M.Tech. Robotics and Automation

(RAU)

Curriculum and Syllabus

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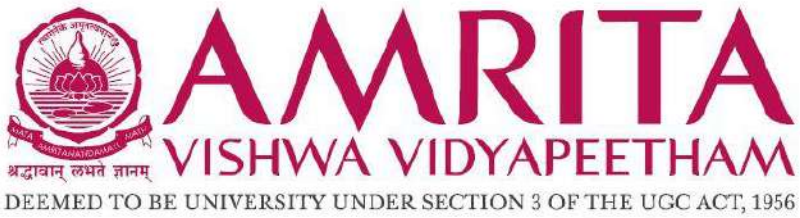


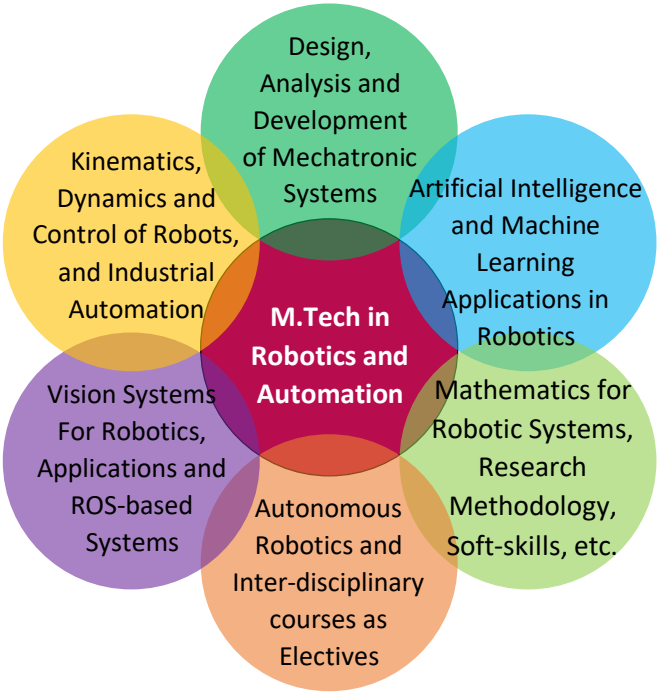
Department of Mechanical Engineering
Amrita School of Engineering
Amritapuri Campus and Bengaluru Campus

Preface

Robotics deals with the design, construction, operation, and application of robots, and has become a highly relevant and upcoming discipline. It is being increasingly applied to almost every field of activity including improving the standard of living of humans, handling dangerous and hazardous situations, relieving mankind of repetitive and tiring activities, exploring outer space and performing complex medical procedures. Many industries also use robots in their manufacturing facilities and research. For instance, robots are used in areas like high heat welding and continuous handling of heavy loads. They can function tirelessly even in the most inhospitable working conditions. Owing to this, robots are taking over from man most of the manipulative, hazardous and tedious jobs in factories, mines, atomic plants, spaceships, deep-sea vessels, etc. The automation of work through robotics has led to substantial increase in productivity in these areas.

Given its diverse applications, the robotics field today demands in-depth knowledge of a broad range of disciplines such as electronics, computers, instrumentation, in addition to mechanics. A graduate entering the workforce in the area of robotics must be thoroughly familiar with intelligent systems and proficient in computer vision, control systems, and machine learning, as well as the design and programming of robotic systems. Specialization in automation also requires the student to apply a wide range of engineering principles to understand, modify or control the manufacture, delivery, and maintenance of technology components in a broad range of industries. Graduates must know how to develop and maintain systems that cost-effectively optimize productivity and quality control.

M.Tech. Program on Robotics and Automation at Amrita Vishwa Vidyapeetham provides a curriculum comprising courses primarily from Mechanical, Electrical and Electronics, Instrumentation, Computer Science and AI streams, as illustrated below:



This M.Tech. program provides a comprehensive educational environment and enables students to gain expertise in next-generation robotics and automation systems. By exposing the students to the lab-integrated courses from multiple disciplines, the delivery of the course and the understanding by the students is focused on "Experiential Learning", where the students are expected to develop hands-on skills on design, development and deployment of robotics and automation systems. Using such a holistic approach, this program intends to prepare a skilled industry workforce as well as expert researchers who will be able to provide leadership in a world that is increasingly dependent on technology.

Program Educational Objectives of the MTech (Robotics and Automation)

PEO1: Provide an interdisciplinary curriculum integrating Mechanical, Electronics & Instrumentation, and Computer Science engineering to build strong technical foundations in robotics.

PEO2: Develop student expertise in next-generation robotics and automation systems through a comprehensive educational environment.

PEO3: Foster a holistic approach to robotics by exposing students to diverse disciplines, preparing them as skilled professionals, researchers, and leaders in a technology-driven world.

Program Outcomes (POs)

PO1: Ability to independently conduct research and develop solutions to practical problems.

PO2: Ability to write and present substantial technical reports and documents effectively.

PO3: Demonstrate advanced mastery in the program specialization beyond undergraduate level requirements.

Program Specific Outcomes (PSOs)

PSO1: Design and develop robotic systems for diverse applications.

PSO2: Implement automated systems integrating IoT, advanced communication, and AI/ML to address industrial and societal challenges.

CURRICULUM

Semester I

Sl. No	Course Code	Course Type#	Course Title	L T P	Credits
1	25MA603	FC	Mathematics for Robotics and Automation	3 0 3	4
2	25RA601	SC	Industrial Automation and IoT	3 0 3	4
3	25RA602	SC	Mechanics of Robots	3 0 3	4
4	25RA603	SC	Embedded Systems for Robotics	3 0 3	4
5	25RA604	FC	Computational Thinking and Data Science	3 0 3	4
6	22ADM501	HU	Glimpses of Indian Culture		P/F
7	23HU601	HU	Career Competency I*	0 0 3	P/F
			Total Credits		**20**

* Non-credit Course

Semester II

Sl. No	Course Code	Course Type#	Course Title	L T P	Credits
1	25RA611	SC	Computer Vision	2 0 3	3
2	25RA612	SC	Robot Control	3 0 3	4
3	25RA613	SC	Motion Planning of Robotics Systems	3 0 3	4
4		E	Elective I	2 0 3 3 0 0	3
5		E	Elective II	2 0 3 3 0 0	3
6	25RM606	SC	Research Methodology	2 0 0	2
7	25AVP501	HU	Mastery over Mind	1 0 2	2
8	23HU611	HU	Career Competency II	0 0 3	1
9	25RA698	P	Industry Internship	0 0 2	1
			Total Credits		**23**

Semester III

Sl. No	Course Code	Course Type#	Course Title	L T P	Credits
1	25RA798	P	Dissertation - Stage I	0 0 20	**10**

Semester IV

Sl. No	Course Code	Course Type#	Course Title	L T P	Credits
1	25RA799	P	Dissertation - Stage II	0 0 30	**15**

FC: Foundation Core, SC: Subject Core, E: Elective, HU: Humanities, P: Project;

Total credits for the M.Tech. Program: 68

Electives

Sl. No.	Course Type	Course Code	Course Title	Credits			
				L	T	P	Total
Industrial Focus							
1	E	25RA731	Additive Manufacturing	2	0	3	3
2	E	25RA732	Digital Twins	2	0	3	3
3	E	25RA733	Systems Engineering Approach	3	0	0	3
4	E	25RA734	Product Design and Development	2	0	3	3
5	E	25RA735	Design for People: Principles and Practices of Human Centered Design	3	0	0	3
6	E	25RA736	Internet of Robotic Things	2	0	3	3
Research Focus							
1	E	25RA741	Humanoid Robotics	2	0	3	3
2	E	25RA742	Advanced Drone Technologies	2	0	3	3
3	E	25RA743	Optimization for Robot Modelling	2	0	3	3
4	E	25RA744	Advanced Robotics and Analysis	3	0	0	3
5	E	25RA745	Biomedical Robotics	3	0	0	3
6	E	25RA746	Soft and Bio-Inspired Robotics	3	0	0	3
Software Focus							
1	E	25RA751	Advanced AI for Robotics	2	0	3	3
2	E	25RA752	Computer Graphics and Animation	3	0	0	3
3	E	25RA753	Virtual Reality and Applications	2	0	3	3
4	E	25RA754	Robot Programming and Simulation	2	0	3	3
5	E	25RA755	Deep Learning	2	0	3	3
6	E	25RA756	Cyber Security	2	0	3	3
Electives from Other Departments							
1		25ES636	Hardware Software Co-Design	3	0	0	3
2		25ES650	Design For IoT and Cloud Computing	2	0	3	3
3		25ES634	Edge AI on Embedded Platforms	2	0	3	3
4		25ES651	Intelligent Systems Design	3	0	0	3
5		25ES644	Web Technologies and Applications	3	0	0	3
6		25ES648	Fault Tolerant System	2	0	3	3

SYLLABUS

Semester I

25MA603	Mathematics for Robotics and Automation	L	T	P	C
		3	0	3	4

Linear Algebra: Vector Algebra, Matrices, System of Linear Equations and Solutions, Vector Space, Eigenvalue and Eigenvectors, Matrix Decomposition Techniques. Application Problems.

Vector Calculus: Differential Calculus – Dot product, Cross product, Derivatives, Scalar field, Divergence and Curl of Vector field. Integral Calculus – Line integral, Surface integrals, Divergence theorem, Stokes theorem, Application Problems.

Numerical Analysis: Numerical Solution of Differential Equations, Numerical Integration, Splines, Interpolation

Optimization: Unconstrained optimization problems – Linear programming, Simplex methods. Constrained optimization problems – Penalty methods. Modern Methods of optimization – Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Neural Network based optimization.

Suggested Lab Sessions:

- Overview of MATLAB / Equivalent.
- Implementation of the contents of the course using MATLAB / Equivalent.
- Develop Mathematical Model of a robotic system as an outcome of the course.

Textbooks / References:

1. Ervin Kreyszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2015.
2. Gilbert Strang, "Linear algebra and its applications", 5th edition, Cengage Learning, 2018.
3. George F Simmons, "Differential equations with applications and Historical notes", Tata McGraw Hill, 3rd edition, Taylor & Francis, 2016.
4. Rao, Singiresu S. Engineering optimization: theory and practice. John Wiley & Sons, 2019.

Course Outcomes:

CO1: Apply the concepts of linear algebra and vector calculus to solve engineering problems.
CO2: Solve computational problems using numerical analysis techniques.
CO3: Implement Laplace and Fourier transform techniques for signal processing problems.
CO4: Apply classical and modern meta-heuristic methods to solve optimization problems.

25RA601	Industrial Automation and IoT	L	T	P	C
		3	0	3	4

Introduction to Industrial automation and its industrial application: Basics of actuation (Pneumatics, Hydraulics, Vacuum, motor), Feedback system (Sensor), Control (PLC, VFD, Servo/Stepper Drives), Supervisory (SCADA, DCS), Planning (ERP, MES), ISO Symbols, Selection of components and System design.

Introduction to PLC based controls: Architecture of PLC, PLC networking, programming – Designing a HMI screen, SCADA design for PLC.

Overview on Mechatronics: Need for modular manufacturing system and Modules of MMS – Step displacement diagram - sequential function chart - I/O module connection. – Integration of different technologies, Simulations of Factory Automation.

Introduction to IoT and Industry4.0: Overview of IoT, Building Blocks of Industry 4.0 - Introduction and need of IIOT – Data mapping between physical system and cyber world – Gateway communication – Working with a IOT App and Data Monitoring - Introduction to AR and VR - Digital Twin concepts.

Suggested Lab Sessions:

- Hands-on Circuiting on Pneumatics, Hydraulics, Vacuum, Motors, Sensors, etc.
- Simulation of industrial systems using Automation Studio/Equivalent.
- PLC Programming - Assemble and test basic Mechatronics circuits (pneumatic, electrical, and software).
- IOT based applications in robotics systems.

Textbooks / References:

1. Anthony Esposito, "Fluid Power with Applications", 7th ed., Pearson Publishers.
2. Kothari, Dwarkadas Pralhaddas, and I. J. Nagrath, “Electric machines”, Tata McGraw-Hill Education, 2004.
3. Frank D. Petruzella, "Programming Logic Controllers", McGraw Hill Book Company
4. Vedam Subrahmaniam, “Electric Drives (Concepts and Applications)”, Tata McGraw-Hill, 2001.
5. Pillai S.K. “A First Course on Electric Drives”, Wiley Eastern Limited, 1998.
6. Ries and Ries, "Programming Logic Controllers", PHI.

Course Outcomes:

CO1: Understand various components of Industrial automation.
CO2: Understand PLC architecture and its programming in automation.
CO3: Analyze pneumatic and hydraulic circuits.
CO4: Design interconnected mechatronics systems using IOT.
CO5: Perform factory automation simulations in Automation Studio / Equivalent

25RA602	Mechanics of Robots	L	T	P	C
		3	0	3	4

Mechanisms: Degrees-of-freedom, overview of standard planar mechanisms

Introduction to Robots: Robot types, trends, applications, classification - Anatomy and architecture of manipulators.

Kinematics of Robotic Arms: Degrees-of-freedom, representation of translation and rotation, Homogeneous Transformation Matrices (HTM), Denavit-Hartenberg (DH) parameters, forward and inverse kinematics of standard serial manipulators (upto 6-axis wrist-partitioned robot), forward and inverse velocity Jacobian matrices and their physical significance.

Statics of Robotic Arms: Static force analysis, Jacobian and force relations.

Dynamics of Robotic Arms: Mass and inertia properties, Euler-Lagrange and Newtons-Euler methods for dynamic analyses of systems with translational and rotational motions, forward and inverse dynamics of serial manipulators.

Motion Planning of Robotic Arms: Joint level and Cartesian level motion, robot programming.

Mobile Robots: Mechanics of wheeled, legged and aerial robots.

Suggested Lab Sessions:

- CAD Software: Part Modelling and Assembly Modelling.
- CAD Software: Analysis of Serial and Parallel Manipulators.
- GeoGebra / Equivalent: Analysis of standard planar mechanisms.
- GeoGebra / Equivalent: Development of HTM module to represent translation and rotation.
- RoboAnalyzer / Equivalent: DH Parameters, Forward and Inverse Kinematics.
- MATLAB/Equivalent: Forward and Inverse Dynamics, Motion Planning.
- RoboAnalyzer / Physical Robot: Programming of Robotic Manipulator.
- Mobile Robots: Wheeled, Legged and Aerial Robots.
- Development of a robotic system using COTS components.

Textbooks / References:

1. S. K. Saha, “Introduction to Robotics”, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2024.
2. A. Ghosal, “Robotics: fundamental concepts and analysis”, 2nd Edition, Oxford University Press, 2023.
3. N. Odrey, M. Weiss, M. Groover, R. Nagel and A. Dutta, “Industrial Robotics Technology Programming and Applications”, 2nd Edition, McGraw Hill Education (India), 2017.
4. Robert J Schilling, “Fundamentals of Robotics, Analysis and Control”, Prentice Hall, 2007.

Course Outcomes:

CO1: Understand the mechanisms and robot classifications, specifications and applications.
CO2: Apply coordinate transformation in the analysis of robotic systems.
CO3: Analyze forward and inverse kinematics of serial manipulators.
CO4: Analyze static and dynamic analyses of serial manipulators.
CO5: Understand the mechanics of mobile robots.

25RA603	Embedded System for Robotics	L	T	P	C
		3	0	3	4

Module 1: Actuators (electrical) - DC motors, BLDC servo motors; PMAC Motors, Induction Motors, Motor characteristics, Basics of power electronic converters, PWM operation, Motor Control structure; Selection of Motors and Controllers – operating regions, operating duty.

Module 2: Sensors and controls: Sensors for measuring position, speed, force, torque etc. review of sensors and transducers, signal conditioning- operational amplifier, filtering, pulse modulation, analog and digital signals, actuation systems- mechanical, pneumatic, hydraulic, and electrical actuation.

Module 3: Microprocessor building blocks, combinational and sequential logic elements, memory, timing, and instruction execution fundamentals with an example of primitive microprocessor, Introduction to Embedded Processors. ARM Architecture – Programmer's Model, Pipelined data path design. Memory system design- Cache Memory, Memory Management unit, Virtual Memory. Overview of 8-bit and 16-bit microcontrollers. Introduction to ARM-based Microcontrollers – Architecture, Peripherals - Input/output ports, Timers, ADC, DAC, PWM, Quadrature Encoder, Advanced communication interfaces.

Suggested Lab Sessions:

- Familiarization with IDE, simulator, development boards, and kits,
- Embedded C Program to configure and use Input/output ports & Timers, ADC and DAC, PWM, UART, SPI, I2C, components.
- Speed control of DC Motor (Setup / DIY kit)
- Experimentation with different types of motors and actuators
- Simulation of Sensors/Microcontrollers in TinkerCAD / Equivalent
- Design and Testing of Circuits using the components covered in the course on physical hardware kits.
- Development of a robotic system as a cumulative outcome of the course.

Textbooks / References:

1. Saurabh Chandrakar Nilesh Bhaskarrao Bahadure, "Microcontrollers and Embedded System Design", First Edition, Dreamtech Press, 2019.
2. Thomas Bräunl, "Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems", Third Edition, Springer-Verlag Berlin Heidelberg, 2008.
3. William Hohl and Christopher Hinds, "ARM Assembly Language: Fundamentals and Techniques", Second Edition, CRC Press, 2016.
4. Rob Toulson and Tim Wilmshurst, "Fast and Effective Embedded Systems Design: Applying the ARM mbed", Newnes, 2012.
5. Steve Furber, "ARM System-on-Chip Architecture", Pearson India, 2015.

Course Outcomes:

CO1: Understand the basics of the embedded system design approach and the components involved.

CO2: Develop mathematical models for sensors, actuators, and understand their input/output characteristics.

CO3: Describe the detailed architecture, internal modules, and addressing modes of ARM-based processors and interfacing with sensors & actuators.

CO4: Develop assembly and high-level language programs for various robotics applications.

25RA604	Computational Thinking and Data Science	L	T	P	C
		3	0	3	4

Module 1: Introduction to Computational Thinking - Abstraction, Decomposition, Pattern Recognition - Algorithm Design: Sequence, Selection, Repetition - Logical Reasoning and Flowcharts-Problem formulation and structured thinking Case study: Simple real-life problem modeling using algorithm. Problem Solving with Algorithms - Searching and Sorting - Applied Computational Thinking Problems.

Module 2: Python basics: Syntax, Data Types, Variables, I/O - Control Flow: Conditionals and Loops -Data Structures: Lists, Tuples, Dictionaries, Sets - Functions and Recursion - File Handling and Exception Handling - Debugging and Code Tracing. Python Libraries, Text Processing, Data Processing and Analysis, Chatbot etc.

Module 3: Data Science: Data Pre-processing: Data cleaning, Data reduction, Data transformation, Data discretization. Visualization and Graphing: Visualizing Categorical and Numerical Distributions, Dimension Reduction: Curse of Dimensionality, Practical Considerations, Correlation Analysis, Principal Components Analysis, Dimension Reduction Using Regression, Classification, Linear Discriminant Analysis.

Module 4: Introduction to Machine Learning: Supervised learning - Regression: Linear regression, logistic regression – Classification: K-Nearest Neighbor, Naïve Bayes, Decision Tree, Random Forest, Support Vector Machine, Perceptron, Error analysis. Unsupervised learning – Clustering: K-means, Hierarchical, Spectral, subspace clustering, Introduction to Neural Networks, Reinforcement learning and generative learning.

Suggested Lab Sessions:

- Implementation of Flowgorithm / Equivalent for Algorithms.
- Overview of Python Programming / Equivalent.
- Implementation of contents of the course using Python / Equivalent.

Textbooks / References:

1. Andrew Ng, Machine learning yearning, URL: http://www. mlyearning. org/(96) 139 (2017).
2. Kevin P. Murphey. Machine Learning, a probabilistic perspective. The MIT Press Cambridge, Massachusetts, 2012.
3. Christopher M Bishop. Pattern Recognition and Machine Learning. Springer 2010
4. Richard O. Duda, Peter E. Hart, David G. Stork. Pattern Classification. Wiley, Second Edition;2007
5. Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2018.
6. John Hopcroft and Ravi Kannan, “Foundations of Data Science”, ebook, Publisher, 2013.

Course Outcomes:

CO1: Apply pre-processing techniques to prepare the data for machine learning applications
CO2: Implement supervised machine learning algorithms for different datasets
CO3: Implement unsupervised machine learning algorithms for different datasets
CO4: Analyze the error to improve the performance of the machine learning models

Semester II

25RA611	Computer Vision	L	T	P	C
		2	0	3	3

Digital image formation and low-level processing: Overview and state-of-the-art, fundamentals of image formation, transformation: orthogonal, Euclidean, affine, projective, etc; Fourier transform, convolution and filtering, image enhancement, restoration, histogram processing.

Depth estimation and multi-camera views: Perspective, binocular stereopsis: camera and epipolar geometry; Homography, rectification, DLT, RANSAC, 3-D reconstruction framework.

Feature extraction: Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.

Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised;

Suggested Lab Sessions:

- Usage of OpenCV / MATLAB / Equivalent for the implementation of the course topics.
- Develop computer vision-based applications in robotic systems.

Textbooks / References:

1. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer-Verlag London Limited 2011.
2. D. A. Forsyth, J. Ponce, “Computer Vision: A Modern Approach”, Pearson Education, 2003.
3. Gonzalez, Woods and Eddins, "Digital Image Processing using MATLAB", Prentice Hall, 2004.

Course Outcomes:

CO1: Understand digital image formation and related processing.
CO2: Apply depth estimation using stereo views.
CO3: Apply feature extraction techniques for detection of edges.
CO4: Perform image segmentation.
CO5: Analyze patterns using clustering and other means.

25RA612	Robot Control	L	T	P	C
		3	0	3	4

Introduction and Motivation: Role of controls (open and closed loop control), Mathematical preliminaries, review of classical control concepts.

Introduction to modern control theory: State Space Design: Modelling of physical systems, Linearization, Concepts of state, State-space, Representation of Linear system, Controllability and Observability, State Observers.

Advanced Controller Design: Kalman Filters as Dynamic System State Observers; Linear Quadratic Regulator (LQR) Design of model-predictive controller.

Case study on control of robotic manipulators, mobile robots and other robotic systems in joint space and task space, controller design- PID control, stability analysis.

Suggested Lab Sessions:

- Usage of MATLAB/Equivalent for the mathematical modelling of physical systems, electro-mechanical systems.
- Usage of MATLAB/Equivalent for the implementation of different control models and stability analysis.
- Usage of MATLAB/Equivalent for the control of robotic systems and their stability analyses.

Textbooks / References:

1. S. K. Saha, “Introduction to Robotics”, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2024.
2. A. Ghosal, “Robotics: fundamental concepts and analysis”, 2nd Edition, Oxford University Press, 2023.
3. K. Ogata, “Discrete-Time Control Systems”, Pearson Education, 2011.
4. M. Spong, M. Vidyasagar, S. Hutchinson, “Robot Modeling and Control”, Wiley & Sons, 2005.
5. Peter Corke, "Robotics, Vision, and Control: Fundamental Algorithms in MATLAB",. Springer, 2013.
6. John J Craig, “Introduction to Robotics: Mechanics and Control”, Pearson, 2018.

Course Outcomes:

CO1: Model control systems in the continuous domain using classical control approach.
CO2: Analyze control systems using state space models.
CO3: Design state feedback controllers and state observers for continuous time and discrete time systems.
CO4: Apply control strategies and stability analysis techniques to robotic systems.
CO5: Use software tools for the analysis and design of control systems.

25RA613	Motion Planning of Robotic Systems	L	T	P	C
		3	0	3	4

Planning in a known environment with Stationary obstacles: Potential fields, Dynamic programming, Graph search, Depth-first, Breadth-first, and Djikstra, A*;

Unknown environment and stationary obstacle: Weighted A, Anytime A*, D* Lite;

Complex high dimensional environment: Sampling based algorithms, Visibility Road maps and randomized trees, graphs: RRT and RRT*;

Realistic robot models: Reed-Shepps Car, Dubins Car, Differential drive robot and kinematic constraints, articulated arms;

Planning in the presence of uncertainty: MDP based approaches;

Planning in the absence of system model: Machine Learning and Reinforced Learning based approaches.

Suggested Lab Sessions:

- Introduction to ROS (2 or latest stable version) - ROS Basic Concepts: Nodes, topics, parameters, services - Simple ROS programs to publish and subscribe messages. Simulation of robot systems in ROS: Manipulators, wheeled robots in scenarios such as in a maze etc., legged robots and UAVs in various environments.
- Implementation of motion planning algorithms in MATLAB/ROS/Equivalent.
- Understanding Kinematic models for Mobile Robots, Maneuverability, Dynamic Path Planning, Scenario based control, path planning and sensor fusion, Workspace & Motion control, Sensors & Actuators for Mobile Robots, Sizing and Torque Calculations.
- Develop Autonomous Robotic System as a physical working prototype.

Textbooks / References:

1. R. Siegwart and Illah R. Nourbakhsh, “Introduction to Autonomous Mobile Robots”, MIT Press, 2004.
2. Steven M. LaValle, “Planning Algorithms”, Cambridge University Press, 2006.
3. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki and S. Thrun, “Principles of Robot Motion: Theory, Algorithms, and Implementations”, MIT Press, Boston, 2005.
4. ROS Wiki.
5. Joseph, Lentin, and Jonathan Cacace, “Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System”, Packt Publishing Ltd, 2018.
6. Jason M. O’Kane, "A Gentle Introduction to ROS" ISBN 978-14-92143-23-9.

Course Outcomes:

CO1: Understand the basic concepts of ROS.
CO2: Understand various types of mobile robots and their kinematic models.
CO3: Implement motion planning in known environments.
CO4: Apply motion planning techniques in unknown environments.
CO5: Implement machine learning and reinforced learning techniques for motion planning.

25RA698	Industry Internship	L	T	P	C
		0	0	2	1

Students must undergo a minimum of two weeks of practical training in Robotics and Automation or allied industries/research laboratory of their choice with the approval of the department. At the end of the training, students should submit a report and certificate of completion to the department in the prescribed format.

This course is mandatory, and a student must pass this course to be eligible for the award of a degree. The student shall make a report. The committee constituted by the department which will assess the student based on the report submitted.

Course Outcomes:
CO1: Familiarize with the industry environment / Research Laboratory.
CO2: Understand the application of theoretical concepts in a practical setting.
CO3: Prepare technical documents/presentations related to the work completed.

Semester III

25RA798	Dissertation Stage I	L	T	P	C
		0	0	20	10

Dissertation (Stage I) should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. Tech. The examination shall consist of the preparation of report consisting of a detailed problem statement, literature review and. initial results of the problem.

The work has to be presented in front of the examiners consisting of Head of the Department and PG coordinator/Faculty Advisor and other invited faculty members (if any). The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

Course Outcomes:
CO1: Identify appropriate methodology to solve a research problem.
CO2: Execute their research investigation adopting the chosen methodology and obtain results.
CO3: Write a technical report in a prescribed format.

Semester IV

25RA799	Dissertation Stage II	L	T	P	C
		0	0	30	15

Dissertation (Stage II) will start in Semester IV which is expected to be a continuation of Dissertation-1. In this phase of the project, students are expected to do the remaining part of their works done in Stage I. To particularly note, this phase of the project involves detailed data acquisition and subsequent analysis of the research problem. The dissertation should be presented in standard format as provided by the department/guide. The candidate has to prepare

a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, details of methodology adopted (experimental/ numerical/ analytical) and results and discussion. The report must bring out the conclusions of the work and future scope for study.

The work has to be presented before the panel of examiners consisting of an approved external examiner, internal examiner/guide as decided by the department head and PG coordinator/faculty advisor. The candidate has to be in regular contact with his/her guide throughout the project duration. All the students are expected to publish their works in reputed journals/conferences (Scopus-indexed).

Course Outcomes:

CO1: Carry out detailed analysis of research data acquired through experimental/ numerical/ analytical methodologies in the context of the existing literature and draw valid conclusions thereof.

CO2: Write the project report systematically in a prescribed format.

CO3: Write research articles worthy of publishing in reputed journals/conferences (SCI-indexed/Scopus-indexed).

Electives: Industrial Focus

25RA731	Additive Manufacturing	L	T	P	C
		2	0	3	3

Unit 1:
Introduction to layered manufacturing, Importance of Additive Manufacturing Additive Manufacturing in Product Development Classification of additive manufacturing processes, Common additive manufacturing technologies; Fused Deposition Modeling(FDM), Selective Laser Sintering(SLS), Stereo Lithography(SLA), Selection Laser Melting (SLM), Jetting, 3D Printing, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM) Capabilities, materials, costs, advantages and limitations of different systems.

Unit 2:
Material science for additive manufacturing-Mechanisms of material consolidation-FDM, SLS, SLM, 3D printing and jetting technologies. Polymers coalescence and sintering, photopolymerization, solidification rates, Meso and macro structures, Process evaluation: process-structure relationships, structure property relationships, Applications: Prototyping, Industrial tooling, Aerospace, Automobile, Medical etc., Quality control and reliability: Defects in FDM, SLS and SLM, Critical process parameters: geometry, temperature, composition, phase transformation, Numerical and experimental evaluation: roles of process parameter combination, process optimization.

Unit 3:
CAD Modelling for 3D printing: 3D Scanning and digitization, data handling &reduction Methods, AM Software: data formats and standardization, Slicing algorithms:-uniform flat layer slicing, adaptive slicing, Process-path generation: Process-path algorithms, rasterisation, part Orientation and support generation.

Suggested Lab Sessions:
CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing features, Different file formats, Export/Import geometries, Part orientation, Layer slicing, Process path selection, Printing, Numerical and experimental evaluation.

Textbooks / References:

1. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.
2. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.

Course Outcomes:
CO1: Demonstrate appropriate level of understanding on principles of additive manufacturing processes.
CO2: Choose appropriate materials for additive manufacturing processes.
CO3: Apply suitable CAD tools and CAD interface for additive manufacturing process.
CO4: Develop physical prototypes by identifying suitable process with optimum process parameters.

25RA732	Digital Twins	L	T	P	C
		2	0	3	3

DIGITAL TWINS: Industrial Revolutions. Digital Twins: Definition, Types of Industry & its Requirements, Characteristics of Digital Twins, Importance, benefits, Impact, and Challenges. Conceptual design methodology of digital twins, Five-dimensional digital twins for the product, Application of Digital Twins in process, product, service industries, History of Digital Twins, Digital Transformation role in industry innovation, Technologies/tools enabling Digital Twins.

DESIGN OF DIGITAL TWINS: Design of Digital Twins: Technological needs. Physics-based approach: Model identification, Model creation. Data-driven approach: Model development using ML/DL models. Digital twins for Prototype, Product, and Performance. Digital Twins validation.

DIGITAL TWINS IN THE DISCRETE INDUSTRY: Discrete Industry: Trends in the Discrete Industry, control system requirements in a Discrete Industry, Digital Twins of a Product, Digital Thread in Discrete Industry, Data Collection & Analysis for Product & production improvements, Automation Simulation, and Digital Enterprise.

DIGITAL TWINS IN THE PROCESS INDUSTRY: Process Industry: Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twins of a plant, Digital Thread in process Industry, Data collection & Analysis for process improvements, process safety, Automation simulation, and Digital Enterprise.

APPLICATIONS OF DIGITAL TWINS: Improvement in product quality, production process, process Safety, identifying bottlenecks and Improve efficiency, achieve flexibility in production, continuous prediction, and tuning of the production process through Simulation, reducing the time to market.

Suggested Lab Sessions:

- Exercise on Model development using MATLAB Simulink, Simscape
- Exercise on Model identification using MATLAB – System Identification
- Model development using Simscape
- Fault Diagnosis of rotating elements using Digital Twins
- Parameter tuning of Digital Twins
- Digital Twins for fan speed control system
- Develop Predictive Models using Digital Twins
- Estimate the remaining useful life using Digital Twin

Textbooks / References:

1. Alp Ustundag and Emre Cevikcan, "Industry 4.0: Managing The Digital Transformation", Springer Series in Advanced Manufacturing., Switzerland, 2017.
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, "Digital Twin Driven Smart Manufacturing", Elsevier Science., United States, 2019.
3. Shyam Varan Nath, Pieter van Schalkwyk, Dan Isaacs, “Building Industrial Digital Twins Design, Develop, and Deploy Digital Twin Solutions for Real-world Industries Using Azure Digital Twins”, Packt Publishing, 2021.

Course Outcomes:

CO1: Introduce the concept of Digital Twins in manufacturing the industry.
CO2: Acquire knowledge of Digital Twins and their importance.
CO3: Design Digital Twins for discrete and process industries.
CO4: Analyze the performance of Digital Twins.
CO5: Discover the advantages and applications of Digital Twins.

25RA733	Systems Engineering Approach	L	T	P	C
		3	0	0	3

Unit 1

Introduction Industrial Automation - Key Technologies and Tools Driving Industrial Automation – Purpose and benefits of industrial Automation

Unit 2

Understanding workflow automation in an automated continuous process – KRA and KPI derivation for better outcome – Different types of automation implementation process - System Intergration approaches for discrete and process automation

Unit 3

Process automation (PID Diagram) - Master slave Concepts – Basics of different controllers and monitoring tools

Unit 4

Case study on industrial automation application

Textbooks / References:

1. Kossiakoff, Alexander, William N. Sweet, Samuel J. Seymour, and Steven M. Biemer. Systems engineering principles and practice. Vol. 83. John Wiley & Sons, 2011.
2. De Canete, Javier Fernandez, Cipriano Galindo, and Inmaculada Garcia-Moral. System Engineering and Automation: An Interactive Educational Approach. Springer Science & Business Media, 2011.

Course Outcomes:

CO1: Understand the key technologies and tools driving industrial automation.
CO2: Apply various automation implementation processes through system integration.
CO3: Implement various controllers and monitoring tools to achieve process automation.
CO4: Analyze case studies on best practices of industrial automation.

25RA734	Product Design and Development	L	T	P	C
		2	0	3	3

Module 1

Introduction: Classification/ Specifications of Products. Product life cycle. Product mix. Introduction to product design. Modern product development process. Innovative thinking. Morphology of design.

Conceptual Design: Generation, selection & realisation of concept. Product architecture. Industrial design: Need and process. Robust Design: Taguchi Designs & DOE. Design Optimization.

Module 2

Ergonomics and Aesthetics: Gross human anatomy. Anthropometry. Man-Machine interaction. Concepts of size and texture, colour. Comfort criteria. Psychological & Physiological considerations. Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design.

Value Engineering and Value Analysis: Definition and basic concepts only. Economic analysis (Basic concepts): Qualitative & Quantitative. Product costing.

Module 3

Design for Manufacturing & Assembly: Methods of designing for Manufacturing & Assembly. Designs for Maintainability. Designs for Environment. Legal factors and social issues. Engineering ethics and issues of society related to design of products.

Basic concepts of Concurrent Engineering, Rapid prototyping techniques including Additive Manufacturing. Tools for product design – Drafting / Modelling software. QFD. CAM Interface. Overview of Patents & IP Acts. Report generation.

Suggested Lab Sessions:

- 3D Modelling in CAD Software (Autodesk Inventor / Equivalent)
- Part Modelling, Complex Surfaces, Assembly Modelling
- Additive Manufacturing using 3D Printers
- Develop a functional and ergonomically viable product as an outcome of the course.

Textbooks / References:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, “Product Design and Development”, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9
2. Chakrabarti, “Indian Anthropometric Dimensions for Ergonomic Design Practice”, National Institute of Design. (1997).

Course Outcomes:

CO1: Apply methods for collection of customer requirements and for formulating product requirements.

CO2: Select an appropriate product design and development process for a given application.

CO3: Choose an appropriate ergonomics for the product.

CO4: Develop methods to minimize the cost.

25RA735	Design for People: Principles and Practices of Human Centered Design	L	T	P	C
		3	0	0	3

Introduction to Usability: History, Classic Examples, Core Principles Representing Users: Goal and task analysis, Personas, User scenarios, Agile user stories and epics. Methods of Data Gathering and Analysis: Lean UX, Ethnographic observation, Interviews, Surveys, User studies, Usability labs, Eye tracking, Biometric measurement, Qualitative and quantitative data methods. Creating Personas: Collecting data sources, Initial drafting, Assessing with stakeholders, Final crafting and prioritization. Working with Personas: Scenario definition with personas, Functionality prioritization with personas, Quality Assurance with personas. User-centered design processes: User participation, Iteration, Identifying expand/collapse phases. Collaboration with Engineering: Managing the tech-centered and human-centered design processes together.

Textbooks / References:

1. Norman, D. The Design of Everyday Things. Basic Books: 2013.
2. Gothelf, J. Lean UX: Applying Lean Principles to Improve User Experience. O'Reilly Media: 2013.

Course Outcomes:

CO1: Understand Usability: History, Classic Examples, Core Principles.
CO2: Understand Methods of Data Gathering and Analysis.
CO3: Analyze Collecting data sources, Initial drafting, Assessing with stakeholders, Final crafting and prioritization.
CO4: Apply Working with Personas.
CO5: Apply User participation, Iteration, Identifying expand/collapse phases.
CO6: Analyze Collaboration with Engineering: Managing the tech-centered and human-centered design processes together.

25RA736	Internet of Robotic Things	L	T	P	C
		2	0	3	3

IoT Foundations - Introduction to Internet of Things, An Overview Introduction – Definition and characteristics of IoT, Physical design of IoT- Things in IoT, IoT protocol, Logical design of IoT – IoT functional blocks, IoT Communication Models, Introduction to SDN, SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing, Examples of IoT based Systems: Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT.

Robotics and IoT Integration - Role of Robotics in IoT, Smart Robotics and Intelligent Automation, IoT-enabled Robotics Applications, Challenges and Opportunities in Robotics and IoT Integration,Future Trends in Robotics and IoT

Ethical and Social Considerations - Ethical Issues in Robotics and IoT, Privacy and Security Concerns, Impact on Society and the Environment, Responsible Design and Development

Suggested Lab Sessions:

- Interface sensors with ESP32/Raspberry Pi and upload real-time data to a cloud platform to demonstrate the physical design of IoT
- Control a robotic system (e.g. mobile robot or robotic arm) remotely using an IoT platform for smart automation to illustrate IoT and Robotics Integration
- Conduct a simulation-based case study analyzing privacy and security risks in smart home IoT systems and proposing mitigation strategies.

Textbooks / References:

1. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
2. Raj Kamal, “Internet of Things – Architecture and Design Principles”, First Edition, McGraw Hill Education, 2017. (ISBN: 978-9352605224).
3. Arshdeep Bahga and Vijay Madisetti, “Internet of Things: A Hands-on Approach", Universities Press, 2014.

Course Outcomes:

CO1: Explain the fundamentals, characteristics, physical and logical design, protocols, and communication models of IoT systems.

CO2: Analyze Software Defined Networking (SDN) concepts and their applications in IoT for efficient data handling and connectivity.

CO3: Evaluate cloud computing, sensor-cloud, fog computing, and data analytics approaches in developing IoT-based smart systems.

CO4: Analyze the integration of robotics and IoT, including applications, ethical and societal impacts, and future trends in smart automation.

Electives: Research Focus

25RA741	Humanoid Robotics	L	T	P	C
		2	0	3	3

Difference between two-legged humanoids and human like wheeled robots. Kinematics – Coordinate Transformations – Characteristics of Rotational Motion – Velocity in Three-Dimensional Space – Robot Data Structure and Programming – Kinematics of a Humanoid Robot.

ZMP and Dynamics – ZMP and Ground Reaction Forces – Measurement of ZMP – Dynamics of Humanoid Robots – Calculation of ZMP from Robot's Motion. Biped Walking – Two-Dimensional Walking Pattern Generation – 3D Walking Pattern Generation – ZMP-based Walking Pattern Generation – Stabilizing Control – Central Pattern Generators.
Methods for gait generation, central pattern generators. Applications of humanoid robots. Humanoid robots in society - current and future applications, comparison with other types of robots. Hardware construction, including the use of microcontrollers and servo motors in connection with humanoid robots.

Suggested Lab Sessions:

- Part and Assembly Modelling in 3D CAD Software (Autodesk Inventor / Equivalent)
- Kinematic analysis of biped architecture in MATLAB and ADAMS/ RecurDyn/ Equivalent
- Dynamic analysis of biped architecture in MATLAB and ADAMS / RecurDyn / Equivalent
- Design and development of a functional biped robot as an outcome of this course

Textbooks / References:

1. Goswami Ambarish, Vadakkepat Prahlad, "Humanoid Robotics: A Reference", Springer, 2019.
2. Shuuji Kajita et. al., "Introduction to Humanoid Robotics", Springer, 2014.
3. John J Craig, "Introduction to Robotics: Mechanics and Control", Third Edition, 2003.
4. Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators".
5. Jean-Claude Latombe, "Robot Motion Planning", Springer Science, 1991.

Course Outcomes:

CO1: Understand various types of humanoid robots.
CO2: Apply kinematics of humanoid robots.
CO3: Apply ZMP and ground reaction forces of humanoid robots.
CO4: Apply dynamics of humanoid robots.
CO5: Analyze biped walking of humanoid robots.
CO6: Analyze various walking pattern generations of humanoid robots.

25RA742	Advanced Drone Technologies	L	T	P	C
		2	0	3	3

Fixed Wing and Multirotor Micro Drones: Introduction 3 Drones 3 Kinematic and dynamics modelling formulation of drones - Transformation and representations 3 Dynamics of a fixed-wing drones, Propeller theory 3 Thrust and drag moment 3 Dynamics of a multi rotor micro drones (MMD) 3 Mathematical modelling of MMD.

State Estimation: Physics and working of Navigational sensors 3 Inertial Sensors 3 Magnetometer 3 Pressure sensors, GPS 3 Camera based navigation 3 Kalman filter 3 Position and velocity analysis, Inertial navigation systems 3 Attitude estimation.

Flight Controls and Motion Planning: PIC control 3 Lateral control of MMD, LQR 3 Design of servo LQR control, Linear model predictive control 3 Design and implementation. Holonomic vehicle boundary value solver, Dubins airplane model boundary value solver 3 collision free navigation, Structural inspection path planning.

Suggested Lab Sessions:

- Study of components of a drone
- Simulation of Drone Flying in a simulator (using hand-held drone controller)
- Assembly of drones
- Calibration and testing of drones
- Flying of drones in the form of simpler to complex tasks

Textbooks / References:

1. R. Beard, and T. W. McLain, Small Unmanned Aircraft: Theory and Practice, Princeton University Press, 2012.
2. R. C. Nelson, Flight Stability and Automatic Control, McGraw Hill, New York, 1998.

Course Outcomes:

CO1: Solve the kinematics and dynamics of fixed wing drones.
CO2: Solve the kinematics and dynamics of fixed wing drones multi rotor micro drones.
CO3: Design the flight controls of drones.
CO4: Design and develop path planning algorithms for drones.

25RA743	Optimization for Robot Modelling	L	T	P	C
		2	0	3	3

Introduction to traditional gradient based Optimization algorithms; Optimality criterion for unconstrained and constrained optimization problems Heuristic, Meta-heuristics, and Evolutionary algorithms: selective algorithms specific to robotic applications.

Spatial representation of a rigid body: Position - Rotational Matrix - Euler angles: problem formulation to find best Euler angles - Roll, Pitch and Yaw angles - Homogeneous transformation matrix, Finding optimal values of Roll, Pitch and Yaw. Kinematic Synthesis: Introduction- Type synthesis Dimensional Synthesis - Evolutionary method, Graph theory approach. Structural Optimization: Topology optimization - Dimensional synthesis using optimization algorithms, Stiffness analysis and optimization.

Manipulator Kinematics: Introduction-Manipulator; Formulating objective function of the forward and inverse kinematics, identify optimum joint angle for the given position vector - Manipulator Jacobian: Finding optimum Jacobian of a manipulator. Path and Trajectory Planning: Introduction - Path Planning algorithms: Identifying optimal path using heuristic approach, Collision detection algorithms; Trajectory Planning: Algorithms, identifying optimum velocity and acceleration along the path.

Suggested Lab Sessions:

- Overview of MATLAB for Optimization problems
- Motion planning for robotic arm considering minimum time, shortest motion, etc.
- Implement collision detection methodologies and optimize motion planning
- Test motion planning algorithms on physical robots.

Textbooks / References:

1. Ghafil, Hazim Nasir, and Károly Jármai. Optimization for Robot Modelling with MATLAB. Springer International Publishing, 2020.
2. Singiresu S Rao, “Engineering Optimization Theory and Practice”, 4th edition, John Wiley & Sons, Inc., 2009.
3. Jha, Panchanand, and Bibhuti Bhusan Biswal. "Optimization Approach for Inverse Kinematic Solution." In Kinematics. IntechOpen, 2017.

Course Outcomes:

CO1: Formulate Homogeneous Transformation Matrix (HTM) of rigid body and compute optimal values of Roll, Yaw and Pitch.
CO2: Develop solutions using optimization procedure for the forward kinematics and inverse kinematics of the robot manipulator.
CO3: Compute optimum path and trajectory of the robot using optimization methods.
CO4: Optimize the dimensions of the physical components of the robot using meta-heuristic approaches.
CO5: Identify an appropriate robot type with minimum dimensionality for a given specific task using optimization procedure.

25RA744	Advanced Robotics and Analysis	L	T	P	C
		3	0	0	3

Review of robot manipulator (Serial and Parallel), DH convention, Forward and Inverse kinematics, Workspace, Analytical and numerical solutions, vibration isolation.

Redundancy and resolution of redundancy in robots, minimizing joint rotations and cartesian motion, Tractrix based approach (resolution, planar and spatial). Experimental 8-link hyper-redundant manipulator, Dynamic equations of motion, derivation & simulation, Recursive inverse dynamics: Newton-Euler formulation, Articulated body algorithm, Chaos and non-linear dynamics, Pseudo-inverse approach, modal approach for straight and circular trajectory.

Simulation on linear control, motion planning, nonlinear position and force control of 6 DOF robot manipulator, partitioning of tasks. Numerical and analytical solutions, Over-constrained and deployable structures 3 modelling and analysis, Cable driven & pneumatically actuated flexible robots.

Textbooks / References:

1. Angeles, J., "Fundamentals of Robotic Mechanical Systems", Springer International Publishing, 2014
2. S. K. Saha, "Introduction to Robotics", 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2024.
3. A. Ghosal, "Robotics: fundamental concepts and analysis", 2nd Edition, Oxford University Press, 2023.

Course Outcomes:

CO1: List and describe the advanced elements of serial and parallel robot manipulators.
CO2: Interpret the algorithms and advanced mathematical formulation of manipulators.
CO3: Apply the mathematical models and algorithms in simulation and analysis.
CO4: Design and develop own robot through analysis, simulation and fabrication.

25RA745	Biomedical Robotics	L	T	P	C
		3	0	0	3

Unit 1

Introduction to Medical Robots: Introduction to Bio-medical robots, Types of Medical Robots, Navigation and paradigms of BioMedical Robots, Forward kinematics, Inverse, Typical applications and benefits of robots in Health care sectors

Design of Medical Robots: Characterization of gestures to the design of robot-design methodology- technological choices-security

Unit 2

Rehabilitation Robotics: Introduction, Exoskeletons-Design concepts, Development and control- Human hand-Biomechanics, Rehabilitation for Limbs-Brain-Machine-Interfaces, Redundancy resolution, Introduction to Rehabilitation Strategies, Robotic prosthetics. Mobile Robot locomotion: Types of locomotion and its salient characteristics of hopping robots, legged robots, wheeled robots, stability, aerial robots, maneuverability, controllability.

Unit 3

Current Topics in Bio-Medical Robotics: Haptic Augmentation in Exoskeletons, Robotic Catheters for percutaneous interventions, Unsupervised learning for mapping in Bio-Robots, Reven–II Robots. Future Trends of Robotics In the Medical Field. Mobile Robot localization and Navigation: Introduction, the challenges of localization, localization based navigation versus programmed solutions, map representation, probabilistic map, map based localization, autonomous map building. Planning and navigation: Planning and reaction, D* algorithm obstacle avoidance.

Textbooks / References:

1. Paula Gomes, "Medical robotics- Minimally Invasive surgery", Woodhead, 2012
2. Jocelyne Troccaz, “Medical Robotics”, Wiley-ISTE, 2012. 2. VanjaBonzovic, ”Medical Robotics”, I-tech Education publishing,Austria,2008.
3. Daniel Faust, “Medical Robots”, Rosen Publishers, 2016.
4. Jacob Rosen, Blake Hannaford & Richard M Satava, “Surgical Robotics: System Applications & Visions”, Springer 2011.
5. Paula Gomes, “Medical robotics: minimally invasive surgery”, Woodhead publishing, year 2012.

Course Outcomes:

CO1: Identify the fundamental parameters of medical and mobile robots and examine their typical applications.

CO2: Develop skills to design and implement robotic assistants for Minimally Invasive Surgery and Image-Guided Interventions and analyze key design parameters of medical robots.

CO3: Evaluate the parameters of rehabilitation systems, exoskeletons, and explore locomotion aspects of mobile robots.

CO4: Investigate recent developments and emerging trends in biomedical robots, and interpret localization and navigation techniques for mobile robots.

CO5: Analyze the core applications of specialized surgical robots and assess their advantages and limitations.

25RA746	Soft and Bio-Inspired Robotics	L	T	P	C
		3	0	0	3

Module 1: Soft Robotics – Introduction, types and recent developments, soft vs rigid robots, History of Soft robots, Bio-Inspiration, Biological Gripping,

Materials for soft robots - Classification of Compliant Material, Polymers, Elastomers, Dielectric Elastomers, Fluid Materials, Hydrogels, Smart Materials, Biological Materials, Carbon-based materials

Design and Fabrication - Structural design of soft robot – Bionic structure, Fabrication methods – Casting manufacturing, Shape deposition manufacturing, 3D printing technology.

Module 2: Soft Actuation – Definition of soft actuation, classification of soft actuators, Principles and Techniques for Diverse Soft Actuators – Fluid driven, Magnetic driven, Cable driven, Shape memory material driven, Electro-active polymer driven and other soft actuators, challenges.

Soft Sensors – Classification of sensors – Passive mode, semi-active mode, active mode and interactive perception mode, Sensing technology – Tactile, Visual and Multisensor technology. Soft robot perception – Visual, Tactile – biological, Visual-Tactile fusion perception. Challenges.

Soft Robot Modeling and Control – Mechanics, Geometrical, Discrete, Lumped, Pseudo-rigid, Surrogate models, Control strategies – Model-based controllers, Model-free controllers.

Soft Robot Applications – Underwater Soft robots, Agricultural Soft robots, Industrial Soft robots, Space Soft robots, Medical Soft robots - Soft robotics in rehabilitation and Healthcare applications, Wearable Soft Robots.

Module 3: Bio-Inspired Robotics - Introduction to biologically inspired Robotics- Evolutionary Robotics-Biomimicry in Robotics- Bio-inspired Locomotion- Bio-inspired Soft Hands- Bio-hybrid Systems- Integration of Bio-inspired and Soft Robotics.

Applications of Bio-Inspired Robotics - Bionic fitness cycle, Robotic Fish-Bio inspired Humanoid Robot neck, Nanorobotics manipulation for biological cell, Measurement of Brain activity robot, Hand motion control using EMG- Hand rehabilitation system.

Textbooks / References:

1. Gareth J. Monkman, “Soft Robotics”, Bentham Books, 2022.
2. Juntian Qu, Zhenkun Li, Qigao Fan, Hongchao Cui, Yueyue Liu, “ Introduction to Advanced Soft Robotics”, Bentham Science Publishers, 2024.
3. Matthew Borgatti, “Soft Robotics: A DIY Introduction to Squishy, Stretchy, and Flexible Robots”, Make Community, 2018
4. Yunhui Liu and Dong Sun, Biologically inspired robotics, CRC Press, 2012.
5. Jean-Arcady Meyer, Agnès Guillot, Biologically Inspired Robots, Springer Handbook of Robotics, 2008.

Course Outcomes:

CO1: Understand the fundamental concepts of soft materials

CO2: Analyze various actuation and sensing capabilities of the soft robot

CO3: Analyze the design, modeling and control of a soft robot in various applications

CO4: Understand the fundamental concepts of bio-inspired robotics

CO5: Demonstrate the application of bio-inspired roboticsCO5: Analyze the core applications of specialized surgical robots and assess their advantages and limitations.

Electives: Software Focus

25RA751	Advanced AI for Robotics	L	T	P	C
		2	0	3	3

Problem solving: Graph based search, Algorithms for searching, Heuristic search, Robot path planning. Knowledge representation: Descriptive representation, Procedural representation, Rule-based representation, Semantic networks, Frames, Ontologies, Knowledge based systems. Expert systems. Artificial neural networks: Perceptron, Learning, Associative memories, Self-organised networks, Applications of neural networks in robotics. Deep learning applications for robotics. Fuzzy logic systems: Fuzzy logic, Fuzzy reasoning, Fuzzy logic-based techniques, Fuzzy relations, Fuzzy control, implementing fuzzy controllers, Fuzzy decision making. Genetic algorithms: Principles, Working, Design, Applications in robotics.

Suggested Lab Sessions:

- Implement graph-based and heuristic search algorithms for robot navigation in MATLAB, Python
- Design an expert system for diagnosing faults in a robotic arm using: Rule-based representation (if-then rules), Semantic networks for representing component relationships. Python (PyCLIPS for rule-based systems)
- Apply neural network models for robotic perception tasks. MATLAB Neural Network Toolbox, Python (TensorFlow/Keras).
- Implement fuzzy logic and genetic algorithm-based controllers for robot motion or task optimization. MATLAB Fuzzy Logic Toolbox, Python (scikit-fuzzy, DEAP for GA).

Textbooks / References:

1. Russell, S.J. and Norvig, P., "Artificial Intelligence – A Modern Approach", Prentice Hall, 2003.
2. Negnewitsky, M., "A Guide to Intelligent Systems", Addison-Wesley, 2005.
3. Inger, G.F., "Artificial Intelligence: Structures and Strategies for Complex Problem Solving", Addison-Wesley, 2005.
4. Nilsson, N.J., "Artificial Intelligence: A New Synthesis", Morgan-Kaufmann, 1998..

Course Outcomes:

CO1: Understand Problem solving: Graph based search, Algorithms for searching.
CO2: Understand Knowledge representation: Descriptive representation, Procedural representation.
CO3: Analyze Semantic networks, Frames, Ontologies, Knowledge based systems.
CO4: Apply Artificial neural networks: Perceptron, Learning, Associative memories.
CO5: Apply Fuzzy logic systems: Fuzzy logic, Fuzzy reasoning.
CO6: Analyze Genetic algorithms: Principles, Working.

25RA752	Computer Graphics and Animation	L	T	P	C
		3	0	0	3

Computer graphics fundamentals –overview of CG pipeline- 2D shapes, clipping, 2D Geometric transformations. Simple Animation with 2D transformations. Three-dimensional viewing: viewing pipeline, projections: parallel projections, perspective projections. 3D transformations.

Illumination models and surface rendering – polygon rendering methods: constant intensity shading, Gouraud shading, Phong shading.– color models, Visible surface detection. Creating 3D Graphics scene using open-source tools such as blender: Creating Three-dimensional (3D) objects, creating 3D graphics scene with objects, Textures, cameras and lighting, Rendering the scene created.

Creating 3D animation using open-source tools such as blender: animation – basic keyframing, auto keyframing, creating bones and skeletons and animate their movement, inverse kinematics. Case study in video sequence editing.

Textbooks / References:

1. Hearn D and Baker P. "Computer Graphics Open GL Version", Fourth Edition, Prentice Hall of India; 2013.
2. Lance Flavell, "Beginning Blender: Open Source 3D Modeling, Animation, and Game Design", Apress,2010
3. James Chronister, "Blender basics classroom tutorial book", Fourth edition, 2011.

Course Outcomes:

CO1: Understand the basic shapes, 2D and 3D viewing in computer graphics.
CO2: Perform geometric transformations on objects.
CO3: Apply graphics algorithms for rendering objects and surfaces.
CO4: Create 3D objects in the graphics environment and render the scene using open-source tools.
CO5: Synthesize 2D and 3D animations using open-source tools.

25RA753	Virtual Reality and Applications	L	T	P	C
		2	0	3	3

Introduction: The three I's of virtual reality, commercial VR technology and the five classic components of a VR system. VR design principles, Input Devices: Three-dimensional position trackers, navigation and manipulation, interfaces and gesture interfaces. Output Devices: Graphics displays, sound displays & haptic feedback. Modelling: Geometric modelling, kinematics modelling, physical modelling, behaviour modelling, model management. Human Factors: Methodology and terminology, user performance studies, VR health and safety issues. Applications: Medical applications, military applications, robotics applications. VR in Unity 3D, Haptic Interfaces with VR and AR.

Suggested Lab Sessions:

- Design and implement a simple interactive VR environment using Unity 3D.
- Analyse and simulate VR input and output device functionalities. Unity 3D with relevant input libraries; optional: Arduino for external haptic device simulation.
- Implement geometric and physical modelling for realistic VR interaction. Model a simple robotic arm in VR demonstrating:
    - Geometric modelling for structure
    - Kinematics for joint movement
    - Physical modelling for collision detection and realistic behaviour.
- Evaluate human factors in VR and explore domain-specific applications. Conduct a user performance study comparing traditional vs VR-based object manipulation tasks (record time and errors).

Textbooks / References:

1. Gregory C. Burdea and Philippe Coiffet, "Virtual Reality Technology", Second Edition, John Wiley and Sons, Inc.
2. Andrew Davison, "Killer Game Programming in Java, "O'Reilly-SPD, 2005.
3. William R.Sherman and Alan Craig, "Understanding Virtual Reality, Interface, Application and Design", Elsevier(Morgan Kaufmann).
4. Bill Fleming, "3D Modeling and surfacing", Elsevier (Morgan Kaufmann).
5. David H.Eberly, "3D Game Engine Design", Elsevier.
6. John Vince, "Virtual Reality Systems", Pearson Education.

Course Outcomes:

CO1: Understand The three I's of virtual reality, commercial VR technology and the five classic components of a VR system.
CO2: Understand VR design principles.
CO3: Analyze Input Devices: Three-dimensional position trackers, navigation and manipulation.
CO4: Apply Output Devices: Graphics displays, sound displays & haptic feedback.
CO5: Apply Modelling: Geometric modelling, kinematics modelling, physical modelling.
CO6: Analyze Medical applications, military applications, robotics applications.

25RA754	Robot Programming and Simulation	L	T	P	C
		2	0	3	3

Overview of Robot Kinematics: DH Parameters, Forward and Inverse Kinematics, Jacobian, Singularity. Understanding the Specification sheet of a robotic manipulator.
Types of reference frames: Base, Tooltip, Camera, Workpiece; Calibration of robot
Motion Planning of Robotic Manipulator: Joint and Cartesian level.

Standard motion of the robot: Joint Motion, P2P Motion, Linear Motion, Circular Motion, Spline Motion, etc., Logic and Looping Statements.

Robot Programming in a Simulated Environment (Proprietary or ROS + Gazebo + MoveIT) and on a physical robotic manipulator.

Suggested Lab Sessions:

- Identification of DH parameters of a given robotic manipulator
- Calibration of robot and setting tooltip coordinate frame
- Joint and Cartesian Jogging
- Teaching of Robot motion as Robot Program
- Simulation of Robot Program using Proprietary Software or ROS + Gazebo + MovIt (using URDF of robots)
- Execution of Robot Program on a physical robot

Textbooks / References:

1. S. K. Saha, “Introduction to Robotics”, 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2024.
2. A. Ghosal, “Robotics: fundamental concepts and analysis”, 2nd Edition, Oxford University Press, 2023.
3. Joseph, Lentin, and Jonathan Cacace, “Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System”, Packt Publishing Ltd, 2018.
4. Jason M. O’Kane, "A Gentle Introduction to ROS" ISBN 978-14-92143-23-9.

Course Outcomes:

CO1: Understand the specifications of a serial robot manipulator
CO2: Implement robot program to teach via points and elementary motions
CO3: Develop 3D model of robot in a simulator environment for motion planning
CO4: Execute robot program on a physical robot

25RA755	Deep Learning	L	T	P	C
		2	0	3	3

Module 1:

Fundamentals of Neural Networks – Types of Machine Learning, Types of Artificial Neural Networks - The McCulloch–Pitts Network, Perceptron, The Sigmoid Neuron, Linear Separable Problem, Multilayer Perceptron (MLP), Optimization Techniques, Exploding Gradient Problem, Weight Initialization, Deep Learning. Convolutional Neural Network (CNN) – Components of CNN Architecture, Rectified Linear Unit (ReLU) Layer, Exponential Linear Unit (ELU, or SELU), Unique Properties of CNN, Architectures of CNN, Applications of CNN.

Module 2:

Recurrent Neural Network (RNN) - Simple Recurrent Neural Network, LSTM Implementation, Gated Recurrent Unit (GRU), Deep Recurrent Neural Network. Autoencoder – Features of Autoencoder, Types of Autoencoder

Module 3:

Restricted Boltzmann Machine – Boltzmann Machine, RBM Architecture, Types of RBM.
Open-Source Frameworks of Deep learning – Python, TensorFlow, Keras, PyTorch.

Applications with Deep Learning – Image Classification using CNN, Visual Speech Recognition using 3D – CNN, Stock Market Prediction using RNN, Next Word Prediction using RNN-LSTM.

Suggested Lab Sessions:

- Implement and analyse perceptron and multilayer perceptron (MLP) models for linear and non-linear classification tasks. Python with TensorFlow or Keras.
- Build a CNN model to classify handwritten digits using the MNIST dataset. Include: Convolution, pooling, ReLU/ELU layers. Evaluation of accuracy and loss curves
- Build a simple RNN to predict the next value in a sine wave sequence. Implement an LSTM model for next word prediction using a sample text corpus.
- Develop an autoencoder to perform dimensionality reduction and reconstruction.

Textbooks / References:

1. S Lovelyn Rose, L Ashok Kumar, D Karthika Renuka, “Deep Learning using Python”, 1st Edn. 2019, John Wiley & Sons.
2. Goodfellow I, Bengio Y, Courville A, & Bengio Y, “Deep learning”, Cambridge: MIT Press, 1st Edition, 2016.
3. Michael Nielsen, “Neural Networks and Deep Learning”, Online book, 2016.
4. Umberto Michelucci, “Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks” A Press, 2018.
5. Francois Chollet "Deep Learning with Python", Manning Publications, 2017.

Course Outcomes:

CO1: Understand the fundamentals of neural networks.
CO2: Design feed-forward networks using different techniques
CO3: Model Convolution Neural Networks and articulate RNN and Autoencoder.
CO4: Understand the architecture of Boltzmann Machines and Frame works for deep learning
CO5: Apply Neural Networks to practical problems.

25RA756	Cyber Security	L	T	P	C
		2	0	3	3

Cyber Security Concepts: Essential Terminologies: CIA, Risks, Breaches, Threats, Attacks, Exploits. Information Gathering (Social Engineering, Foot Printing & Scanning). Open Source/ Free/ Trial Tools: nmap, zenmap, Port Scanners, Network scanners.

Cryptography and Cryptanalysis: Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of FirewallsTypes of Firewalls, User Management, VPN Security, Security Protocols: - security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer-IPSec. Open Source/ Free/ Trial Tools: Implementation of Cryptographic techniques, OpenSSL, Hash Values Calculations MD5, SHA1, SHA256, SHA 512, Steganography (Stools).

Infrastructure and Network Security: Introduction to System Security, Server Security, OS Security, Physical Security, Introduction to Networks, Network packet Sniffing, Network Design Simulation. DOS/ DDOS attacks. Asset Management and Audits, Vulnerabilities and Attacks. Intrusion detection and Prevention Techniques, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation. Open Source/ Free/ Trial Tools: DOS Attacks, DDOS attacks, Wireshark, Cain & abel, iptables/ Windows Firewall, snort, suricata, fail2ban.

Cyber Security Vulnerabilities & Safe Guards: Internet Security, Cloud Computing &Security, Social Network sites security, Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Authorization, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards- Overview, Access control, IT Audit, Authentication. Open Web Application Security Project (OWASP), Web Site Audit and Vulnerabilities assessment. Open Source/ Free/ Trial Tools: WinAudit, Zap proxy (OWASP), burp suite, DVWA kit.

Malware: Explanation of Malware, Types of Malware: Virus, Worms, Trojans, Rootkits, Robots, Adware9s, Spywares, Ransom wares, Zombies etc., OS Hardening (Process Management, Memory Management, Task Management, Windows Registry/ services another configuration), Malware Analysis. Open Source/ Free/ Trial Tools: Antivirus Protection, Anti Spywares, System tuning tools, Anti Phishing.

Security in Evolving Technology: Biometrics, Mobile Computing and Hardening on Android and IOS, IOT Security, Web server configuration and Security. Introduction, Basic security for HTTP Applications and Services, Basic Security for Web Services like SOAP, REST etc., Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges. Open Source/ Free/ Trial Tools: adb for android, xcode for ios, Implementation of REST/ SOAP web services and Security implementations.

Cyber Laws and Forensics: Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyberspace, Cyber Security Standards. The INDIAN Cyberspace, National Cyber Security Policy 2013. Introduction to Cyber Forensics, Need of Cyber Forensics, Cyber Evidence, Documentation and Management of Crime Sense, Image

Capturing and its importance, Partial Volume Image, Web Attack Investigations, Denial of Service Investigations, Internet Crime Investigations, Internet Forensics, Steps for Investigating Internet Crime, Email Crime Investigations. Open Source/ Free/ Trial Tools: Case Studies related to Cyber Law, Common Forensic Tools like dd, md5sum, sha1sum, Ram dump analysis, USB device.

Suggested Lab Sessions:

- Implementation to gather information from any PC9s connected to the LAN using whois, port scanners, network scanning, Angry IP scanners etc.
- Implementation of Symmetric and Asymmetric cryptography.
- Implementation of Steganography.
- Implementation of MITM- attack using wireshark/ network sniffers
- Implementation of Windows security using firewall and other tools
- Implementation to identify web vulnerabilities, using OWASP project
- Implementation of IT Audit, malware analysis and Vulnerability assessment and generate the report.
- Implementation of OS hardening and RAM dump analysis to collect the Artifacts and other information9s.
- Implementation of Mobile Audit and generate the report of the existing Artiacts.
- Implementation of Cyber Forensics tools for Disk Imaging, Data acquisition, Data extraction and Data Analysis and recovery.

Textbooks / References:

1. William Stallings, Cryptography and Network Security, Pearson Education/PHI, 2006.
2. V.K. Jain, Cryptography and Network Security, Khanna Publishing House.
3. Gupta Sarika, Information and Cyber Security, Khanna Publishing House, Delhi.
4. Atul Kahate, Cryptography and Network Security, McGraw Hill.

Course Outcomes:

CO1: Understand, appreciate, employ, design and implement appropriate security technologies and policies to protect computers and digital information.

CO2: Identify & Evaluate Information Security threats and vulnerabilities in Information Systems and apply security measures to real time scenarios.

CO3: Identify common trade-offs and compromises that are made in the design and development process of Information Systems.

CO4: Demonstrate the use of standards and cyber laws to enhance information security in the development process and infrastructure protection.

Electives: Offered by Other Departments

25ES636	Hardware Software Co-Design	L	T	P	C
		3	0	0	3

Introduction to System Level Design –Generic Co-Design Methodology–Hardware-Software Co-Design Models and Architectures –Languages for System Level Specification, Design and Modelling.

Design Representation for System Level Synthesis –Models of Computation–Architectural, Selection–Partitioning–Scheduling and Communication.

Hardware - Software Co-Simulation of Embedded Systems–Synthesis–Verification and Virtual Prototyping - Implementation Case Studies – Performance Analysis and Optimization – Re-Targetable Code Generation – FPGAs and Heterogeneous platforms

Textbooks / References:

1. Patrick R. Schaumont, "A Practical Introduction to Hardware/Software Co-design", Second Edition, Springer, 2013.
2. Jorgen Staunstrup and Wayne Wolf, "Hardware/Software Co-design: Principle and Practice", Kluwer Academic Publishers, 1997.
3. Giovanni De Micheli, "Readings in Hardware Software Co-design ", Morgan Kaufmann, Academic Press, 2002.
4. Daniel D. Gajski, Frank Vahid, Sanjiv Narayan, Jie Gong, "Specification and Design of Embedded Systems", Pearson Education publishing, 1994 edition, 2008 Impression.
5. Vivado Design Suite User Guide: Embedded Processor Hardware Design UG898 (v2017.3) October 27, 2017.

Course Outcomes:

CO1: Understand the need for hardware software co-design in the design flow process.
CO2: Analyse hardware-software co-design problems for systems with moderate complexity.
CO3: Apply hardware-software co-design methods and techniques for embedded systems.
CO4: Apply different levels of abstractions and models for verification of embedded co-design.

25ES650	Design for IoT and Cloud Computing	L	T	P	C
		2	0	3	3

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things -RFIDs, NFC, Web of Things - Embedded Systems Design: power and energy consumption; hardware design elements, software platforms –OS and applications, code optimization, validation and robust code generation; system integration, debugging and test methodology; tools for coding, debugging, optimization, and documentation; measurement of system performance, Creating virtual prototypes -hardware software emulation. IoT Reference Architectures, Introduction to Node Red, Visual Prototyping with Arduino and connectivity to IoT platforms, Applications: Healthcare and home automation examples. Cloud Computing: Infrastructure as a Service (IaaS), Cloud Database, Cloud storage. Platform as a Service (PaaS) for Web Rapid Application Development (RAD), Distributed Storage, Distributed Computing frameworks. Connectivity to remote server database, data access-storage processing. Development of cloud server and web applications.

Suggested Lab Sessions:

- Circuiting of IoT Systems (Simulator)
- Circuiting of IoT Systems (Physical setup or DIY kits)
- Implementation of the web services on cloud infrastructure
- Development of a cloud based setup for a relevant IoT application

Textbooks / References:

1. Barry, P., and Crowley, P., "Modern Embedded Computing", Morgan Kaufmann, 2012.
2. Vijay Madisetti and Arshdeep Bahga, "Internet of Things: A Hands-on Approach", Hardcover Import, 2014.
3. Thomas Erl, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall, May 2013.
4. Michael J. Kavis, "Architecting the Cloud: Design Decisions for Cloud Computing Service Models (SaaS, PaaS, &IaaS)", Wiley CIO Series, January 2014.
5. George Reese, "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud", O'Reilly, 2009.

Course Outcomes:

CO1: Understand the challenges and requirement of IoT framework.
CO2: Distinguish applications from ubiquitous computing, IoT and WoT.
CO3: Discuss the issues in system integration, debugging, testing and analysing the system performance.
CO4: Design an IoT application.

25ES634	Edge AI on Embedded Platforms	L	T	P	C
		2	0	3	3

Introduction to Edge AI and Embedded Inference. Overview of Edge AI – definitions, applications, and market trends. Comparison with cloud-based inference. Characteristics of embedded platforms for AI: constraints and design trade-offs. Overview of typical edge AI workflows – data collection, model training, deployment. Introduction to neural network models: CNN, DNN, quantization, pruning, and compression for edge inference. Overview of popular model formats – ONNX, TFLite, and CoreML. Embedded AI Toolchains and Deployment Pipelines. Introduction to hardware accelerators: NPU, DSP, GPU in embedded SoCs. Overview of AI toolchains: NXP eIQ (for i.MX), TI TIDL (for Sitara, Jacinto SoCs), Coral Edge TPU, and NVIDIA Jetson. Model optimization: post-training quantization, compilation, and deployment. Use of ONNX Runtime, TensorFlow Lite, and vendor SDKs. Layer mapping and performance profiling. Deployment flow: preprocessing, inference, and post-processing on the device. Applications, Security, and Performance Evaluation. Application case studies: real-time object detection, smart camera, human presence detection, gesture control, predictive maintenance. Integrating edge AI with peripherals (camera, microphone, sensors). Performance metrics: latency, throughput, power, and memory. Challenges in model accuracy vs efficiency. Introduction to secure model deployment – model integrity, secure boot, and encrypted weights. Future directions: federated learning, Edge-to-Cloud AI, TinyML.

Suggested Lab Sessions:

- Overview of microcontrollers and embedded systems
- Implementation of neural networks using edge computing
- Implement AI toolchains for model conversion, optimization and deployment
- Implement security and integration aspects for AI-enabled embedded systems.

Textbooks / References:

1. G. M. Iodice, TinyML Cookbook – Second Edition. *Birmingham, UK: Packt Publishing*, Nov. 2023.
2. S. Guo and Q. Zhou, Machine Learning on Commodity Tiny Devices. *CRC Press*, Oct. 2022.
3. D. A. Patterson and J. L. Hennessy, Computer Organization and Design: RISC-V Edition – The Hardware Software Interface, 2nd ed. *Burlington, MA, USA: Morgan Kaufmann*, 2021.
4. Texas Instruments, "TIDL (TI Deep Learning) User Guide," [Online]. Available: https://www.ti.com/tool/TIDL.
5. NXP Semiconductors, "eIQ Machine Learning Software Development Environment," [Online]. Available: https://www.nxp.com/eiq.
6. IEEE Standards Association, IEEE P2805: Standard for Functional Requirements for AI Edge Devices (Draft), IEEE, 2023.
7. P. Pareek, S. Mishra, M. J. C. S. Reis, and N. Gupta, Cognitive Computing and Cyber Physical Systems. Cham, Switzerland: *Springer*, Feb. 2025.

Course Outcomes:

CO1: Understand the architecture and design trade-offs of Edge AI systems.
CO2: Apply embedded AI toolchains for model conversion, optimization, and deployment.
CO3: Analyse AI model performance metrics in embedded contexts.
CO4: Evaluate security and integration aspects of AI-enabled embedded systems.

25ES651	Intelligent Systems Design	L	T	P	C
		3	0	0	3

Intelligent Systems – Definition, Need and role of embedded engineers. Architectures of intelligent systems – Automation, sensors, artificial intelligence techniques, actuators. Intelligent agents – definition, applications of intelligent agents in science, technology, business and commercial. Supporting technologies - Data mining, knowledge management, control and automation. Types of systems – Expert Systems, Recommendation Systems, Cognitive Systems, Swarm intelligent systems, Hybrid computing systems. Behaviour Oriented Design (BOD) – Definition, Extension to object-oriented design, process of specifying agency, specifying the agent's priorities using POSH dynamic plans.

Textbooks / References:

1. Karray F, Karray FO, De Silva CW, "Soft computing and intelligent systems design: theory, tools, and applications", *Pearson Education*; 2009.
2. Larry Bielawski, Robert Lewand, "Intelligent Systems Design: Integrating Expert Systems, Hypermedia, and Database Technologies", First Edition, *Wiley Professional Computing*.
3. Alexander M. Meystel, James S. Albus, "Intelligent Systems: Architecture, Design, and Control", First Edition, *Wiley – Interscience Publication*, 2002.
4. Anindita Das, "Artificial Intelligence and Soft Computing for Beginners", 2nd Edition, *Arizona Business Alliance,* 2014.

Course Outcomes:

CO1: Understand the need and scope of intelligent systems and the role of embedded engineers in the design of such systems.

CO2: Familiarize the components of intelligent systems especially intelligent agents and its applications.

CO3: Analyse the various types of intelligent systems.

CO4: Understand Behaviour Oriented Design and process of defining agents.

25ES644	Web Technologies and Applications	L	T	P	C
		2	0	3	3

Web essentials: Creating a website – Working principle of a website – Browser fundamentals – Authoring tools – Types of servers: Application Server – Web Server – Database Server; Scripting essentials: Need for Scripting languages – Types of scripting languages – Client-side scripting

Server-side scripting – PHP – Working principle of PHP – PHP Variables – Constants – Operators – Flow Control and Looping – Arrays – Strings – Functions – File Handling – PHP and MySQL – PHP and HTML – Cookies – Simple PHP scripts. XML-Documents and Vocabularies-Versions and Declaration-Namespaces- DOM based XML processing Event-oriented Parsing: XML-Documents and Vocabularies-Versions and Declaration - Namespaces - DOM based XML processing Event-oriented Parsing

Application essentials: Creation of simple interactive applications – Simple database applications – Multimedia applications – Design and development of information systems – Personal Information System – Information retrieval system – Social networking applications.

Suggested Lab Sessions:

Textbooks / References:

1. Robin Nixon, "Learning PHP, MySQL, JavaScript, CSS & HTML5", Fifth Edition, O'REILLY, 2018.
2. Jeffrey C. Jackson, "Web Technologies--A Computer Science Perspective", Pearson Education, 2006.
3. Robert. W. Sebesta, "Programming the World Wide Web", Eighth Edition, Pearson Education, 2015.
4. Bates, "Web Programming: Building Internet Applications", Third Edition, Wiley, 2010.
5. R. Kelly Rainer, Casey G. Cegielski, Brad Prince, "Introduction to Information Systems", Eighth Edition, Wiley Publication, 2019.

Course Outcomes:

CO1: Comprehend the concepts of responsive web design.
CO2: Apply markup and scripting languages to design and validate dynamic web pages.
CO3: Evaluate the appropriateness of client/server applications.
CO4: Develop client/server applications with database.

25ES648	Fault Tolerant System	L	T	P	C
		2	0	3	3

Goals and Applications of Fault Tolerant Computing - Reliability, Availability, Safety, Dependability, Long Life, Critical Computation, High Availability Applications, Fault Tolerance as a Design Objective. Fault Models - Faults, Errors, and Failures, Causes and Characteristics of Faults, Logical and Physical Faults, Error Models.

Fault Tolerant Design Techniques: Hardware redundancy, Software Redundancy, Time redundancy and Information redundancy. Check pointing, Fault tolerant networks, Reconfiguration-based fault tolerance.

Reliability Evaluation Techniques - Failure Rate, Mean Time to Repair, Mean Time Between Failure, Reliability Modelling, Fault Coverage, M-of-N Systems, Markov Models, Safety, Maintainability, Availability. Case studies of fault tolerant systems and current research issues - Space Shuttle, Tandem 16 Non-Stop System, Recovery oriented computing, Fault tolerant platforms for Automotive Safety-Critical, Reliability and Fault tolerance in Collective Robot Systems.

Suggested Lab Sessions:

- Overview of MATLAB / Equivalent for implementation of models for reliability, availability, safety, dependability, etc.
- Implementation of error models and failure analysis models
- Implement fault tolerant design for a relevant application

Textbooks / References:

1. Israel Koren and C. Mani Krishna, "Fault Tolerant Systems", Elsevier, 2nd edition, 2020.
2. D. K. Pradhan, "Fault-Tolerant Computing, Theory and Techniques", Prentice-Hall, 1998
3. M. L. Shooman, "Reliability of Computer Systems and Networks Fault Tolerance Analysis and Design," Wiley, 2003
4. Elena Dubrova, "Fault-Tolerant Design," Springer-Verlag New York, 2013.
5. Barry W. Johnson, "Design and Analysis of Fault-Tolerant Digital System", Addison, 2009.

Course Outcomes:

CO1: Understand basics of fault tolerance and fault models.
CO2: Discuss various forms of redundancies and fault tolerant design techniques.
CO3: Develop concepts on system reliability.
CO4: Comprehend different fault tolerant design concepts.

Other Courses

25RM606	Research Methodology	L	T	P	C
		2	0	0	2

Module 1: Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Re- search, Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of reasoning in re- search.
Problem Formulation, Understanding Modelling & Simulation, Conducting Literature Review, Ref- erencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes.

Module 2: Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Sys- tems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results.

Module 3: Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript.
References, Citation and listing system of documents Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.

Textbooks / References:

1. Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8th Edition, McGraw-Hill, 2011.
2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers.
3. Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
4. Michael P. Marder, "Research Methods for Science", Cambridge University Press, 2011.
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Law & Business, 6 edition July 2012

Course Outcomes:

CO1: To define research, methodology and steps involved in research.
CO2: To learn to define a problem, and research hypothesis. To understand the importance of literature survey, gaps and challenges.
CO3: To learn the basic concepts of research design, sampling, modeling & simulation and under- stand the importance of citation, H-index, Scopus.
CO4: To learn to write technical report, paper and thesis.
CO5: To know about intellectual property rights, ethics in research and plagiarism.

23HU601	Career Competency I	L	T	P	C
		0	0	3	P/F

Soft Skills

Introduction to 'campus to corporate transition'.

Communication and listening skills: Communication process, barriers to communication, verbal and non-verbal communications, elements of effective communication, listening skills, empathetic listening, role of perception in communication.

Assertiveness skills: The concept, assertiveness and self-esteem, advantages of being assertive, assertiveness and organizational effectiveness.

Self-perception and self-confidence: Locus of control (internal v/s external), person perception, social perception, attribution theories-self presentation and impression management, the concept of self and self-confidence, how to develop self-confidence.

Goal setting: The concept, personal values and personal goals, goal setting theory, six areas of goal setting, process of goal setting: SMART goals, how to set personal goals

Time management: the value of time, setting goals/ planning and prioritizing, check the time killing habits, procrastination, tools for time management, rules for time management, strategies for effective time management

Presentation skills: The process of presentation, adult learning principles, preparation and planning, practice, delivery, effective use of voice and body language, effective use of audio visual aids, dos and don'ts of effective presentation

Public speaking: An art, language fluency, the domain expertise (Business GK, Current affairs), self-confidence, the audience, learning principles, body language, energy level and conviction, student presentations in teams of five with debriefing

Verbal

Vocabulary: Familiarize students with the etymology of words, help them realize the relevance of word analysis and enable them to answer synonym and antonym questions. Create an awareness about the frequently misspelt words, commonly confused words and wrong form of words in English.

Grammar: Train students to understand the nuances of English Grammar and thereby enable them to spot grammatical errors and punctuation errors in sentences.

Reasoning: Stress the importance of understanding the relationship between words through analogy questions and learn logical reasoning through syllogism questions. Emphasize the importance of avoiding the gap (assumption) in arguments/ statements/ communication.

Oral Communication Skills: Aid students in using the gift of the gab to improve their debating skills.

Writing Skills: Introduce formal written communication and keep the students informed about the etiquettes of email writing. Make students practise writing emails especially composing job application emails.

Aptitude

Numbers: Types, Power Cycles, Divisibility, Prime, Factors & Multiples, HCF & LCM, Surds, Indices, Square roots, Cube Roots and Simplification.

Percentage: Basics, Profit, Loss & Discount, and Simple & Compound Interest.

Ratio, Proportion & Variation: Basics, Alligations, Mixtures, and Partnership.

Averages: Basics, and Weighted Average.

Time and Work: Basics, Pipes & Cistern, and Work Equivalence.

Time, Speed and Distance: Basics, Average Speed, Relative Speed, Boats & Streams, Races and Circular tracks.
Statistics: Mean, Median, Mode, Range, Variance, Quartile Deviation and Standard Deviation.
Data Interpretation: Tables, Bar Diagrams, Line Graphs, Pie Charts, Caselets, Mixed Varieties, and other forms of data representation.
Equations: Basics, Linear, Quadratic, Equations of Higher Degree and Problems on ages.
Logarithms, Inequalities and Modulus: Basics

Textbooks / References:

Soft Skills

Communication and listening skills:

1. Andrew J DuRbin , "Applied Psychology: Individual and organizational effectiveness", Pearson- Merril Prentice Hall, 2004
2. Michael G Aamodt, "An Applied Approach, 6th edition", Wadsworth Cengage Learning, 2010

Assertiveness skills:

1. Robert Bolton, Dorothy Grover Bolton, "People Style at Work..and Beyond: Making Bad Relationships Good and Good", Ridge Associates Inc., 2009
2. John Hayes "Interpersonal skills at work", Routledge, 2003
3. Nord, W. R., Brief, A. P., Atieh, J. M., & Doherty, E. M., "Meanings of occupational work: A collection of essays (pp. 21- 64)", Lexington, MA: Lexington Books, 1990

Self-perception and self-confidence:

1. Mark J Martinko, "Attribution theory: an organizational perspective", St. Lucie, 1995
2. Miles Hewstone, "Attribution Theory: Social and Functional Extensions", Blackwell, 1983

Time management:

1. Stephen Covey, "The habits of highly effective people", Free press Revised edition, 2004
2. Kenneth H Blanchard , "The 25 Best Time Management Tools & Techniques: How to Get More Done Without Driving Yourself Crazy" , Peak Performance Press, 1st edition 2005
3. Kenneth H. Blanchard and Spencer Johnson, "The One Minute Manager" , William Morrow, 1984

Verbal

1. Erica Meltzer, "The Ultimate Guide to SAT Grammar"
2. Green, Sharon, and Ira K. Wolf, "Barron's New GRE", Barron's Educational Series, 2011
3. Jeff Kolby, Scott Thornburg & Kathleen Pierce, "Nova's GRE Prep Course"
4. Kaplan, "Kaplan New GRE Premier", 2011-2012
5. Kaplan's GRE Comprehensive Programme
6. Lewis Norman, "Word Power Made Easy", Goyal Publishers, Reprint edition, 1 June 2011
7. Manhattan Prep, "GRE Verbal Strategies Effective Strategies Practice from 99th Percentile Instructors"
8. Pearson- "A Complete Manual for CAT", 2013
9. R.S. Aggarwal, "A Modern Approach to Verbal Reasoning"
10. S. Upendran, "Know Your English", Universities Press (India) Limited, 2015
11. Sharon Weiner Green, Ira K. Wolf, "Barron's New GRE, 19th edition (Barron's GRE)",

2019
12. Wren & Martin, "English Grammar & Composition"
13. www.bbc.co.uk/learningenglish
14. www.cambridgeenglish.org
15. www.englishforeveryone.org
16. www.merriam-webster.com

Aptitude

1. Arun Sharma, "How to Prepare for Quantitative Aptitude for the CAT Common Admission Test", Tata Mc Graw Hills, 5th Edition , 2012
2. Arun Sharma, "How to Prepare for Logical Reasoning for the CAT Common Admission Test", Tata Mc Graw Hills, 2nd Edition, 2014
3. Arun Sharma, "How to Prepare for Data Interpretation for the CAT Common Admission Test", Tata Mc Graw Hills, 3nd Edition, 2015
4. R.S. Aggarwal, "Quantitative Aptitude For Competitive Examinations", S. Chand Publishing, 2015
5. R.S. Aggarwal, "A Modern Approach To Verbal & Non-Verbal Reasoning", S. Chand Publishing, Revised -2015
6. Sarvesh Verma, "Quantitative Aptitude-Quantum CAT" , Arihant Publications, 2016
7. www.mbatious.com
8. www.campusgate.co.in
9. www.careerbless.com

Course Outcomes:

CO1: Soft Skills - To develop positive mindset, communicate professionally, manage time effectively and set personal goals and achieve them.

CO2: Soft Skills - To make formal and informal presentations with self-confidence.

CO3: Aptitude - To analyze, understand and employ the most suitable methods to solve questions on arithmetic and algebra.

CO4: Aptitude - To analyze, understand and apply suitable techniques to solve questions on logical reasoning and data analysis.

CO5: Verbal - To infer the meaning of words and use them in the right context. To have a better understanding of the nuances of English grammar and become capable of applying them effectively.

CO6: Verbal - To identify the relationship between words using reasoning skills. To understand and analyze arguments and use inductive/deductive reasoning to arrive at conclusions and communicate ideas/perspectives convincingly.

23HU611	Career Competency II	L	T	P	C
		0	0	3	1

Soft Skills

Interpersonal skill: Ability to manage conflict, flexibility, empathetic listening, assertiveness, stress management, problem solving, understanding one's own interpersonal needs, role of effective team work in organizations

Group problem solving: The process, the challenges, the skills and knowledge required for the same.

Conflict management: The concept, its impact and importance in personal and professional lives, (activity to identify personal style of conflict management, developing insights that helps in future conflict management situations.)

Team building and working effectively in teams: The concept of groups (teams), different stages of group formation, process of team building, group dynamics, characteristics of effective team, role of leadership in team effectiveness. (Exercise to demonstrate the process of emergence of leadership in a group, debrief and reflection), group discussions.

Interview skills: what is the purpose of a job interview, types of job interviews, how to prepare for an interview, dos and don'ts of interview, One on one mock interview sessions with each student.

Verbal

Vocabulary: Help students understand the usage of words in different contexts. Stress the importance of using refined language through idioms and phrasal verbs.

Grammar: Enable students to identify poorly constructed sentences or incorrect sentences and improvise or correct them.

Reasoning: Facilitate the student to tap her/his reasoning skills through critical reasoning questions and logical ordering of sentences.

Reading Comprehension: Enlighten students on the different strategies involved in tackling reading comprehension questions.

Public Speaking Skills: Empower students to overcome glossophobia and speak effectively and confidently before an audience.

Writing Skills: Practice closet tests that assess basic knowledge and skills in usage and mechanics of writing such as punctuation, basic grammar and usage, sentence structure and rhetorical skills such as writing strategy, organization, and style.

Aptitude

Sequence and Series: Basics, AP, GP, HP, and Special Series.

Geometry: 2D, 3D, Coordinate Geometry, and Heights & Distance.

Permutations & Combinations: Basics, Fundamental Counting Principle, Circular Arrangements, and Derangements.

Probability: Basics, Addition & Multiplication Theorems, Conditional Probability and Bayes' Theorem.

Logical Reasoning I: Arrangements, Sequencing, Scheduling, Venn Diagram, Network Diagrams, Binary Logic, and Logical Connectives, Clocks, Calendars, Cubes, Non-Verbal reasoning and Symbol based reasoning.

Logical Reasoning II: Blood Relations, Direction Test, Syllogisms, Series, Odd man out, Coding & Decoding, Cryptarithmetic Problems and Input - Output Reasoning.

Data Sufficiency: Introduction, 5 Options Data Sufficiency and 4 Options Data Sufficiency.

Campus recruitment papers: Discussion of previous year question papers of all major recruiters of Amrita Vishwa Vidyapeetham.
Miscellaneous: Interview Puzzles, Calculation Techniques and Time Management Strategies.

Textbooks / References:

Soft Skills

1. Thomas L.Quick, "Successful team building", AMACOM Div American Mgmt Assn, 1992
2. Brian Cole Miller, "Quick Team-Building Activities for Busy Managers: 50 Exercises That Get Results in Just 15 Minutes", AMACOM; 1 edition, 2003.
3. Patrick Lencioni, "The Five Dysfunctions of a Team: A Leadership Fable", Jossey-Bass, 1st Edition, 2002.

Verbal

1. "GMAT Official Guide" by the Graduate Management Admission Council, 2019
2. Arun Sharma, "How to Prepare for Verbal Ability And Reading Comprehension For CAT"
3. Joern Meissner, "Turbocharge Your GMAT Sentence Correction Study Guide", 2012
4. Kaplan, "Kaplan GMAT 2012 & 13"
5. Kaplan, "New GMAT Premier", Kaplan Publishing, U.K., 2013
6. Manhattan Prep, "Critical Reasoning 6th Edition GMAT"
7. Manhattan Prep, "Sentence Correction 6th Edition GMAT"
8. Mike Barrett "SAT Prep Black Book The Most Effective SAT Strategies Ever Published"
9. Mike Bryon, "Verbal Reasoning Test Workbook Unbeatable Practice for Verbal Ability, English Usage and Interpretation and Judgement Tests"
10. www.bristol.ac.uk/arts/skills/grammar/grammar_tutorial/page_55.htm
11. www.campusgate.co.in

Aptitude

1. Arun Sharma, "How to Prepare for Quantitative Aptitude for the CAT Common Admission Test", Tata Mc Graw Hills, 5th Edition, 2012
2. Arun Sharma, "How to Prepare for Logical Reasoning for the CAT Common Admission Test", Tata Mc Graw Hills, 2nd Edition , 2014
3. Arun Sharma, "How to Prepare for Data Interpretation for the CAT Common Admission Test", Tata Mc Graw Hills, 3nd Edition , 2015
4. R.S. Aggarwal, "Quantitative Aptitude For Competitive Examinations", S. Chand Publishing , 2015
5. R.S. Aggarwal, "A Modern Approach To Verbal & Non-Verbal Reasoning", S. Chand Publishing , Revised -2015
6. Sarvesh Verma, "Quantitative Aptitude-Quantum CAT" , Arihant Publications , 2016
7. www.mbatious.com
8. www.campusgate.co.in
9. www.careerbless.com

Course Outcomes:

CO1: Soft Skills - To demonstrate good interpersonal skills, solve problems and effectively participate in group discussions.
CO2: Soft Skills - To write technical resume and perform effectively in interviews.

CO3: Aptitude - To identify, investigate and arrive at appropriate strategies to solve questions on arithmetic by managing time effectively.
CO4: Aptitude - To investigate, understand and use appropriate techniques to solve questions on logical reasoning and data analysis by managing time effectively.
CO5: Verbal - To be able to use diction that is more refined and appropriate and to be competent in knowledge of grammar to correct/improve sentences.
CO6: Verbal - To be able to examine, interpret and investigate passages and to be able to generate ideas, structure them logically and express them in a style that is comprehensible to the audience/recipient.

25AVP501 **MASTERY OVER MIND** **1-0-2-2**

PG SYLLABUS

COURSE OBECTIVES

Master Over the Mind (MAOM) is an Amrita initiative to implement schemes and organize university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3). This program as part of our efforts for sustainable stress reduction introduces immediate and long-term benefits and equips every attendee to manage stressful emotions and anxiety facilitating inner peace and harmony. With a meditation technique offered by Amrita Chancellor and world-renowned humanitarian and spiritual leader, Sri Mata Amritanandamayi Devi (Amma), this course has been planned to be offered to all students of all campuses of AMRITA, starting off with all first years, wherein one hour per week is completely dedicated for guided practical meditation session and one hour on the theory aspects of MAOM. The theory section comprises lecture hours within a structured syllabus and will include invited guest lecture series from eminent personalities from diverse fields of excellence. This course will enhance the understanding of experiential learning based on university's mission: "Education for Life along with Education for Living" and is aimed to allow learners to realize and rediscover the infinite potential of one's true Being and the fulfilment of life's goals.

COURSE OUTCOME

After successful completion of the course, students will be able to:	
S.No.	**Course Outcomes**
1.	Understand the scientific benefits of meditation. (CO1)
2.	Explain the science behind meditation and its effects on physical and mental well-being (CO2).
3.	Understand the meditation techniques to cultivate emotional intelligence and improve relationships (CO3).
4.	Learn and practice MAOM meditation in daily life (CO4).
5.	To apply the effect of meditation to compassion-driven action (CO5)

Syllabus:

Scientific benefits of Meditation (CO1)

Scientific benefits of meditation, exploring its effects on physical and mental wellbeing.

Learn about the different types of meditation practices, the essential elements of meditation, and the empirical evidence supporting its benefits.

Video resource-Swami Atmanandamrita Puri

Science Behind Meditation (CO2)

A: A preliminary understanding of the Science of meditation. What can modern science tell us about this tradition-based method?

B: How meditation helps humanity according to what we know from scientific research

Reading 1: Does Meditation Aid Brain and Mental Health (Dr Shyam Diwakar)

Reading 2: 'Science and Spirituality.' Chapter 85 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

Role of Meditation in Emotional intelligence (CO3)

Learn how meditation practices can enhance self-awareness, self-regulation, motivation, empathy, and social skills, leading to improved relationships and decision-making. Improve communication, emotional intelligence, and interpersonal skills. Logical and analytical reasoning

Practicing MA OM Meditation in Daily Life (CO4)

Guided Meditation Sessions following scripts provided (Level One to Level Five)

Reading 1: MA OM and White Flower Meditation: A Brief Note (Swami Atmananda Puri)

Reading 2: 'Live in the Present Moment.' Chapter 71 in Amritam Gamaya (2022). Mata Amritanandamayi Mission Trust.

Meditation and Compassion-driven Action (CO5)

Understand how meditation can help to motivate compassion-driven action.

Reading 1: Schindler, S., & Friese, M. (2022). The relation of mindfulness and prosocial behavior:What do we (not) know? Current Opinion in Psychology, 44, 151-156.

Reading 2: 'Sympathy and Compassion.' Chapter 100 in Amritam Gamaya (2022). Mata Amritanandamyi Mission Trust.

Textbooks / References:

1. Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019

2. Swami Amritaswarupananda Puri," The Color of Rainbow "published by MAM, Amritapuri. 3. Craig Groeschel, "Winning the War in Your Mind: Change Your Thinking, Change Your Life" Zondervan Publishers, February 2019

4. R Nagarathna et al, "New Perspectives in Stress Management "Swami Vivekananda Yoga Prakashana publications, Jan 1986

5. Swami Amritaswarupananda Puri "Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation", August 2019

6. Swami Amritaswarupananda Puri "From Amma's Heart - Amma's answer to questions raised during world tours" March 2018

7. Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.

8. Mata Amritanandamayi Devi "Compassion: The only way to Peace:Paris Speech", MA Center, April 2016.

9. Mata Amritanandamayi Devi "Understanding and collaboration between Religions", MA Center, April 2016.

10. Mata Amritanandamayi Devi "Awakening of Universal Motherhood: Geneva Speech" M A center, April 2016.

GLIMPSES OF INDIAN CULTURE

P/F

22ADM501: GLIMPSES OF INDIAN CULTURE

A. Prerequisite: nil

B. Nature of Course: Theory

C. Course Objectives:

- The course "Glimpses of Indian Culture" aims to provide students with a comprehensive understanding of various aspects of Indian culture, with a focus on its spiritual, philosophical, and religious dimensions.
- Through an exploration of the chapters from the provided book, students will gain insights into the foundational principles, practices, and symbols that shape the diverse cultural landscape of India
- Aligned with the Indian Knowledge Systems (IKS) framework outlined in the National Education Policy, this course serves as an introduction to the vast reservoir of wisdom and knowledge rooted in Indian heritage.
- By engaging with the chapters in the book, students will develop a holistic appreciation for the rich tapestry of Indian culture, spanning from its philosophical underpinnings to its artistic expressions, rituals, and societal values.
- This course aims to cultivate cultural sensitivity, critical thinking, and a deeper understanding of the diverse spiritual and cultural traditions that have shaped India's identity over millennia.

D. Course Outcomes: After successful completion of the course, Students will be able to:

CO	Course Outcomes	Knowledge level [Bloom's Taxonomy]
CO01	Recall key concepts and terms associated with Sanatana Dharma, scriptures, and core cultural elements of India. Statement: Demonstrate the ability to remember essential terms, concepts, and principles discussed in the chapters on Sanatana Dharma, scriptures, and cultural aspects.	Remembering

CO02	Explain the concepts of Īśvara, Guru Tattva, Avatara Tattva, and the Theory of Karma as foundational elements of Indian cultural philosophy. Statement: Understand the profound meanings of Īśvara, Guru, Avatara, and Karma, elucidating their importance in shaping Indian cultural thought.	Understanding
CO03	Apply the knowledge of Purusharthas, Sanyasa, and Yajna to analyze real-life ethical and spiritual scenarios. Statement: Utilize insights from Purusharthas, Sanyasa, and Yajna to navigate ethical dilemmas and make informed decisions.	Applying
CO04	Analyze the symbolism in cultural practices, Nataraja iconography, and temple architecture. Statement: Deconstruct the layers of symbolism in various cultural aspects, including Nataraja representation and temple architecture, unraveling their deep meanings.	Analyzing
CO05	Evaluate the significance of temples as cradles of culture and explore alternative systems in India's cultural landscape. Statement: Assess the role of temples in preserving cultural heritage and critically examine the diversity of cultural and spiritual systems in India.	Evaluating
CO06	Develop projects or presentations that highlight the essence of Sanatana Dharma, sadhana, and the cultural significance of symbols. Statement: Create expressive projects that capture the essence of Sanatana Dharma, convey the practices of sadhana, and portray the cultural meanings of symbols.	Creating

POs Programme Outcomes	**COs**
PO1: Engineering Knowledge PO2: Problem Analysis PO3: Design/Development of Solutions PO4: Conduct Investigations of complex problems PO5: Modern tools usage PO6: Engineer and Society PO7: Environment and Sustainability PO8: Ethics PO9: Individual & Teamwork PO10: Communication PO11: Project management & Finance PO12: Lifelong learning B.Tech. EEE Programme Specific Outcome (PSO) PSO1: Awareness of Future Technology: Develop solutions for future systems using smart technologies. PSO2:	• CO 1: Recall key concepts and terms associated with Sanatana Dharma, scriptures, and core cultural elements of India. • CO 2: Explain the concepts of Īśvara, Guru Tattva, Avatara Tattva, and the Theory of Karma as foundational elements of Indian cultural philosophy • CO 3: Apply the knowledge of Purusharthas, Sanyasa, and Yajna to analyze real-life ethical and spiritual scenarios. • CO 4: Analyze the symbolism in cultural practices, Nataraja iconography, and temple architecture. • CO 5: Evaluate the significance of temples as cradles of culture and explore alternative systems in India's cultural landscape. • CO 6: Develop projects or presentations that highlight the essence of Sanatana Dharma,

Research and Innovation: Identify engineering challenges, approach using cutting edge research tools and execute innovative solutions.	sadhana, and the cultural significance of symbols.

E. CO-PO Mapping: [affinity[#]: 3 – high; 2- moderate; 1- slightly]

COs	Program Outcomes [POs]												Program Specific Outcomes [PSOs]*	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO01	-	-	-	-	-	-	-	2	-	-	-	3	-	-
CO02	-	-	-	-	-	1	-	2	-	-	-	3	-	-
CO03	-	-	-		-	3	3	3	2	-	-	2	-	-
CO04	-	-	-	-	-	3	-	-	-	-	-	3	-	-
CO05	-	-	-	-	-	2	3	-	-	-	-	2	-	-
CO06	-	-	-	-	-	2	2	2	2	-	-	3	-	-
Total														
Average														

F. SYLLABUS GLIMPSES OF INDIAN CULTURE [P/F]

Course Syllabus

Chapter 1 - *What is Sanatana Dharma*
Chapter 2 - *The Heritage ofScriptures*
Chapter 3 - *The idea of Īśvara*
Chapter 4 - *Guru Tattva and Avatara Tattva*
Chapter 5 - *Theory of Karma*
Chapter 6 - *Purusharthas*
Chapter 7 - *Sanyasa*
Chapter 8 - *Yajna*
Chapter 9 - *Symbolism*
Chapter 10 - *Understanding Nataraja*
Chapter 11 - *Temples: The Cradle of Culture*
Chapter 12 - *Other Heterodox Systems in India*
Chapter 13 - *Sadhana*

GLIMPSES OF INDIAN CULTURE

Reference Books:

The Eternal Truth by Mata Amritanandamayi Devi
Temples: Centers for Spiritual Practice by Mata Amritanandamayi Devi
All About Hinduism by Swami Sivananda
Art of God Symbolism by Swami Chinmayananda
*Temples in India by Swami Sivanand*a

G. Evaluation Pattern: 60:40

Component	Weightage	Remarks
Internal	60	-
External	40	-
TOTAL	100	