MTech Robotics and Automation
Curriculum and Syllabus
Revised on: August 2023
Previous revisions: 2021, 2019, 2016, 2014

Department of Mechanical Engineering
Amrita School of Engineering
Amritapuri Campus – 690525
Preface

Robotics, the branch of technology that deals with the design, construction, operation, and application of robots, 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 and 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 in order 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.

The Amrita Vishwa Vidyapeetham Robotics and Automation MTech Program is unique in that it provides an academic curriculum that pulls from Mechanical Engineering, Electrical and Electronics Engineering, Instrumentation Engineering and Computer Science disciplines, exposing the students to the breadth of and interdependence among the engineering disciplines and offering the students exactly what is required to master the technical knowledge required.

This MTech program will provide a comprehensive educational environment and enable students to gain expertise in next generation robotics and automation systems. By exposing our students to do course work from multiple disciplines and preparing them to think about robotics from a holistic approach, our program will 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.
PEO1: This program offers an interdisciplinary academic curriculum that draws from Mechanical Engineering, Electronics and Instrumentation Engineering, and Computer Science disciplines. By exposing students to the breadth and interdependence among these engineering fields, it provides exactly what is required to master the technical knowledge needed for success.

PEO2: This program offers a comprehensive educational environment, empowering students to develop expertise in cutting-edge robotics and automation systems of the next generation.

PEO3: Provide students with exposure to diverse disciplines through coursework, fostering a holistic approach to robotics and equipping them to become a skilled workforce for the industry, as well as empowering them to become expert researchers and visionary leaders in an increasingly technology-driven world.

Program Outcomes (POs)

PO1: An ability to independently carry out research/ investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
Semester 1

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* Non-credit Course

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* FC – Foundation Core, SC – Subject Core, E – Elective, HU – Humanities, P - Project

Total credits for the MTech program: 68
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Unit-1 (Linear Algebra)

Unit-2 (Vector Calculus)
Univariate, Multivariate and vector functions, Motion of a particle in space, Differentiation and Taylor’s series expansion of univariate functions, Partial differentiation, chain rule, Gradient of vector function(Jacobian), Gradient of a vectors with respect to a matrix, Gradient of matrices with respect to a matrix, Identities for computing gradients, Back propagation and automatic differentiation, Gradients in deep neural networks, Higher order partial derivatives, Hessian, Taylor’s series expansion of multivariate functions, Quadratic forms, Unconstrained optimization problems, Method of steepest descends, Conjugate gradient Method. Vector calculus for physical field problems, Directional derivative and direction of maximum derivative, divergence and curl of vector fields, rotational and irrotational vector fields, Conservative vector fields, Vector integral calculus, line, surface and volume integrals, Stokes theorem, Green's theorem and Gauss divergence theorem, applications of vector calculus theorems to field problems, Algebra of Cartesian Tensors, Index notation, Isotropic tensors, Invariants of a tensor, Computer programming exercises based on these topics.


Unit-3
Random experiment, Sample space, Event space, Probability, Probability space, Discrete and continuous probabilities, PMF, CDF, PDF, sum and product rules, Conditional probability, Bayes theorem, Mean, Variance, Covariance, Correlation, Empirical means and covariances, Statistical independence, Conditional independence, Inner products, Gaussian distribution, Marginal and conditional of Gaussian, Product of Gaussian distributions, Sums and linear transformations, Conjugacy and exponential family, Binomial, Poisson and Beta distributions, Change of variables, Computer programming exercises based on these topics.

Two-dimensional convolution, 2D Discrete-Space Fourier Transform, Inverse 2-D Fourier Transform, Fourier Transform of 2-D or Spatial Convolution, Symmetry properties of Fourier Transform, Continuous-Space Fourier Transform.
TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Capability to solve problems in linear algebra.
CO2: Capability to do differentiation for solving optimization problems.
CO3: Capability to solve problems in probability and develop probabilistic models.
CO4: Capability to solve problems using computers.

23RA601 CONTROL SYSTEMS 3-0-2-4

Mathematical Modeling of physical systems- Transfer function-stability with reference to 's' plane, transient and steady state analysis, steady state errors, Performance Indices. controllers- P, PI and PID modes of feedback control.
Analysis of control systems in state space -State space model of a system, state transition matrix, state space representation in canonical forms, solution of homogeneous state equations, controllability and observability.
Design of control systems in state space- Design by pole placement, State Feedback gain using Ackerman's formula. State Observers- Full order observer, reduced order observer, Design of control system with observers.
(Laboratory session on the topic using Matlab)

Digital control system: Sampled data systems, sampling, quantization, data reconstruction and filtering of sampled signals. Z transfer function, mapping from s plane to z plane.

Z transform analysis of closed loop and open loop systems, Stability analysis of closed loop systems in the z plane: stability tests. State space analysis of sampled data systems- Controllability, observability, control law design, decoupling by state variable feedback, Estimator/Observer design: full order observers, reduced order observers.
(Laboratory session on the topic using Matlab)

Nonlinear systems: Introduction - characteristics of nonlinear systems. Types of nonlinearities. Analysis through Linearisation about an operating point. Stability Analysis- Definition of stability-asymptotic stability and instability - Liapunov methods to stability of linear and nonlinear systems
(Laboratory session on the topic using Matlab)

TEXTBOOKS/REFERENCES:

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: Understand the nonlinear systems characteristics and analyze the stability of nonlinear systems.
CO5: Use software tools for the analysis and design of control systems.

23RA602 MECHANICS AND CONTROL OF ROBOTS 3-0-2-4


TEXTBOOKS/REFERENCES:
Course Outcomes

CO1: Understand various robot classifications, specifications and applications.
CO2: Apply coordinate transformations to map position and orientation coordinates from end effector to robot base.
CO3: Analyze forward and inverse kinematics to manipulate objects by robots.
CO4: Analyze forward and inverse dynamics to manipulate objects by robots.
CO5: Understand the control schemes used for robotic manipulators.
CO6: Construct simulations in RoboAnalyzer/Matlab to verify kinematics and dynamics of robots.

23RA603 VISION SYSTEMS AND DIGITAL IMAGE PROCESSING 3-0-2-4

Two-Dimensional Signals and Systems: Sampling in two dimensions: Sampling theorem, Change in Sample rate, Down sampling, Ideal decimation, Up sampling, Ideal interpolation. Continuous Image characterization: Psychophysical vision properties, Photometry, Colorimetry.

TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand 2D signals and systems.
CO2: Apply sampling in two dimensions.
CO3: Apply fundamentals of digital image processing.
CO4: Analyze transforms and filtering.
CO5: Analyze color image processing.
CO6: Construct simulations in OpenCV/Matlab to study digital image processing.

23RA604 MACHINE LEARNING 3-0-2-4


TEXTBOOKS/REFERENCES:

Course Outcomes

CO2: Design and implement various machine learning algorithms in a range of real-world applications.
CO3: Understand strengths and weaknesses of many popular machine learning approaches.
CO4: Analyze the underlying mathematical relationships within and across Machine Learning
algorithms.

CO5: Apply the paradigms of supervised and un-supervised learning.

Sensors: General Concept of Measurement: Basic block diagram, stages of generalised measurement system, state characteristics; accuracy, precision, resolution, repeatability, reproducibility, sensitivity, zero drift, linearity, Dynamic characteristics, zero order instrument, first order instrument, time delay, Sensors and Principles: Resistive sensors, Potentiometer and strain gauges Inductive sensors: Self-inductance type, mutual inductance type, LVDT Capacitive sensors- piezoelectric sensors, thermocouples, thermistors radiation pyrometry - Fibre optic temperature sensor photo electric sensors, pressure and flow sensors, vision sensors.

Signal conditioning: Amplification, Filtering, Level conversion, Linearisation, Buffering, sample and hold circuit quantisation multiplexer/ demultiplexer, analog to digital converters, digital to analog converters. Data acquisition and conversion: General configuration single channel and multichannel data acquisition system. Digital Filtering, data logging, data conversion, introduction to digital transmission systems, PC-based data acquisition system. Interface systems and standards.

Microcontroller fundamentals: ARM ASM programming and basics of C; IO Interfacing: LED and Switch; Design and Development Process: Architecture, Micro architecture, Design, Implementation, Verification and Validation; Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines; The Parallel Interface: GPIO; The Serial Interface: UART; PLL programming; Timer: SysTick; Fixed Point; Software: Structs, Stacks and Recursion; IO Synchronization; Interrupts; DAC: Music Synthesis and Music Playback; ADC: Real world interfacing and Data Acquisition. Labs include prototypes of actual embedded systems using Arduino/ Raspberry Pi 4/ LabVIEW and myRIO, etc.

TEXTBOOKS/REFERENCES:

Course Outcomes
CO1: Understand general concept of measurement in sensors.
CO2: Apply principles of sensors.
CO3: Apply fundamentals of signal conditioning.
CO4: Analyze data acquisition and conversion.
CO5: Analyze microcontroller programming.
CO6: Construct embedded systems using Arduino/ Raspberry Pi/ LabVIEW and myRIO.
Introduction to Industrial Automation with case studies.

Introduction to PLC based controls - Architecture of PLC, PLC networking, programming, and wiring, HMI and SCADA design for PLC, Simulations of Factory Automation.

Introduction to Industry 4.0 – Details and Challenges.

Introduction to Pneumatic and Hydraulic Systems - Systems components, Symbols, System design and simulation using Automation Studio.

Introduction to Electric motors - Motor controls: VFD and Servo drives, Matlab Simulations.

TEXTBOOKS/REFERENCES:
[9] Siemens "PLC Handbook".
[10] Ries and Ries, "Programming Logic Controllers", PHI.

Course Outcomes
CO1: Understand various components of Industrial automation.
CO2: Understand PLC architecture.
CO3: Apply PLC networking and programming.
CO4: Analyze pneumatic and hydraulic circuits.
CO5: Analyze motor controls-VFD and servo drives.
CO6: Construct simulations in Automation Studio and real pneumatic and hydraulic circuits.

23RA613  AUTONOMOUS ROBOT SYSTEMS  3-0-2-4

Introduction to ROS - ROS Basic Concepts: Nodes, topics, parameters, services - Simple ROS programs to publish and subscribe messages. Simulation of typical robot system in ROS: Manipulators, wheeled robots in scenarios such as in a maze etc., legged robots and UAVs in various environments. Simulation of Husky Mobile Platform using ROS - Online Control of Husky in a structured environment.


TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand basic concepts of ROS.
CO2: Analyze simple programs and simulate robots in ROS.
CO3: Construct simulations of Husky mobile platform using ROS.
CO4: Understand various types of mobile robots and their kinematic models.
CO5: Apply maneuverability, workspace and motion controls of mobile robots.
CO6: Analyze various algorithms for SLAM.

23RA731  CNC MACHINES  3-0-2-4


TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand various components of NC and CNC machines and their working principles.
CO2: Understand constructional features of CNC machines.
CO3: Apply part programming in CNC machines.
CO4: Analyze simulation for CNC turning operations.
CO5: Analyze simulation for CNC milling operations.
CO6: Analyze economics and maintenance of CNC machines.

23RA732 PROCESS CONTROL AND INSTRUMENTATION 3-0-2-4


TEXTBOOKS/ REFERENCES:


Course Outcomes

CO1: Understand Process Modelling hierarchies, theoretical and empirical models.
CO2: Apply Feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio control, Multi-loop and multivariable control.
CO3: Apply: PID design, tuning, trouble shooting, tuning of multiloop PID control systems.
CO4: Analyze Decoupling control, Instrumentation for process monitoring and preparation of P&I diagrams.
CO5: Analyze Statistical process control, supervisory control, direct digital control, distributed control, PC based automation.
CO6: Analyze Programmable logic controllers and SCADA in process automation.

**TEXTBOOKS/REFERENCES:**


**Course Outcomes**

CO1: Understand Process Modelling hierarchies, theoretical and empirical models.
CO2: Apply Feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio control, Multi-loop and multivariable control.
CO3: Apply: PID design, tuning, trouble shooting, tuning of multiloop PID control systems.
CO4: Analyze Decoupling control, Instrumentation for process monitoring and preparation of P&I diagrams.
CO5: Analyze Statistical process control, supervisory control, direct digital control, distributed control.

**FPGA BASED SYSTEM DESIGN**


**TEXTBOOKS/REFERENCES:**

Course Outcomes

CO1: Understand ASICs, CMOS logic and ASIC library design.
CO2: Apply Combinational Logic Cell - Sequential logic cell – Data path logic cell.
CO3: Apply Logical effort, Library cell design, Library architecture, Programmable logic cells and I/O cells.
CO4: Analyze Block RAM – Distributed RAM-Configurable Logic Blocks-LUT based structures.
CO5: Analyze Design Entry and Testing.
CO6: Analyze Floor Planning, Placement and Routing.

23RA735 EMBEDDED SYSTEMS DESIGN 3-0-2-4
Microcontroller fundamentals: ARM ASM programming and basic of C; IO Interfacing: LED and Switch; Design and Development Process: Architecture, Micro architecture, Design, Implementation, Verification and Validation; Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines; The Parallel Interface: GPIO; The Serial Interface: UART; PLL programming; Timer: SysTick; Fixed Point; Software: Structs, Stacks and Recursion; Device Driver: Interfacing with an Hitachi HD44780 display; IO Synchronization; Interrupts; DAC: Music Synthesis and Music Playback; ADC: Real world interfacing and Data Acquisition. Labs include prototypes of actual embedded systems, e.g., Traffic Light Controller (FSM), LCD Device Driver (Hitachi HD44780), Digital Piano (DAC, Interrupts), Digital Vernier Caliper (ADC, Interrupts, LCD), Distributed Data Acquisition (Interrupts, ADC, LCD, UART) accomplished using Arduino based system. Basics of system booting and Boot Loaders. Concurrency, Timeouts, Inter Process Communication. Capstone Design Project, A popular video game, e.g., Space Invaders, Connect-4, Pipe Dream, etc.

TEXTBOOKS/REFERENCES:

Course Outcomes
CO1: Understand Microcontroller fundamentals: ARM ASM programming and basic of C, IO Interfacing: LED and Switch.
CO3: Apply Development Tools: Block Diagrams, Flow Charts, Call Graphs, Dataflow Graphs, Finite State Machines.
CO4: Apply Software: Structs, Stacks and Recursion.
CO5: Analyze prototypes of actual embedded systems.
CO6: Analyze Concurrency, Timeouts, Inter Process Communication.

23RA736    DATA DRIVEN MODELING OF ROBOTIC SYSTEMS   3-0-2-4


TEXTBOOKS/REFERENCES:


Course Outcomes

CO2: Apply Eigenvalues, Eigenvectors and Solvability.
CO3: Apply Curve fitting: Least Square Fitting Methods, Polynomial Fits and Splines.
CO4: Apply Singular Value Decomposition.
CO5: Analyze Balanced Models for Control.
CO6: Analyze Data Driven Control.

23RA737    ESSENTIALS FOR MECHATRONIC PROTOTYPING   3-0-2-4

Introduction to computer aided engineering softwares – overview and operation of 3D modelling features and tools - parametric modelling – generative design – modelling and visualization of structural analysis parameters through FEA software – multibody dynamics simulation and

TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand computer aided engineering softwares.
CO2: Apply overview and operation of 3D modelling features and tools - parametric modelling.
CO3: Apply generative design.
CO4: Apply modelling and visualization of structural analysis parameters through FEA software.
CO5: Analyze multibody dynamics simulation and evaluation.
CO6: Analyze additive manufacturing guidelines and design limitations for 3D printing.

23RA741 HUMANOID ROBOTICS 3-0-2-4


TEXTBOOKS/REFERENCES:

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.

23RA742 SWARM INTELLIGENCE 3-0-2-4


TEXTBOOKS/REFERENCES:


Course Outcomes
CO1: Understand swarm intelligence and key principles (e.g., self-organization), natural and artificial examples.
CO2: Apply open space, multi-source foraging experiments: biological data and microscopic models.
CO3: Apply to a classical operational research problem: The Travel Salesman Problem (TSP).
CO4: Apply Ant-based algorithms (ABC, Ant-Net) to routing in telecommunication networks.
CO5: Analyze unsupervised multi-agent machine-learning techniques for automatic design and optimization.
CO6: Analyze machine-learning techniques to automatic design and optimization in single-robot and multi-robot experiments.

23RA743 BEHAVIOUR BASED ROBOTICS 3-0-2-4

This course is designed to investigate and study methods and models in embodied cognitive science and artificial intelligence, with particular focus on behaviour-based techniques on robots. All models and architectures will be theoretically scrutinized and evaluated with respect to their conceptual clarity, support by empirical data, plausibility, etc. without neglecting issues of practicality such as feasibility of implementation, real-time/real-world issues, computational resources, etc. Topics include introduction to embodied cognitive science and behaviour-based robotics, reactive behaviour-based architectures, perception, deliberative systems, hybrid systems, subsumption architecture, etc.

TEXTBOOKS/REFERENCES:

Course Outcomes
CO1: Understand methods and models in embodied cognitive science and artificial intelligence.
CO2: Apply behaviour-based techniques on robots.
CO3: Analyze models and architectures with respect to their conceptual clarity, supported by empirical data.
CO4: Apply embodied cognitive science.
CO5: Analyze reactive behaviour-based architectures.
CO6: Analyze subsumption architecture.
Topics consist of rehabilitation engineering, artificial tissue and organs, implantable neural prosthesis, orthopaedic implants and implanted devices, biology-machine interface, minimally invasive surgical instruments, surgical robot, introduces its basic principle, key technology and its development and application. They include introduction to Biomechatronic Systems, design and manufacturing of Bio-mechatronic products, musculoskeletal mechanics, review of multi-body dynamics, principles of motor control and sensorimotor integration, simulation of human movement, human locomotion and gait studies, motor control in patients with neurological disorders, artificial tissue and organ, orthopaedic implants, Biology-Machine Interface, implantable neural prosthesis, minimally invasive surgical instruments, surgical robot.

TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand topics that consist of rehabilitation engineering, artificial tissue and organs.
CO2: Apply its basic principle, key technology and its development and application.
CO3: Analyze design of Bio-mechatronic products.
CO4: Apply manufacturing of Bio-mechatronic products.
CO5: Analyze review of multi-body dynamics, principles of motor control and sensorimotor integration.
CO6: Analyze simulation of human movement, human locomotion and gait studies.

TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand topics of linear programming.
CO2: Understand topics of non-linear programming.
CO3: Analyze simplex technique, Duality and Sensitivity.
CO4: Apply Constrained and Unconstrained Nonlinear Programming.
CO5: Apply Genetic Algorithms.
CO6: Analyze Evolutionary Multi-Objective Optimization (MOO).

23RA746 HAPTIC INTERFACES 3-0-2-4


TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand topics of Haptics.
CO2: Understand topics of Kinesthetic haptic devices: Kinematics and Dynamics.
CO3: Analyze Rendering and control.
CO4: Apply Dynamic simulations, sensors, and actuators.
CO5: Apply Tele-operation: Implementation, Transparency and Stability.
CO6: Analyze Human haptics: Mechanoreceptors, Kinesthesia.

23RA747 INNOVATING IN TECHNOLOGY 3-0-2-4

TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand Core innovation lenses: attitudes, activities, conversations, rhythm and examples.
CO2: Understand Working with Technology and Business constraints.
CO4: Apply Cross-discipline research and Targeting Social Impact.
CO5: Apply Effective brainstorming. Expanding and Contracting phases.
CO6: Analyze Sketching vs. Prototyping and Working with end users.

23RA748 MEASURING USER INTERFACE QUALITY 3-0-2-4

How to conduct a usability study. What to measure: Identifying top tasks, Common metrics, Task completion metrics, Performance metrics, Qualitative and quantitative metrics, Biometrics. When to measure: Before development, During development, Prelaunch, Post Launch, Common problems and solutions to effective timing. How to measure: overview of approaches, usability labs, automated measurement, remote testing, field testing. With Who to measure: understanding user samples, identifying valid participants, techniques for finding participants. Taking Action: communicating findings, presenting usability issues, strategies for resolution.

TEXTBOOKS/REFERENCES

Course Outcomes

CO1: Understand how to conduct a usability study.
CO2: Understand identifying top tasks, Common metrics, Task completion metrics, Performance metrics, Qualitative and quantitative metrics, Biometrics.
CO3: Analyze when to measure: Before development, During development, Pre launch, Post Launch.
CO4: Apply overview of approaches, usability labs, automated measurement, remote testing, field testing.
CO5: Apply user samples, identifying valid participants, techniques for finding participants.
CO6: Analyze Taking Action: communicating findings, presenting usability issues, strategies for resolution.

23RA749       DESIGN FOR PEOPLE: PRINCIPLES AND PRACTISES OF HUMAN CENTERED DESIGN  3-0-2-4


TEXTBOOKS/REFERENCES:


Course Outcomes

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.

23RA750       MECHANISMS FOR ROBOT SYSTEMS  3-0-2-4
Generalities of robot mechanics - overview of trajectory generation and planning in robot systems - motion curve definition and coefficients - analysis on effect of coefficient parameters (velocity/acceleration/ jerk) - motion curve design limitations and optimization modalities.


TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand Generalities of robot mechanics.
CO2: Understand Kinematic pairs & trajectory generation mechanisms.
CO3: Analyze Actuators in the industry: electric/hydraulic/pneumatic actuators.
CO4: Apply piezoelectric, magnetostrictive, thermal SMA, electroactive polymers, pneumatic muscles.
CO5: Apply linear transmission – rotational transmission (conventional reducers, cycloidal drives, strain wave drives).
CO6: Analyze technological constraints in actuators, speed reducers, structures.

TEXTBOOKS/REFERENCES:


Course Outcomes

CO4: Apply Geometric Stability and Required Torques.
CO5: Apply Kinematics and Dynamics.
CO6: Analyze Improving Leg Speed by Soft Computing Techniques.

23RA761 DESIGN AND ANALYSIS OF ALGORITHMS 3-0-2-4

Algorithm Analysis: Methodologies for Analyzing Algorithms, Asymptotic Notation, Recurrence Relations. Data Structures: Linear Data Structures (Stacks, Queues, Linked-Lists, Vectors), Trees (Binary Search Trees, AVL trees, Red-Black trees, B-trees), Hash-Tables (Dictionaries, Associative Arrays, Database Indexing, Caches, Sets) and Union-Find Structures. Searching and Sorting (Insertion and Selection Sort, Quicksort, Mergesort, Heapsort, Bucket Sort and Radix

TEXTBOOKS/REFERENCES:


Course Outcomes

CO3: Analyze Comparison of sorting algorithms and lower bounds on sorting.
CO4: Apply Graph Algorithms: Elementary Algorithms, i.e., Breadth-first search, Depth-first search.
CO5: Apply Network Flow and Matching.
CO6: Analyze Nondeterministic Polynomial Time Problems.

23RA762 ADVANCED PERCEPTION FOR ROBOTICS AND AI 3-0-2-4

This course is an advanced survey of the state of the art in machine vision, focused primarily on robotics applications and human-computer interfaces. Topics covered will be related to 3D reconstruction of objects and scenes from video, camera motion estimation from video, object detection and recognition, and tracking, cloud robotics as it relates to robot vision. They include optical flow estimation: motion field and optical flow, calculating optical flow, flow-based motion
analysis, robust incremental optimal flow. Object detection and recognition: Global methods, transformation search-based methods, geometric correspondence-based approaches, flexible shape matching, interest point detection and region descriptors, three-dimensional object recognition. Tracking and video analysis: Point tracking, deterministic methods, statistical methods, kernel tracking, template and density based appearance models multi view appearance models, Silhouette tracking, contour evolution, shape matching, LiDAR and Point Cloud.

TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand robotics applications and human-computer interfaces.
CO2: Understand 3D reconstruction of objects and scenes from video, camera motion estimation from video.
CO3: Analyze optical flow estimation: motion field and optical flow, calculating optical flow.
CO4: Apply Object detection and recognition.
CO5: Apply geometric correspondence-based approaches.
CO6: Analyze Tracking and video analysis.

23RA763 COMPUTATIONAL INTELLIGENCE 3-0-2-4


TEXTBOOKS/REFERENCES:


Course Outcomes

CO1: Understand Computational intelligence.
CO2: Understand Adaptation, Self-organization and Evolution, Biological and artificial neuron, Neural Networks Concepts, Paradigms, Implementations.
CO3: Analyze Evolutionary computing.
Course Outcomes

CO1: Understand Active contours Model Snake- Split and merge, Mean shift and mode finding.
CO2: Understand Detectors and Descriptors, Chain Codes, Polygonal Approximations.
CO3: Analyze Feature Matching-Object Recognition.
CO4: Apply Image Formation: Geometric image formation, Photometric image formation.
CO5: Apply Projective Geometry, transformation of 2-d and 3-d.

TEXTBOOKS/REFERENCES:


TEXTBOOKS/REFERENCES:

Course Outcomes
CO1: Understand Problem solving: Graph based search, Algorithms for searching.
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.


TEXTBOOKS/REFERENCES:

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.

23RA767 NON-LINEAR CONTROL THEORY 3-0-2-4


TEXTBOOKS/REFERENCES:

Course Outcomes

CO1: Understand Nonlinear Behaviour.
CO3: Analyze Finite State Automata and Hybrid Systems.
CO4: Apply Singular Perturbations, Harmonic Balance, Model Reduction, Feedback Linearization.
CO5: Apply Storage Functions and Lyapunov Functions.
CO6: Analyze Local Stability, Centre Manifold Theorems, Bifurcations.
The goal of this course is to develop virtual reality simulations and applications that incorporate haptic interaction. Theoretical topics include haptic rendering in 3-D virtual environments, simulation of haptic interaction with rigid and deformable objects, haptic interfaces, psychophysics of touch. Applied topics include an introduction to the CHAI 3D/Unity 3D haptics library, implementation of algorithms for haptic rendering, collision detection, and deformable body simulation.

TEXTBOOKS/REFERENCES:

Course Outcomes
CO1: Understand develop virtual reality simulations.
CO2: Understand haptic rendering in 3-D virtual environments.
CO3: Analyze simulation of haptic interaction with rigid and deformable objects.
CO4: Apply haptic interfaces, psychophysics of touch.
CO5: Apply CHAI 3D/Unity 3D haptics.
CO6: Analyze implementation of algorithms for haptic rendering, collision detection.

Introduction to UAV - Types of UAV - Geometry and Mechanics of UAVs including transformations, angular velocity, principal moment of inertia, equations of motions, ROS based Control, Trajectories and Motion Planning, Sensing and Probabilistic State Estimation, Visual Motion Estimation, Visual SLAM, Architectures, UAV and AGV interoperable frameworks.

TEXTBOOKS/REFERENCES:

Course Outcomes
CO1: Understand UAV and types of UAV.
CO2: Understand Geometry and Mechanics of UAVs including transformations.
CO3: Analyze ROS based Control, Trajectories and Motion Planning.
CO4: Apply Sensing and Probabilistic State Estimation.
CO5: Apply Visual Motion Estimation, Visual SLAM.
CO6: Analyze Architectures, UAV and AGV interoperable frameworks.

23RM705

RESEARCH METHODOLOGY


Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes.


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:
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 understand 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.

Pre-requisite: An open mind and the urge for self-development, basic English language skills and knowledge of high school level arithmetic.

Course Objectives:
• Help students transit from campus to corporate and enhance their soft skills
• Enable students to understand the importance of goal setting and time management skills
• Support them in developing their problem solving and reasoning skills
• Inspire students to enhance their diction, grammar and verbal reasoning skills

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.
**C06: 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.

**CO-PO Mapping**

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**Syllabus**

**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

**References**

**Soft Skills**

Communication and listening skills:


Assertiveness skills:

- John Hayes “Interpersonal skills at work”, Routledge, 2003

Self-perception and self-confidence:


Time management:

- Stephen Covey, “The habits of highly effective people”, Free press Revised edition, 2004
- Kenneth H. Blanchard and Spencer Johnson, “The One Minute Manager”, William Morrow, 1984

**Verbal**

- Erica Meltzer, “The Ultimate Guide to SAT Grammar”
- Jeff Kolby, Scott Thornburg & Kathleen Pierce, “Nova’s GRE Prep Course”
- Kaplan’s GRE Comprehensive Programme
- Manhattan Prep, “GRE Verbal Strategies Effective Strategies Practice from 99th Percentile Instructors”
- Wren & Martin, “English Grammar & Composition”
- www.bbc.co.uk/learningenglish
- www.cambridgeenglish.org
- www.englishforeveryone.org
- www.merriam-webster.com

**Aptitude**

- www.mbatious.com
- www.campusgate.co.in
- www.careerbless.com

**Evaluation Pattern**

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Internal</th>
<th>External</th>
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<td>Continuous Assessment (CA)* – Aptitude</td>
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<td><strong>Total</strong></td>
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Pass / Fail

*CA - Can be presentations, speaking activities and tests.

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

**Pre-requisite:** Willingness to learn, team spirit, basic English language and communication skills and knowledge of high school level arithmetic.

**Course Objectives:**
- Help students to understand the importance of interpersonal skills and team work
- Prepare the students for effective group discussions and interviews participation.
- Help students to sharpen their problem solving and reasoning skills
- Empower students to communicate effectively by using the correct diction, grammar and verbal reasoning skills

**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.

**CO-PO Mapping**
Syllabus

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 gloss ophobia 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.


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.

References

Soft Skills

Team Building

**Verbal**
- “GMAT Official Guide” by the Graduate Management Admission Council, 2019
- Arun Sharma, “How to Prepare for Verbal Ability And Reading Comprehension For CAT”
- Joern Meissner, “Turbocharge Your GMAT Sentence Correction Study Guide”; 2012
- Kaplan, “Kaplan GMAT 2012 & 13”
- Mike Barrett “SAT Prep Black Book The Most Effective SAT Strategies Ever Published”
- Mike Bryon, “Verbal Reasoning Test Workbook Unbeatable Practice for Verbal Ability, English Usage and Interpretation and Judgement Tests”
- www.bristol.ac.uk/arts/skills/grammar/grammar_tutorial/page_55.htm
- www.campusgate.co.in

**Aptitude**
- www.mbatious.com
- www.campusgate.co.in
- www.careerbless.com

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