Shirpur Education Society's

R. C. Patel Institute of Technology, Shirpur

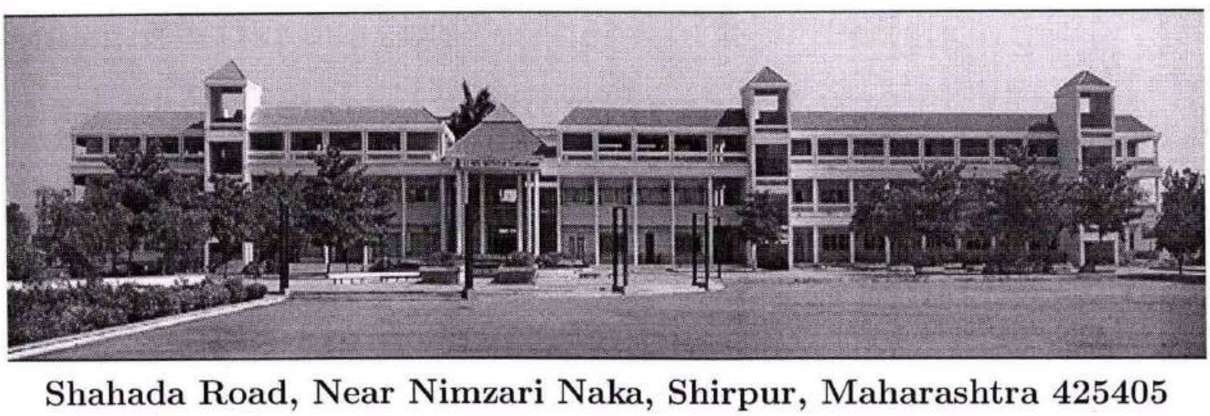
(An Autonomous Institute)

Course Structure and Syllabus

Final Year B. Tech

Computer Science and Engineering (Data Science)

With effect from Year 2025-26



Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405
Ph: 02563 259 802, Web: www.rcpit.ac.in

Semester-VIII(w.e.f. 2025-26)														
Sr	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Total	Credit	
							Continuous Assessment (CA)							
							TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average of (TT1 &TT2)	ESE			
				L	T	P	[A]			[B]	[C]	[A+B+C]		
1@	PE1	22PECS8011T	High Performance Computing*	3			25	10	10	10	65	100	3	3
		22PECS8012T	Data Ethics*	3			25	10	10	10	65	100	3	
		22PECS8013T	Introduction to Quantum Computing*	3			25	10	10	10	65	100	3	
			NPTEL/Swayam Course#	3			25	10	10	10	65	100	3	
2@	PE2	22PECS8021T	Social Network Analysis*	3			25	10	10	10	65	100	3	3
		22PECS8022T	Applied Game Theory*	3			25	10	10	10	65	100	3	
		22PECS8023T	Robotics and AI*	3			25	10	10	10	65	100	3	
			NPTEL/Swayam Course#	3			25	10	10	10	65	100	3	
3	INT	22INTCS8030L	Internship			20	150				150	300	10	
4	MC	22MCCS8040T	Disaster Management and Preparedness	2									Audit Course	
			Total	8		20	200			20	280	500	16	

1. @ Any 1 Elective Course.
2. * Professional Elective Courses offered for the students doing Internship at institute level.
3. # Professional Elective Courses offered for the students doing Internship at Industry. These courses are to be studied in self study mode using NPTEL/Swayam platform.
4. Students doing internship at industry shall submit certificate of NPTEL examination OR They have to appear examinations conducted by institute like TT1,TT2 and ESE.
5. Students undergoing internship have the option to appear for both the NPTEL examination and the End Semester Examination (ESE) conducted by the institute for the respective course. In such cases, the better of the two scores (NPTEL or ESE) shall be considered for final grading.
6. List of NPTEL courses will be declared by concerned BOS at the beginning of the semester-VIII.

Prepared by:
Dr. M. S. Patil

Checked by:
Dr. P. S. Sanjekar

Prof. Dr. U. M. Patil
BOS Chairman

Prof. S. P. Shukla
C.O.E.

Prof. Dr. P. J. Deore
Dean Academics/Dy. Director

Prof. Dr. J. B. Patil
Director

Semester - VIII

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
High Performance Computing (22PECS8011T)		

Prerequisite: Parallel Computing, Distributed Computing

Course Objective(s):

1. This course in High-Performance Computing (HPC) for Data Science with an emphasis on GPU parallel computing introduces students to the fundamental concepts and practical skills necessary for harnessing the power of Graphics Processing Units (GPUs) in data-intensive computations.
2. Throughout the course, students will explore GPU architecture, CUDA programming, memory optimization techniques, parallel programming patterns, and performance optimization strategies.
3. They will also delve into advanced topics like GPU-accelerated libraries and the integration of GPUs with popular data science frameworks. By the end of this course, students will be equipped to leverage GPU parallel computing to significantly enhance the efficiency and performance of data science applications.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the architecture of modern GPUs, CUDA programming model, and parallel programming challenges.	L2	Understand
CO2	Solve data parallelism problems and use CUDA memory models effectively.	L3	Apply
CO3	Analyze GPU performance metrics, including memory coalescing, thread scheduling, and control divergence impacts.	L4	Analyze
CO4	Assess different GPU computing frameworks and libraries (cuBLAS, cuDNN) based on application requirements and efficiency.	L5	Evaluate

High Performance Computing (22PECS8011T) Course Contents

Unit-I 08 Hrs.

Introduction to Heterogeneous Parallel Computing:

Introduction: Architecture Of A Modern GPU, Challenges In Parallel Programming, Parallel Programming Languages And Models.

Data Parallelism: Data Parallelism, CUDA C Program Structure, A Vector Addition Kernel, Device Global Memory And Data Transfer, Kernel Functions And Threading, Kernel Launch

Unit-II 08 Hrs.

CUDA Parallelism Model:

Scalable Parallel Execution: CUDA Thread Organization, Mapping Threads To Multidimensional Data, Synchronization And Transparent Scalability, Resource Assignment, Thread Scheduling And Latency Tolerance

Memory And Data Locality: CUDA Memories, Tiled Parallel Algorithms, Tiled Matrix Multiplication, Tiled Matrix Multiplication Kernel, Boundary Checks, Memory As A Limiting Factor To Parallelism

Unit-III 08 Hrs.

Performance Considerations On GPUs:

Memory Access Performance: Global Memory Bandwidth, Memory Coalescing in CUDA, Channels and Banks in Dram Systems, Techniques For Reducing Memory Transfers Between CPU And GPU.

Thread Execution Efficiency: Warps And SIMD Hardware, Dynamic Partitioning Of Resources, Performance Impact Of Control Divergence.

Unit-IV 08 Hrs.

Parallel Computation Patterns:

Parallel Patterns: Convolution: 1d Parallel Convolution- A Basic Algorithm, Constant Memory and Caching, Tiled 1d Convolution with Halo Cells, A Simpler Tiled 1d Convolution- General Caching.

Parallel Computation Patterns (Histogram): Atomic Operations In Cuda, Atomic Operation Performance-Block versus Interleaved Partitioning, Latency versus Throughput of Atomic Operations, Atomic Operation in Cache Memory, Privatization Technique For Improved Throughput.

Unit-V 04 Hrs.

Efficient Host-Device Data Transfer:

Pinned Host Memory, Task Parallelism in CUDA, Overlapping Data Transfer with Computation, CUDA Unified Memory.

Unit-VI 06 Hrs.

Advanced Topics in GPU Computing:

Introduction to GPU-accelerated libraries (cuBLAS, cuDNN, cuGraph), GPU computing frameworks (TensorFlow, PyTorch) and their integration with GPUs, Introduction to GPU clusters and distributed GPU computing.

Application Case Study- Machine Learning: Convolutional Neural Networks, Convolutional Layer: A Basic CUDA Implementation of Forward Propagation, Reduction of Convolutional Layer to Matrix Multiplication, cuDNN Library.

Text Books:

1. Georg Hager, Gerhard Wellein, "Introduction to High Performance computing for Scientist and Engineers", CRC press, 2019.

2. Duane Storti and Mete Yurtoglu, "CUDA for Engineers", Addison-Wesley,1st Edition, 2016.

Reference Books:

1. David B. Kirk and Wen-mei W. Hwu, "Programming Massively Parallel Processors: A Hands-on Approach", Morgan Kaufmann, 2nd Edition, 2012.

2. Charles Severance and Kevin Dowd, "High Performance Computing" , O'Reilly Media, 2nd Edition, 1998.

3. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, "Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems", O'Reilly, 1^{st} Edition, 2020.

4. Jason Sanders and Edward Kandrot , "CUDA by Example: An Introduction to General-Purpose GPU Programming" , Addison-Wesley, 2010.

5. NVIDIA Corporation , "GPU Gems", Addison-Wesley

6. Gerhard Hager and Markus Hadwiger , "Programming the GPU with CUDA", Springer

7. Brian Tuomanen and Daniel Kim, "Deep Learning with CUDA", O'Reilly Media

Weblinks:

1. HPC: https://archive.nptel.ac.in/courses/106/105/106105033/.

2. HPC Springer Journal: https://link.springer.com/book/10.1007/978-3-030-13325-2.

3. Programming Model: https://homepage.physics.uiowa.edu/ ghowes/teach/phys5905/lect/NumLec11_IntroH

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Data Ethics (22PECS8012T)		

Prerequisite: Fundamentals of Data Analysis, Machine Learning

Course Objective(s):

1. To enable students to understand and apply ethical principles in data-driven technologies through the concepts of fairness, privacy-preserving learning, explainable AI, and responsible governance.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain data privacy, security, bias and accountability issues in real world problem.	L2	Understand
CO2	Apply different concepts of Data Ethics to solve real world problem.	L3	Apply
CO3	Analyze model transparency in the field of data science.	L4	Analyze
CO4	Design ethical governance strategies and assess the broader social impact of AI and data systems.	L6	Create

Data Ethics (22PECS8012T)
Course Contents

Unit-I 08 Hrs.

Introduction to Data Ethics: Overview and Importance of Data Ethics. The significance of data ethics in modern technology, its impact on individuals and society.

Historical Examples of Data Ethics Violations: A historical perspective on data ethics violations, such as data breaches and misuse of data. Consequences of ethical lapses and their implications for technology and society.

Overview of Ethical Theories: Exploration of ethical theories, including utilitarianism, deontology, virtue ethics, and their application in data ethics. Applying Ethical Frameworks to Data-Related Dilemmas Practical application of ethical frameworks to analyze and address data-related ethical dilemmas.

Case Study: Facial recognition technology by the New York Police Department (NYPD) in the wake of protests of police brutality and racial injustice in 2020.

Unit-II 07 Hrs.

Data-driven Business Model: Data as payment, good data, Data at risk, Data brokers in a grey area, a need for new business models, Needs of customers: general concern for digital surveillance, targeted ads and prices, demand for data control, act, consumers cookies and using VPM, false data on the rise, obfuscation, from lack of knowledge to resignation, pay for privacy, Best practices for data ethics, Emerging Technologies and Ethical Challenges, Examination of ethical challenges posed by emerging technologies like AI, IoT, and blockchain.

Case Study: COVID-19 Vaccine Distribution and Equity, ethical dilemmas in cutting-edge projects.

Unit-III 07 Hrs.

Bias & Analysis: Introduction and Importance of Algorithm Fairness, the reasons for unfairness, Analyzing and measuring unfairness, Sources of Bias, Dealing with Bias, Mitigating Bias , Further Considerations, addressing different types of bias, Examples, causes and detection strategies of algorithmic biases, Detecting and Addressing Bias in Data and Algorithms, Understanding the types of bias in data and algorithms (selection bias and algorithmic bias),techniques and tools for identifying and mitigating bias in data-driven projects.

Case Studies: Aequitas - A Toolkit for Auditing Bias and Fairness in Machine Learning Models.

Unit-IV 08 Hrs.

Data Privacy: Data Privacy and Legal Frameworks, Data Privacy Laws and Regulations, GDPR, CCPA, and HIPAA, Understanding the key principles and requirements of privacy laws, Data commodification's, examples of companies complying with or violating data privacy regulations, Data Collection and Storage Ethics Considerations for ethical data collection methods, including informed consent, data minimization, and transparency, Exploring fairness in machine learning models and algorithmic transparency.

Data Storage and Secure Handling: Encryption, and data handling protocols, Strategies for ensuring data security and integrity, Cybersecurity and Data Breaches, Handling Data Breaches Responsibly, Ethical and legal obligations following a data breach, including incident response and notification procedures.

Case studies: Facebook's Data Privacy Controversies, Ethical data collection in various contexts.

Unit-V 07 Hrs.

Data Ethics and Trust: Introduction to digital trust, the snowden effect, the sharing economy, ethical data use, sharing and access, ethical considerations when sharing data with partners, stakeholders, and the public, Strategies for ensuring responsible data sharing and access Best Practices for Responsible Data Use, Strategies for integrating data ethics into professional practices, software development, system design, and decision-making processes.

Case studies: Real-world examples of organizations implementing responsible data use practices.

Unit-VI 05 Hrs.

Data Governance and Regulation: Introduction to Data Governance, Importance of Governance, Examples of Data Governance in action, The Business value of Data Governance, why data Governance is easier in the public cloud, Ingredients of Data Governance: Tools

Case studies: The Volkswagen (VW) emissions scandal.

Text Books:

1. Christoph Stückelberger, Pavan Duggal, "Data Ethics: Building Trust: How Digital Technologies Can Serve Humanity", Globethics Publications, 1^{st} Edition, 2023.

2. Gry Hasselbalch & Pernille Tranberg, "Data Ethics", PubliShare, 1^{st} Edition, 2016.

Reference Books:

1. Ian Foster, Rayid Ghani, Ron S. Jarmin, Frauke Kreuter, Julia Lane, "Big Data and Social Science: Data Science Methods and Tools for Research and Practice", Chapman and Hall/CRC, 2^{nd} Edition, 2020.

2. Evren Eryurek, Uri Gilad, Valliappa Lakshmanan, "Data Governance: The Definitive G - People, Processes, and Tools to Operationalize Data Trustworthiness", Shroff/O'Reilly, Edition, 2021.

3. Loukides, Mike, Hilary Mason, and DJ Patil, "Ethics and Data Science- Doing Good Data Science", Sebastopol, CA: O'Reilly Media., 2018.

4. Sandvig, Christian, Kevin Hamilton, Karrie Karahalios, and Cedric Langbort, "Auditing Algorithms: Research Methods for Detecting Discrimination on Internet Platforms", Computational Culture, 2014.

5. Ananny, Mike, "Toward an Ethics of Algorithms : Convening Observation , Probability and Timeliness", Science, Technology, & Human Values vol. 41 no. 1, pp. 93–117, 2016.

Web Links:

1. Ethics in Data Science: https://www.analyticsvidhya.com/blog/2022/02/ethics-in-data-science-and-proper-privacy-and-usage-of-data/

2. Business Insights Harvard: https://online.hbs.edu/blog/post/data-ethics

3. Data Science Professionals: https://emeritus.org/blog/data-science-and-analytics-data-science-course-curriculum/

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Introduction to Quantum Computing (22PECS8013T)		

Prerequisite: Computer System Fundamentals, Machine Learning, Information Security

Course Objective(s):

1. To introduce the basics of Quantum Computing and Quantum state transformation and classical computation versions.
2. To understand advanced Quantum Computation Algorithms and basics of Quantum Machine Leaming.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze fundamental quantum computing concepts such as qubits, quantum states, superposition, entanglement, and basic quantum gates.	L4	Analyze
CO2	Apply quantum computation techniques and advanced quantum algorithms to address simple real-world computational problems.	L3	Apply
CO3	Apply quantum machine learning and quantum deep learning techniques using parameterized quantum circuits and implement basic quantum cryptography protocols.	L3	Apply

Introduction to Quantum Computing (22PECS8013T)
Course Contents

Unit-I 07 Hrs.

Complex Numbers, Vector Space, and Dirac Notation:

Complex Numbers, Complex Conjugation, Vector Space, Basic set, Dirac Notation, Ket and Bra, Inner Product, Linearly Dependent and Independent Vectors, Dual Vector Space, Computational Basis, Outer Product, Spin and Qubit.

Unit-II 07 Hrs.

Quantum Computing vs. Classical Computing:

History of quantum computation and quantum information, Quantum State, Bloch sphere, Dense coding, Physical quantum phenomena: Spin, Quantum superposition, Interference and Entanglement.
Logic Gates and Circuits: Boolean Algebra, Functional Completeness, Gates, Circuits, Universal Gates, Gates and Computation,
Quantum Gates and Circuits: Qubits, The CNOT, Pauli, Hadamard, Toffoli Gates, Quantum Gate, Quantum Gates Acting on one Qubit, No Cloning Theorem, Quantum Computation, Multiple qubit gates, Qubit copying circuit, Example: Bell states, quantum teleportation.

Unit-III 06 Hrs.

Quantum Computing algorithms:

Classical computations on a quantum computer, Quantum parallelism, Quantum key distribution, Superdense coding, quantum teleportation, applications of teleportation, probabilistic versus quantum algorithms, phase kick-back, Quantum phase estimation and quantum Fourier Transform, eigenvalue estimation, Shor's Factorization Algorithm, Grover's Search Algorithm, Quantum algorithms summarized.

Unit-IV 05 Hrs.

Quantum Cryptography algorithm:

Cryptography using principles of quantum computing, No-cloning theorem, Quantum key distribution Algorithm, Quantum secret sharing Algorithm.

Unit-V 0[illegible] Hrs.

Quantum Machine Learning Basic (QML):

Variational Quantum Circuits, Parameterized quantum circuits, Parameterized quantum circuit properties, Entangling capability, Parameterized quantum circuits for machine learning Data encoding

Methods, Basis encoding, Amplitude encoding, Angle encoding, Arbitrary encoding, Supervised learning, Quantum variational classification, Quantum kernel estimation, Variational training, Quantum Support Vector Machine (QSVM).

Unit-VI 08 Hrs.

Quantum Deep Learning (QDL):

Basics of Quantum Neural Networks, Finite difference gradients, Analytic gradients, Natural gradients, Simultaneous Perturbation Stochastic Approximation, Training in practice, exponentially vanishing gradients (barren plateaus), Quantum Convolutional Neural Network.

Text Books:

1. Parag K. Lala, 'Quantum Computing', McGraw Hill, 1st Edition, 2020.
2. Chris Bernhardt, 'Quantum Computing for Everyone', MIT Press, 1st Edition, 2020.

Reference Books:

1. Jack D. Hidary, 'Quantum Computing: An Applied Approach', Springer, 2nd Edition, 2021.
2. Johan Vos, 'Quantum Computing in Action', Manning Publications, 1st Edition, 2022.

Weblinks:

1. https://qiskit.org/leam

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Social Network Analysis (22PECS8021T)		

Prerequisite: Probability and Statistics, Machine Learning

Course Objective(s):

1. To equip students with the knowledge and analytical skills necessary for the study of massive networks, addressing the associated computational, algorithmic, and modeling challenges, and to cultivate a research-oriented perspective on the structure, dynamics, and analysis of large-scale networks.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze social networks using visualization techniques and structural measures.	L4	Analyze
CO2	Illustrate network growth patterns and ranking methodologies in complex networks.	L4	Analyze
CO3	Examine methods for detecting communities, predicting links, and modelling information flow.	L3	Apply
CO4	Apply anomaly detection and representation learning approaches for network analysis.	L3	Apply

Social Network Analysis (22PECS8021T)
Course Contents

Unit-I 08 Hrs.

Society & Network: Introduction, Use of social networks, defining a network, types of network (link-centric, node and link centric, local view, temporal view, generalization, real-world network), levels of social network analysis, graph visualization tools.

Network Measures: Network basics, node centrality, assortativity, transitivity and reciprocity, similarity, degeneracy.

Network Growth Models: Overview of real-world networks and their properties, brief introduction to Erdős-Rényi Random Network Model, Watts Strogatz Model, and Preferential Attachment Model with their key characteristics and limitations.

Unit-II 07 Hrs.

Link Analysis:

Application of link analysis, Signed networks: Balance Theory of Undirected Signed Networks, Status Theory of Signed Networks, Triad Balance vs Status, Strong and Weak Ties: Strength of a Tie, Triadic Closure, Dunbar Number, Local Bridges and Importance of Weak Ties, PageRank, DivRank, SimRank, PathSim.

Unit-III 07 Hrs.

Community Detection: Application of community detection, types of communities, community detection methods, Disjoint Community Detection: Node-centric community detection, modularity and community detection, Overlapping Community Detection: Clique Dynamics, Local Community Detection.

Link Prediction: Applications of link prediction, Evaluating Link Prediction methods.

Unit-IV 06 Hrs.

Cascade Behaviors & Network Effects: Preliminaries and Important Terminologies, Cascade Models, Probabilistic Cascades, Epidemic Models, Independent Cascade Models, Cascade Prediction.

Unit-V 06 Hrs.

Anomaly Detection in Networks:

Outliers verses network based anomalies. Anomaly in Static Networks: Plain and attributed networks, relational learning, Anomaly in Dynamic Networks: Preliminaries, feature and decomposition based approaches, Challenges in anomaly detection.

Unit-VI 08 Hrs.

Graphical Representation Learning:

Intuition behind representation learning, representation learning methods.

Graph Convolutional Network (GCN) and its variations and applications in social network analysis.

Dynamic Graph Convolutional Networks (DGCN) & Continuous-Time Dynamic Graph Neural Networks (CTDGNN): Advanced models for analyzing evolving social networks

Text Books:

1. Tanmoy Chakraborty, "Social Network Analysis", First Edition, Wiley, 2021.

2. Stephen P Borgatti, Martin G. Everett, Jeffrey C. Johnson, "Analyzing Social Networks", Sage Publications Ltd, 2nd Edition, 2018.

3. William L. Hamilton, "Graph Representation Learning", Morgan & Claypool Publishers,2020.

Reference Books:

1. Xiaoming Fu, Jar-Der Luo, Margarete Boos, 'Social Network Analysis Interdisciplinary Approaches and Case Studies', 1st Edition, CRC Press, 2020.

2. Dr. Krishna Raj P.M., Mr. Ankith Mohan, Dr. Srinivasa K.G, "Practical Social Network Analysis with Python (Computer Communications and Networks)", First Edition, Springer, 2019.

3. John Scott, "Social Network Analysis", Fourth Edition, SAGE Publications Ltd,2017. Yang, Franziska Barbara Keller, LuZheng, "Social Network Analysis: Methods and Examples", First Edition, SAGE Publications, 2016.

Weblinks:

1. A course on Social Network Analysis
   https://onlinecourses.nptel.ac.in/noc22_cs117/preview

2. Social Network Analysis 101: Ultimate Guide Comprehensive Introduction for Beginners:
   https://visiblenetworklabs.com/guides/social-network-analysis-101/

3. Real-world use cases of Social Network Analysis
   https://www.latentview.com/social-media-analytics/a-guide-to-social-network-analysis-and-its-use-cases/

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Applied Game Theory (22PECS8022T)		

Prerequisite: Linear Algebra, Calculus, Probability, Statistics and Basic algorithm design and analysis.

Course Objective(s):

1. To understand how individuals and groups make strategic decisions in competitive and cooperative situations, using mathematical models and algorithms to analyze, predict, and optimize outcomes in real-world scenarios such as economics, AI, and multi-agent systems.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze strategic, zero-sum, and non-zero-sum games to identify Nash equilibria and optimal strategies.	L4	Analyze
CO2	Apply algorithmic techniques and reinforcement learning to compute equilibria and model multiagent interactions.	L3	Apply
CO3	Evaluate evolutionary, cooperative, and Bayesian game scenarios for fairness, stability, and decision-making efficiency.	L5	Evaluate

Applied Game Theory ((22PECS8022T)
Course Contents

Unit-I — 04 Hrs.

Introduction to Game Theory:

Strategic games, players, strategies, payoffs; dominance, minimax, saddle points; pure & mixed strategy Nash equilibria; real-world examples: auctions, pricing, simple multi-agent interactions

Unit-II — 05 Hrs.

Zero-Sum and Non-Zero-Sum Games:

Zero-sum games, saddle points, matrix games; mixed strategies; non-zero-sum games, iterated elimination of dominated strategies; Lemke–Howson algorithm.

Unit-III — 08 Hrs.

Evolutionary and Cooperative Game Theory:

Evolutionarily Stable Strategies (ESS), replicator dynamics, fictitious play; cooperative games: transferable utility, core, Shapley value, nucleolus; correlated equilibria; Multi-Agent Reinforcement Learning (MARL) and reward shaping with human feedback.

Unit-IV — 08Hrs.

Bayesian and Algorithmic Game Theory:

Bayesian games, Bayes–Nash equilibrium, auctions, bilateral trading; complexity of equilibrium computation; mechanism design basics; Vickrey auction, incentive compatible resource allocation.

Unit-V — 10 Hrs.

Repeated and Extensive Form Games:

Repeated games: Nash Folk Theorem, subgame perfect equilibrium, one-shot deviation principle; extensive form games: game trees, backward induction, sequential equilibria

Unit-VI — 07 Hrs.

Game Design, Simulation, and Real-World Applications:

Game design principles: payoff engineering, fairness, multiplayer dynamics; applications: oligopoly models, voting games, matching markets, resource allocation, utility theory; RL-based strategy optimization and human-in-the-loop feedback.

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Text Books:

1. Game Theory: An Introduction, 3rd Edition by E.N. Barron, Wiley, 2024.

2. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", MIT Press, 2nd Edition, 2022.

3. Binmore, K., Game Theory: A Very Short Introduction, OUP, 2010.

Reference Books:

1. Shoham Y., Leyton-Brown K., "Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations" , Cambridge University Press, 2024.

2. Thomas Ferguson, "Game Theory" , World Scientific, 2018

Web Links:

1. NPTEL Course: https://nptel.ac.in/courses/106105237

2. IIT Bombay: Useful Lecture Notes on Game Theory — IEOR @ IIT Bombay

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech	Semester: VIII
Robotics and AI (22PECS8023T)		

Prerequisite: Linear algebra and Probability theory.

Course Objective(s):

1. To introduce fundamental concepts, kinematics, perception, planning, and control in robotics with an emphasis on data acquisition, machine learning, and autonomous navigation.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Illustrate the fundamental principles, components, and kinematics of robotic systems.	L3	Apply
CO2	Apply sensor data acquisition, preprocessing, and fusion techniques using Python and ROS.	L3	Apply
CO3	Analyze computer vision, path planning, and SLAM algorithms for perception and navigation.	L4	Analyze
CO4	Develop control and decision-making strategies for autonomous robot operation.	L6	Create

Robotics and AI (22PECS8023T)
Course Contents

Unit-I 06 Hrs.

Introduction to Robotics:

Evolution of Robotics, Types of robots – industrial, mobile, humanoid, and autonomous, Components of robotic system (sensing, actuation, control, AI), Types of Sensors – IMU, LiDAR, Camera, GPS, Ultrasonic, Proximity Sensors (Infrared), Vision Sensors, Accelerometers, Gyroscopes, and Encoders (Linear or Rotary), Types of Actuators – Electric (DC, Stepper, Servo Motors), Hydraulic, Pneumatic, and Emerging Smart Actuators (Piezoelectric, Shape Memory Alloy, Electroactive Polymer).

Unit-II 10 Hrs.

Robot Kinematics and Motion planning:

Coordinate frames and transformations – homogeneous transformation matrices,Forward and inverse kinematics; Denavit–Hartenberg (D–H) parameters,Differential kinematics and Jacobians – conceptual and numerical examples,Configuration space and robot motion representation, Motion planning introduction, path and trajectory concepts,Types of trajectory planning – Point-to-Point (PTP) and Continuous Path (CP).

Unit-III 08 Hrs.

Data Acquisition and Preprocessing:

Data collection and preprocessing from multiple sensors through frameworks and middleware (e.g., ROS) for acquisition, synchronization, and refinement of sensor data., Understanding sensor data formats and structures (CSV, JSON, image/video files and ROS bag files). Noise handling using Gaussian, Median, and Kalman filtering methods. Aligning multi-sensor data streams (camera, LiDAR, IMU) using temporal synchronization, spatial calibration, and sensor fusion methods. Handlingmissing or corrupted data using interpolation, statistical imputation, and smoothing methods, Sensor calibration using intrinsic and extrinsic methods for camera– LiDAR and IMU sensors.

Unit-IV 08 Hrs.

Robot Perception:

Introduction to robot perception and environment understanding, Computer vision in robotics – image acquisition, feature extraction, and object recognition,Application of machine learning and deep learning for perception: Classification using CNN and SVM, Object detection using YOLO and SSD, Image segmentation using U-Net and SegNet, building 3D representations from LiDAR using Voxel Grid Mapping or from stereo vision using SGBM (Semi-Global Block Matching).

Unit-V 04 Hrs.

Path Planning:

Path planning algorithms Rapidly-exploring Random Tree(RRT), and PRM, Simultaneous Localization and Mapping (SLAM),Components – Localization, mapping, sensor data processing.

Unit-VI 06 Hrs.

Autonomous Navigation:

Types of SLAM Visual SLAM, LiDAR-based SLAM, RGB-D SLAM, Data association and map building, Learning-based SLAM and navigation using neural implicit mapping and policy learning, Integration of SLAM with path planning and control for autonomous navigation, Evaluation metrics accuracy, drift, real-time performance, and scalability, Reinforcement Learning for Navigation using Q-Learning, Sim-to-Real Transfer Domain Randomization, Imitation Learning, Challenges, and Evaluation.

Text Books:

1. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 3rd Edition, MIT Press, 2022.
2. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in Python", 3rd Edition,Springer, 2023.
3. Jonathan Cacace, "Ultimate Robotics Programming with ROS 2 and Python", 1st Edition, 2024.

Reference Books:

1. Mohamed M. Atia, "Sensor Fusion Approaches for Positioning, Navigation, and Mapping: How Autonomous Vehicles and Robots Navigate in the Real World with MATLAB Examples", 1st Edition, Springer, 2025.
2. Christoph Bartneck, Tony Belpaeme, Friederike Eyssel, Takayuki Kanda, Merel Keijsers & Selma Šabanović, "Human-Robot Interaction – An Introduction", 2nd Edition, Cambridge University Press, 2024.
3. Larry T. Ross, Stephen W. Fardo & Michael F. Walach, "Industrial Robotics Fundamentals", 4th Edition, Jones & Bartlett Learning, 2023.

Web Links:

1. Introduction to Robotics by IIT Madras and Robotics by IIT Kharagpur https://swayam.gov.in/nc_details/NPTEL
2. https://www.udemy.com/course/robotics-course/
3. https://www.coursera.org/courses?query=robotics

Program: Computer Science & Engineering (Data Science)	Final Year B.Tech.	Semester: VIII
Internship (22INTCS8030L)		

Course Objective(s):

1. To expose technically students for the industrial environment, allowing them to gain real-world experience and develop into competent professionals.
2. To provide opportunities to learn and enhance the practical technical skills required for professional roles.
3. To familiarize students with current technological developments relevant to their field of study.
4. To develop technical writing skills for reports and projects.
5. To introduce students to the responsibilities and ethics of the engineering profession.
6. To develop an understanding of employee psychology, habits, attitudes, and problem-solving approaches.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply theoretical knowledge to real-world engineering problems through hands-on experience in industry or field settings.	L3	Apply
CO2	Apply technical knowledge and problem-solving approaches to address complex engineering problems in an industrial environment.	L2	Apply
CO3	Analyze organizational structures, workflows, and technologies to understand industry practices and operational challenges.	L4	Analyze
CO4	Develop technical documentation, reports, and presentations reflecting experiential learning and problem-solving approaches.	L6	Create
CO5	Discuss career goals and identify areas for personal and professional development based on internship exposure.	L2	Understand

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Internships offer valuable educational and career development opportunities by providing students with practical experience in their field of study. In Semester–VIII, students have two options for their internship: Industry Internship and In-house Internship.

1. Industry Internship

Industry Internship Guidelines:

- The Training and Placement (T&P) cell of the institute will arrange internships for students in industries/organizations after the seventh semester.
- Students are expected to accept internship offers regardless of the company, job profile, location, or stipend offered.
- Alternatively, students can individually apply by submitting "Student Internship Program Application" (available on Institute Website) for industry internships, adhering to the prescribed guidelines as follows:
    1. Only T&P department granted internship will be considered.
    2. The internship duration should be of minimum 12 Weeks.
    3. Each student needs to take prior permission from T&P department before proceeding for any internship opportunity on his/her own.
    4. Each student will be monitored twice (virtually/through online meetings) during the internship period in the presence of an industry mentor and the departmental faculty mentor and the concerned TPC.
    5. If any student wants to withdraw from the Internship, he/she can only be allowed within two weeks of joining the same. Such students will have to continue the semester VIII academic activities regularly along with In-house internship.

Expected Activity in Industry Internship:

- Students may choose to work on innovation or entrepreneurial activities resulting in start-ups or undergo internships with Industry/NGO/ Government organizations/Micro/ Small/ Medium enterprises to prepare for the industry.
- Every student is required to prepare a file containing documentary proofs of the activities done by him/her. The evaluation of these activities will be done twice (virtually/through online meetings) during the internship period by the committee constituted by the Head of the Department which shall include Industry mentor, faculty mentor and Department T&P Co-ordinator (TPC). The assessment criteria for continuous assessment is as per Table 4.
- The ESE will be jointly evaluated by an industry mentor, faculty member and department coordinator (TPC). The evaluation criteria is as per Table 5.

Table 4: Continuous Assessment for Industry Internship

Internship Objectives and Goals (30 Marks)	Internship Experience Skills Gained/Enhanced (30 Marks)	Professional Development and Growth (30 Marks)	Internship Report (30 Marks)	Presentation (30 Marks)

Table 5: Evaluation Criteria of Industry Internship

Internship Objectives and Goals (30 Marks)	Internship Experience Skills Gained/Enhanced (30 Marks)	Professional Development and Growth (30 Marks)	Internship Report (30 Marks)	Presentation (30 Marks)

Industry Internship Report:

- Upon completion of the internship, students should prepare a comprehensive report that reflects their observations and learnings during the internship period. Students can consult their Industrial Supervisor, Faculty Mentor, or T&P Co-ordinator/Officer for guidance on selecting special topics and problems for the report.
- The internship report will be evaluated based on the following criteria:
  i. Adequacy and purposeful write-up.
  ii. Variety and relevance of learning experience.
  iii. Practical applications and connections with the fundamental theories and concepts covered in the course (Semester I to VII).

2. In-house Internship

The in-house internship provides students with research-oriented opportunities to cultivate a research mindset. It serves as an extension of the project completed in VI and VII semesters (Project Stage-I & II) or offers new objectives provided by the department or research guide.

1. The in-house internship can be pursued individually or as a group activity.
2. If extending a project from Stage II, at least one student in the group must have participated in Stage I & II.
3. If working on the topic offered by the department or in-house mentor, a group of fresh students can form a team.
4. The maximum group size is limited to four students.
5. In case of extension of project stage II, the outcomes should be in the form of product development/technology transfer along with patent and copyright / one research publication (UGC care listed journal/conference). Students can work jointly with any government

funding agency or industry. In such cases, a detailed project report shall be submitted after verification by the in-house mentor and industry/funding agency mentor/authority. In case of standalone/non-sponsored activity, i.e. without any funding agency/industry collaboration, the detailed project report shall be submitted after verification by the in-house mentor.

6. If pursuing a Topic offered by the department or in-house mentor, the outcome of the in-house internship should include the publication of a research paper, preferably in an SCI/Scopus/UGC care listed/indexed Journal/Conference. The detailed project report must be submitted and verified by the in-house mentor.
7. All the designated work shall be submitted to the department in the form of a report in hardbound as well as soft copy.
8. **Evaluation Scheme:**

   I. Continuous Assessment:

   (a) A logbook (as per Table 6) of the work done must be maintained by each group.

   (b) Each in-house internship activity will be reviewed twice in the semester. In the first review (as per Table 7), at least 40% work shall be completed including the topic identification /introduction/scope of the work, literature survey, problem definition and objectives. The remaining 60% of work shall be completed in the second review (as per Table 8) including implementations, key findings, publications/ patenting/copyright/product development etc.

   II. End Semester Examination:

   End semester examination (as per Table 9) will be jointly evaluated by the faculty mentor and an external examiner appointed by the HOD in consultation with the COE.

9. **Assessment Formats:**

Table 6: Log Book Format

Sr	Week (Start Date: End Date)	Work Done	Sign of In-house mentor	Sign of Coordinator
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Table 7: First Review

Topic Identification & Validation (20 Marks)	Literature Survey (20 Marks)	Problem Definition (20 Marks)	Objectives (15 Marks)

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Table 8: Second Review

Implementation (20 Marks)	Publications (20 Marks)	Report (20 Marks)	Presentation (15 Marks)

Table 9: End Semester Examination

Topic Identification & Validation (30 Marks)	Literature Survey & Problem Definition (30 Marks)	Objectives & Implementation or Product Development (30 Marks)	Presentation (30 Marks)	Report, Publications/Patent/IPR Documents (30 Marks)