4	-	60	-	40	2
23UD2245PE107	Software Lab - II (Elective Courses)	-	4	-	60	-	40	2
23UD2245IK108	Indian Knowledge System	2	-	-	60	-	40	2
	Total	**17**	**8**	**1**	**280**	**100**	**420**	**22**

Course Type and Acronyms used

1. Basic Science Course (BSC)
2. Engineering Science Course (ESC)
3. Program Core Course (PCC)
4. Vocational Skill Enhancement Course (VSEC)
5. Co-curricular Course (CC)
6. Ability Enhancement Course (AEC),

L - Lecture, TH - Theory,
P / PR - Practical,
CA - Continuous Assessment,
MSE - Mid Semester Examination,
ESE - End Semester Examination,
CR - Credit
Indian Knowledge System (IKS)

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Second Semester

Course Code	Course Name	Weekly Hours			Examination Scheme			Credit
		L	P	T	CA	MTE	ESE	
23UD2245PC201	Cloud Computing	3	-	1	20	20	60	4
23UD2245PE202	**Core Elective-III** A. Intrusion Detection System B. Geospatial Data Analysis C. Graph Databases	3	-	-	20	20	60	3
23UD2245PE203	**Core Elective-IV** A. Advanced Computer Networks B. Vector Databases C. Virtual Reality	3	-	-	20	20	60	3
23UD2245PE204	**Open Elective-II** A. AI Ethics B. Entrepreneurship C. Sustainability Engineering	3	-	-	20	20	60	3
23UD2245PE205	Intellectual Property Rights	3	-	-	20	20	60	3
23UD2245PE207	Cloud Computing Lab	-	4	-	60	-	40	2
23UD2245PE208	Laboratory - III (Elective Courses)	-	4	-	60	-	40	2
23UD2245PE209	Seminar	-	4	-	60	-	40	2
	Total	**16**	**12**	**1**	**460**	**100**	**540**	**22**
Exit Requirements								
23UD2245PE2010	Research Project leading to ONE Conference Paper / Book Chapter / Journal Paper	-	8	-	40	-	60	4

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Third Semester

Course Code	Course Name	Weekly Hours			Examination Scheme			Credit
		L	P	T	CA	MSE	ESE	
23UD2245PC301	Research / Industry Internship of TWO months duration	-	16	-	60	-	40	8
23UD2245PC302	M.Tech Seminar		08		60	-	40	4
23UD2245PE303	Project Phase - I	-	16	-	60	-	40	08
Total		**-**	**40**	**-**	**120**	**-**	**80**	**20**
Fourth Semester								
23UD2245PE401	Project Phase - II	-	24	-	60	-	40	16
Total		**-**	**24**	**-**	**60**	**-**	**40**	**16**

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

COURSE CONTENT

Unit No.	Topic	Hours
1	**Deep Unsupervised Learning:** Autoencoders, Variational Auto-encoders, Adversarial Generative Networks, Auto-encoder and DBM Attention and memory models, Dynamic memory networks, Applications of	05 Hrs
2	**Deep Learning to Computer Vision:** Image segmentation, object detection, automatic image captioning, Image generation with Generative adversarial networks, video to text with LSTM models, Attention models for computer vision tasks.	05 Hrs
3	**Graph Neural Networks:** Graphs and Graph Structured Data, Tasks on Graph Structured Data, Graph Neural Networks, Basic Graph Theory, Graph Fourier Transform.	05 Hrs
4	**Models:** Spectral-based GNN layers, Spatial-based GNN layers, Pooling Schemes for Graph-level Representation Learning, Attacks and Robustness of Graph Neural Networks, Deeper Graph Neural Networks, Scalable Learning For Graph Neural Networks, Self-supervised Learning for Graph Neural Networks.	05 Hrs
5	**Large Language Models:** What is a Large Language Model?, Evolution of NLP → LLM era, Common LLMs (GPT, Llama, Claude, PaLM, Gemini), Capabilities: generation, summarization, classification, reasoning, Differences: ChatGPT vs. AI models vs. search engines, Attention mechanism (self-attention, multi-head attention), Tokenization (BPE, WordPiece, SentencePiece), Embeddings and positional encodings, Encoder vs. decoder vs. encoder-decoder architectures, Pre-training: objective (next-token prediction), data scale, Fine-tuning: supervised + reinforcement learning from human feedback (RLHF), Alignment and safety tuning, Computational requirements & scaling laws, Prompt engineering basics, API usage (OpenAI, HuggingFace), LLM pipelines: text generation, summarization, Q&A, Model evaluation (BLEU, ROUGE, perplexity), Strengths, Limitations & Risks.	05 Hrs

Text/Reference Books:

1. Deep Learning by Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press.
2. The Elements of Statistical Learning by T. Hastie, R. Tibshirani, and J. Friedman, Springer.
3. Probabilistic Graphical Models by D. Koller, and N. Friedman, MIT Press.

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

COURSE CONTENT

Unit No.	Topic	Hours
1	Review of Software Engineering	03 Hrs
2	Various Definitions of Software Architecture	05 Hrs
3	Architecture Documentation: SEI Framework, Module View, Component and Connector View, Deployment View	05 Hrs
4	Pattern-Oriented Software Architecture: Layer, MVC, Pipe-Filter, Publish/Scriber, Presentation, Abstraction, and Control Patterns.	05 Hrs
5	Software Architecture Quality Attributes, Evaluating Software Architecture, Architecture Decisions, Architecture Knowledge Management, Technology Architectures.	05 Hrs

Text/Reference Books:

1. Paul Clements, Documenting Software Architecture, Addison Wesley.
2. Fran Buschman, Pattern-Oriented Software Architecture, Vol I.

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

COURSE CONTENT

Unit No.	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.	03 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 analyser, 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.	04 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 the balanced corpus, Concordance and corpora, characteristics of Gold Standard Corpora.	03 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	03 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.	03 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 Benjamin / 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	**Model Checking**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit No.	Topic	Hours
1	Modeling systems as Finite-state machines, Using the model-checker NuSMV.	03 Hrs
2	Linear-time properties for verification, Regular properties – automata over finite words, Omega-regular properties – automata over infinite words, Model checking omega-regular properties.	04 Hrs
3	Linear Temporal Logic (LTL), Algorithms for LTL.	03 Hrs
4	Computation Tree Logic (CTL), Algorithms for LTL, Models with timing constraints – timed automata.	03 Hrs
5	More on timed automata, Probabilistic models I, Probabilistic models II, Probabilistic models III.	03 Hrs

Text/Reference Books:

1. Principles of Model-checking, Christel Baier and Joost-Pieter Katoen, MIT Press (2008).

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

COURSE CONTENT

Unit No.	Topic	Hours
1	**Networks and Society:** Introduction, Applications, Three levels of Social Network Analysis, Historical Development, Graph Visualisation Tools.	03 Hrs
2	**Network Measures:** Network Basics, Node Centrality, Assortativity, Transitivity and Reciprocity, Similarity, Degeneracy.	04 Hrs
3	**Network Growth Models:** Properties of Real-World Networks, Random Network Model, Ring Lattice Network Model, Watts-Strogatz Model, Preferential Attachement Model, Price's Model.	03 Hrs
4	**Link Analysis:** Applications of Link Analysis, Signed Networks, Strong and Weak Ties, Link Analysis Algorithms, Page Rank, Personalised PageRank, DivRank, SimRank.	03 Hrs
5	**Community Structure in Networks:** Applications of Community Detections, Types of Communities, Community Detection Methods, Disjoint Community Detection, Overlapping Community Detection, Local Community Detection, Community Detection vs. Community Search, Evolution of Community Detection Methods.	03 Hrs

Text/Reference Books:

1. Chakraborty T (2021). *Social Network Analysis*. Wiley India Pvt. Ltd..

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

COURSE CONTENT

Unit No.	Topic	Hours
1	A model of distributed computations: A distributed program, A model of distributed executions, Models of communication networks, Global state of a distributed system, Cuts of a distributed computation, Past and future cones of an event, Models of process communications.	03 Hrs
2	Logical time: Introduction, A framework for a system of logical clocks, Scalar time, Vector time, Efficient implementations of vector clocks, Jard–Jourdan's adaptive technique, Matrix time, Virtual time, Physical clock synchronisation: NTP.	04 Hrs
3	Global state and snapshot recording algorithms: System model and definitions, Snapshot algorithms for FIFO channels, Variations of the Chandy–Lamport algorithm, Snapshot algorithms for non-FIFO channels, Snapshots in a causal delivery system, Monitoring global state, Necessary and sufficient conditions for consistent global, snapshots, consistent global snapshots in a distributed computation.	03 Hrs
4	Message ordering and group communication: Message ordering paradigms, Asynchronous execution with synchronous communication, Synchronous program order on an asynchronous system, Group communication, Causal order (CO), Total order, A nomenclature for multicast, Propagation trees for multicast, Classification of application-level multicast algorithms, Semantics of fault-tolerant group communication, Distributed multicast algorithms at the network layer.	03 Hrs
5	Termination detection: System model of a distributed computation, Termination detection using distributed snapshots, Termination detection by weight throwing, A spanning-tree-based termination detection algorithm, Message-optimal termination detection, Termination detection in a very general distributed computing model, Termination detection in the atomic computation model, Termination detection in a faulty distributed system. Distributed mutual exclusion algorithms: Lamport's algorithm, Ricart–Agrawala algorithm, Singhal's dynamic information-structure algorithm, Lodha and Kshemkalyani's fair mutual exclusion algorithm, Quorum-based mutual exclusion algorithms, Maekawa's algorithm, Agarwal–El Abbadi quorum-based algorithm, Token-based algorithms, Suzuki–Kasami's broadcast algorithm, Raymond's tree-based algorithm.	03 Hrs

Text/Reference Books:

1. Ajay D. Kshemkalyani and Mukesh Singhal, Distributed Computing: Principles, Algorithms, and Systems, Cambridge University Press.
2. Vijay K. Garg, Elements of Distributed Computing, Wiley Paperback, 2014.
3. Hagit Attiya, Jennifer Welch, Distributed Computing: Fundamentals, Simulations, and Advanced Topics, Wiley.
4. Andrew S. Tanenbaum, Maarten van Steen, Distributed Systems: Principles and Paradigms, Prentice Hall of India.

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

COURSE CONTENT

Unit No.	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.	03 Hrs
2	Multi-qubit states - No-cloning theorem - Superdense coding - Pure states to Bell states – Bell inequalities. Protocols with multi-qubits: Swapping - Teleportation - gates: CNOT - Toffoli gate - NAND - FANOUT - Walsh Hadamard.	04 Hrs
3	Measurement: Projective operators - General, Projective and POVM measure. Ensemble: Density operators - pure and mixed ensemble - time evolution - post measurement density operator.	03 Hrs
4	Composite systems: Partial trace - Reduced density operator - Schmidt decomposition - Purification- bipartite entanglement. Quantum computing: Classical computing using qubits - Quantum parallelism - Deutsch's algorithm -Deutsch Josza algorithm.	03 Hrs
5	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.	03 Hrs

Text/Reference Books:

1. Quantum Computation and Quantum Information, M. A. Nielsen and I. L. Chuang, Cambridge University Press
2. Quantum Information and Computation, CIT Lecture Notes by J. Preskill.
3. Quantum Theory: Concepts and Methods, Asher Peres, Kluwer Academic Publishers.

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

COURSE CONTENT

Unit No.	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	03 Hrs
2	Descriptive Analytics: Basic statistics and visualisations for educational data, Identifying patterns, trends, and outliers	04 Hrs
3	Predictive Analytics: Regression analysis for educational outcomes, Classification for student performance prediction	03 Hrs
4	Personalised Learning Paths: Adaptive learning systems, Recommender systems for educational content	03 Hrs
5	Social Network Analysis in Educational Contexts: Analyzing collaborative learning patterns, Identifying influential students and groups	03 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	**VLSI and CAD**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit No.	Topic	Hours
1	Matrices: Linear dependence of vectors, solution of linear equations, bases of vector spaces. orthogonality, complementary orthogonal spaces and solution spaces of linear equations.	03 Hrs
2	Graphs: representation of graphs using matrices; paths, connectedness; circuits, cutsets, trees; fundamentals circuit and cutset matrices; voltage and current spaces of a directed graph and their complementary orthogonality.	04 Hrs
3	Algorithms and data structures: efficient representation of graphs; elementary graph algorithms involving BFS and DFS trees, such as finding connected and 2-connected components of a graph, the minimum spanning tree, shortest path between a pair of vertices in a graph.	03 Hrs
4	Algorithms for VLSI Physical Design, Synthesis, Circuit Simulation and Digital Design Automation.	03 Hrs
5	Algorithms for Design Automation using FPGA/CPLD, Fault Tolerant Systems, VLSI Testing.	03 Hrs

Text/Reference Books:

1. K. Hoffman and R.E. Kunze, Linear Algebra, Prentice Hall(India), 1986.
2. N. Balabanian and T.A. Bickart, Linear Network Theory; Analysis, Properties, Design and Synthesis, Matrix Publishers, Inc., 1981.
3. T. Cormen, C.Leiserson and R.A. Rivest, Algorithms, MIT press and McGraw Hill,1990.
4. N. Shervani, Algorithms for VLSI Physical Design Automation, 3rd Edn., KluwerAcademic Publishers, 1998
5. W. J. McCalla, Fundamentals of Computer-Aided Circuit Simulation, KluwerAcademic Publishers, 1987
6. G. De Micheli, Synthesis and optimization of Digital Circuits, Tata McGraw Hill, 2003.
7. S. H. Gerez, Algorithms for VLSI Design Automatiom, John Wiley & Sons, 1999.

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

COURSE CONTENT

Unit No.	Topic	Hours
1	Introduction - Introduction to cyber security, Confidentiality, integrity, and availability. Foundations - Fundamental concepts, CIA, CIA triangle, data breach at target.	03 Hrs
2	Security Management, Governance, Risk, and Compliance (GRC) - GRC framework, security standards. Contingency planning - Incidence response, Disaster Recovery, BCP. Cyber security policy - ESSP, ISSP, SYSSP.	04 Hrs
3	Risk Management - Cyber Risk Identification, Assessment, and Control. Cyber security: Industry perspective - Defense Technologies, Attack, Exploits.	03 Hrs
4	Cyber security technologies - Access control, Encryption, Standards. Foundations of privacy - Information privacy, Measurement, Theories. Privacy regulation - Privacy, Anonymity, Regulation, Data Breach.	03 Hrs
5	Privacy regulation in Europe, Privacy: The Indian Way - Data Protection, GDPR, DPDP, Aadhar. Information privacy: Economics and strategy, Economic value of privacy, privacy valuation, WTA and WTC, Business strategy and privacy, espionage, Privacy vs safety.	03 Hrs

Text/Reference Books:

1. Michael E. Whitman, Herbert J. Mattord, (2018). Principles of Information Security, 6th edition, Cenage Learning, N. Delhi.
2. Van Kessel, P. Is cyber security about more than protection? EY Global Information Security Survey 2018-2019.
3. Johnston, A.C. and Warkentin, M. Fear appeals and information security behaviours: An empirical study. MIS Quarterly, 2010.
4. Arce I. et al. Avoiding the top 10 software security design flaws. IEEE Computer Society Center for Secure Design (CSD), 2014.
5. Smith, H. J., Dinev, T., & Xu, H. Information privacy research: an interdisciplinary review. MIS Quarterly, 2011.
6. Subramanian R. Security, privacy and politics in India: a historical review. Journal of Information Systems Security (JISSec), 2010.
7. Acquisti, A., John, L. K., & Loewenstein, G. What is privacy worth? The Journal of Legal Studies, 2013

8. Xu H., Luo X.R., Carroll J.M., Rosson M.B. The personalisation privacy paradox: An exploratory study of the decision-making process for location-aware marketing. Decision Support Systems, 2011.

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

COURSE CONTENT

Unit No.	Topic	Hours
1	Research Concepts – concepts – meaning – objectives – motivation. Types of research – descriptive research – conceptual research – theoretical research – applied research – experimental research.	03 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	04 Hrs
3	Hypothetical proposals for future development and testing, selection of Research tasks.	03 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.	03 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 research methods.	03 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 Mc Graw 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

COURSE CONTENT

List of Experiments:

1. Installation and working on various tools viz. Hadoop, Python, Spark, NoSQL, ANACONDA, Tensorflow, Keras, AWS, etc.
2. Understanding key technology foundations required for Big Data.
3. Learning Hadoop system for implementing Big Data problems.
4. Development of real-time data based application using Hadoop.
5. Development of applications using pytorch library.
6. Knowledge extraction from given data.
7. Use of machine learning and deep learning techniques for solving image related problems.
8. Comparative evaluation of deep learning models.

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

COURSE CONTENT

Unit No.	Topic	Hours
1	An overview of the 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 equinoxes, 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 the 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	**Cloud Computing**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to Cloud Computing:** Definition and evolution of cloud computing, Cloud service models: IaaS, PaaS, SaaS, Cloud deployment models: Public, private, hybrid, multi-cloud, Benefits and challenges of cloud computing, Case studies: Real-world examples of cloud adoption	03 Hrs
2	**Cloud Infrastructure and Virtualization:** Virtualization technologies: Hypervisors, containers, Infrastructure as a Service (IaaS) and virtual machines, Cloud network architecture and security considerations, Scalability, elasticity, and resource provisioning. Case studies: Cloud infrastructure management and optimization	04 Hrs
3	**Cloud Services and Platforms:** Platform as a Service (PaaS) and application deployment, Software as a Service (SaaS) and cloud-based applications, Microservices architecture and serverless computing, DevOps and continuous integration/continuous deployment (CI/CD) in the cloud.Case studies: Developing and deploying applications on cloud platforms	03 Hrs
4	**Cloud Security and Compliance:** Cloud security challenges and best practices, Identity and access management (IAM) in the cloud, Data encryption, privacy and compliance regulations, Threat detection, incident response, and disaster recovery, Case studies: Security breaches and mitigation strategies	03 Hrs
5	**Cloud Migration and Management:** Strategies for migrating applications to the cloud, Cloud cost management and optimisation, Performance monitoring and management tools, Vendor lock-in and multi-cloud management, Case studies: Successful cloud migration and management stories	03 Hrs

Text/Reference Books:

1. "Cloud Computing: Concepts, Technology & Architecture" by Thomas Erl, Ricardo Puttini, and Zaigham Mahmood
2. "Cloud Native Patterns: Designing Change-tolerant Software" by Cornelia Davis
3. "The DevOps Handbook: How to Create World-Class Agility, Reliability, & Security in Technology Organizations" by Gene Kim, Jez Humble, Patrick Debois, and John Willis
4. "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance" by Tim Mather, Subra Kumaraswamy, and Shahed Latif
5. "Architecting for Scale: High Availability for Your Growing Applications" by Lee Atchison
6. "Cloud Computing: Principles and Paradigms" by Rajkumar Buyya, James Broberg, and Andrzej M. Goscinski
7. "Mastering Cloud Computing: Foundations and Applications Programming" by Raj Buyya, Christian Vecchiola, and S. Thamarai Selvi

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

COURSE CONTENT

Unit No.	Topic	Hours
1	Intruder types, intrusion methods, processes and detection, message integrity and authentication, honey pots.	03 Hrs
2	General IDS model, data mining based IDS, Denning model, data mining framework for constructing features and models for intrusion detection systems.	04 Hrs
3	Unsupervised anomaly detection, CV5 clustering, SVM, probabilistic and statistical modelling, general IDS model and taxonomy, evaluation of IDS, cost-sensitive IDS. NBAD, specification-based and rate-based DDOS, scans/probes, predicting attacks, network-based anomaly detection, stealthy surveillance detection; Defending against DOS attacks in scout: signature-based solutions, snort rules.	03 Hrs
4	Host-based anomaly detection, the taxonomy of security flaws in software, and self-modelling system calls for intrusion detection with dynamic window size.	03 Hrs
5	Secure intrusion detection systems, network security, secure intrusion detection environment, secure policy manager, secure IDS sensor, alarm management, intrusion detection system signatures, sensor configuration, signature and intrusion detection configuration, IP blocking configuration, and intrusion detection system architecture.	03 Hrs

Text/Reference Books:

1. Endorf, C., Schultz E. and Mellander J., “Intrusion Detection and Prevention,” McGraw-Hill. 2003.
2. Bhatnagar, K., “Cisco Security”, Course Technology, 2002.
3. Marchette, D. J., “Computer Intrusion Detection and Network Monitoring: A Statistical Viewpoint”, Springer. 2001.
4. Rash, M., Orebaugh, A. and Clark, G., “Intrusion Prevention and Active Response: Deploying Network and Host IPS”, Syngress. 2005.
5. Cooper, M., Northcutt, S., Fearnow, M. and Frederick, K., “Intrusion Signatures and Analysis”, Sams. 2001.

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

COURSE CONTENT

Unit No.	Topic	Hours
1	**Introduction to Geospatial Data Analysis:** Understanding geographic information systems (GIS), Basics of geospatial data representation: Maps, coordinates, projections, Importance of geospatial data in various domains Applications of geospatial data analysis in computer engineering, Case studies: Real-world examples of geospatial data utilization	03 Hrs
2	**Data Acquisition and Preprocessing:** Sources of geospatial data: Satellite imagery, GPS, remote sensing, Data formats and standards: GeoJSON, Shapefiles, raster data, Geospatial data collection techniques and tools, Quality assessment and data preprocessing, Case studies: Acquiring and preprocessing geospatial data	04 Hrs
3	**Spatial Analysis Techniques:** Spatial data visualization and cartography, Spatial querying and geocoding, Spatial interpolation and extrapolation, Overlay analysis and proximity analysis, Case studies: Analyzing spatial relationships and patterns,	03 Hrs
4	**Geospatial Data in Machine Learning:** Integration of geospatial data with machine learning models, Feature engineering for geospatial data, Predictive modeling using geospatial attributes, Clustering and classification of geospatial data, Case studies: Machine learning applications in geospatial analysis	03 Hrs
5	**Geospatial Data Applications:** Environmental monitoring and management, Urban planning and transportation analysis, Disaster management and emergency response, Location-based services and navigation systems, Case studies: Geospatial data analysis for diverse applications	03 Hrs

Text/Reference Books:

1. "Geospatial Analysis: A Comprehensive Guide to Principles, Techniques, and Software Tools" by Michael de Smith, Michael Goodchild, and Paul Longley
2. "GIS Fundamentals: A First Text on Geographic Information Systems" by Paul Bolstad
3. "Python for Data Science Handbook: Essential Tools for Working with Data" by Jake VanderPlas
4. "Mastering Geospatial Analysis with Python" by Silas Toms and Paul Crickard
5. "Geocomputation with R" by Robin Lovelace, Jakub Nowosad, and Jannes Muenchow
6. "Remote Sensing and GIS for Ecologists: Using Open Source Software" by Martin Wegmann, Benjamin Leutner, Stefan Dech
7. "Geospatial Data Science Techniques and Applications" by Hassan A. Karimi

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

COURSE CONTENT

Unit No.	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	03 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	04 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 Organizations choose graph databases Common use cases real-world examples	03 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	03 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	03 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	**Advanced Computer Networks**	CA 20 MSE 20 ESE 60

COURSE CONTENT

Unit No.	Topic	Hours
1	Review of Fundamentals of Computer N/Ws, TCP/IP reference model, Interior and Exterior Gateways routing application layered protocols such as DHCP, BOOTP OSI, TCP/IP, ATMX.25, frame relay, switching techniques in communication system.	03 Hrs
2	Fundamentals of Optical Networks, SONET/SDH Introduction, TDM Networks elements, Generation of optical N/W's.	04 Hrs
3	Introduction to key optical node Organization and key other terms, Cross connect Terminology, brief introduction to TDM and WDM, Evolution of optical system, Key Attributes of optical fiber, Digital Multiplexing Hierarchy, Characterization of optical fiber, timing and Synchronization.	03 Hrs
4	Fiber Optic Technologies History, Basic fundamentals Operation, Physical properties, networking elements. Wavelength Division Multiplexing Principle of Operation, CDM/DWDM, and WDM networks elements, Impairments and Compensation in WDM.	03 Hrs
5	SONET/ SDH Multiservice platform. Protection / Restoration and diversity in optical N/W's, MPLS/GMPLS introduction.	03 Hrs

Text/Reference Books:

1. Optical Networks Control, Bala Rajagopalan, Gerg Bernstein, Debanjan saha.
2. Optical Networks and WDM, Walter J. Goralski, McGraw-Hill 2001.
3. Computer Networks: A System Approach, Larry L. Peterson, Bruce S. Davie, Morgan Kaufmann.
4. WDM Optical Networks: Concepts, Design and Algorithms, C. Siva Ram Murthy, Prentice Hall.

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

COURSE CONTENT

Unit No.	Topic	Hours
1	**Multidimensional Point Data:** Range trees, priority search trees, Quadtrees, K-d trees, one-dimensional ordering bucket methods, PK trees,	03 Hrs
2	**Object-based and Image-based Representations:** Interior based representation, boundary-based representations, Difference-based compaction methods.	04 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.	03 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.	03 Hrs

Text/Reference Books:

1. Hanan Samet, Foundations of Multidimensional and Metric Data Structures, The Morgan Kaufmann Series in Data Management Systems

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

COURSE CONTENT

Unit No.	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).	03 Hrs
2	**Geometry of Virtual Worlds:** Geometric modelling, 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.	04 Hrs
3	**Light and Optics:** Three interpretations of light, Refraction, Simple lenses, Diopters, Imaging, properties of lenses, Lens aberrations, and Optical system of eyes. **Visual Physiology:** Photoreceptors, Sufficient resolution for VR, Light intensity, Eye movements, Eye movement issues for VR, Neuroscience of vision.	03 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.	03 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.	03 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 II AI Ethics	Examination Scheme					
TH	3	PR	0	CR	3		CA	20	MSE	20	ESE	60

COURSE CONTENT

The objective of this course is to provide computer engineering graduate students with a comprehensive understanding of the ethical challenges and considerations in the development, deployment, and impact of artificial intelligence (AI) technologies. Students will learn to critically analyze the ethical implications of AI systems and develop strategies to design and implement AI technologies socially responsible.

Unit No.	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	03 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	04 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	03 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	03 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	03 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 Entrepreneurship	Examination Scheme					
TH	3	PR	0	CR	3		CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit No.	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	03 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	04 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	03 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	03 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	03 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 No.	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	03 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	04 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	03 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	03 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	03 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 Intellectual Property Rights	Examination Scheme					
TH	3	PR	0	CR	3		CA	20	MSE	20	ESE	60

COURSE CONTENT

Unit No.	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.	03 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.	04 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.	03 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.	03 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.	03 Hrs

Text 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.