MTech Robotics and Automation
Curriculum and Syllabus
Revised on: August 2021
Previous revisions: 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.
Program Educational Objectives of the MTech (Robotics and Automation)

PEO1: This program provides an academic curriculum that pulls from Mechanical Engineering, Electronics and 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.

PEO2: This programme provides a comprehensive educational environment and enables students to gain expertise in next generation robotics and automation systems.

PEO3: Expose students to course work from multiple disciplines and prepare them to think about robotics from a holistic approach and 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 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.
### CURRICULUM

#### 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

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**Total Credits for MTech Program:** 68
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SYLLABUS

21MA617 MATHEMATICS FOR ROBOTICS AND AUTOMATION 3-0-2-4

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.

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.

21RA601 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 Introduction to robot control, Control schemes used for a robotic manipulator-Joint motion control, Resolved motion control, and Adaptive control schemes.
(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 Understand the control schemes used for robotic manipulators.
CO6: Use software tools for the analysis and design of control systems.

21RA602  KINEMATICS AND DYNAMICS 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: Apply forward and inverse kinematics to manipulate objects by robots.
CO4: Analyze forward and inverse kinematics to manipulate objects by robots.
CO5: Analyze forward and inverse dynamics to manipulate objects by robots.
CO6: Construct simulations in RoboAnalyzer/Matlab to verify kinematics and dynamics of robots.

21RA603 DIGITAL IMAGE PROCESSING 3-0-2-4

**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 Matlab to study digital image processing.

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**21RA604 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 unsupervised learning.

21RA611                  MECHATRONIC DEVICES AND SYSTEMS                 3 0 2 4

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 and others.

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.

21RA612         INDUSTRIAL AUTOMATION         3-0-2-4

Introduction to Industrial Automation with case studies. Introduction to Industry 4.0.

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 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.

21RA613 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 various types of mobile robots and their kinematic models.
CO2: Apply maneuverability, workspace and motion controls of mobile robots.
CO3: Analyze maneuverability, workspace and motion controls of mobile robots.
CO4: Understand various algorithms for SLAM.
CO5: Analyze simple programs and simulate robots in ROS.
CO6: Construct simulations of Husky mobile platform using ROS.

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.

21RA702 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.

21RA703 ADVANCED PROCESS CONTROL 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.
CO6: Design of Fuzzy-Logic based controller, Design of Neural Network based controller.

21RA704 FPGA BASED SYSTEM DESIGN 3-0-2-4

Introduction to ASICs, CMOS logic and ASIC library design: Types of ASICs - Design Flow
CMOS transistors, CMOS design rules - Combinational Logic Cell - Sequential logic cell – Data
path logic cell - transistors as resistors - transistor parasitic capacitance - Logical effort - Library
cell design - Library architecture. Programmable logic cells and I/O cells: Digital clock Managers-
Clock management- Regional clocks- Block RAM – Distributed RAM-Configurable Logic
Blocks-LUT based structures – Phase locked loops- Select I/O resources –Anti fuse - static RAM
- EPROM and EEPROM technology. Device Architecture: Spartan 6 - Vertex 4 architecture- Altera
Cyclone and Quartus architectures. Design Entry and Testing: Verilog and VHDL - logic synthesis
- Types of simulation –Faults- Fault simulation - Boundary scan test Automatic test pattern
- FPGA partitioning - partitioning methods - floor planning placement - physical design flow -
global routing - detailed routing - special routing - circuit extraction - DRC.

TEXTBOOKS/REFERENCES:

1997.

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
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.
This course looks at components, interfaces and methodologies for building systems. Specific topics include microcontrollers, design, verification, hardware/software synchronization, interfacing devices to the computer, timing diagrams, real-time operating systems, data collection and processing, motor control, analog filters, digital filters, and realtime signal processing. Topics include Computer Architecture review, Design of I/O Interfaces, Software Design, Real Time Operating Systems, Multitasking (preemptive scheduling, resource sharing and priority determination), Digital Signal Processing, HighSpeed Interfacing, File system management, Interfacing Robotic Components, High-Speed Networks, Robotic Systems.

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.

DATA-DRIVEN METHODS FOR ROBOTIC SYSTEMS


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.

21RA708 ESSENTIALS FOR MECHATRONIC PROTOTYPING 3-0-2-4


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.

21RA711 PROBABILITY AND STATISTICS 3-0-2-4

Probability: Introduction to data analysis and statistics, Algebra of sets, Counting, Axioms of probability, Conditional probability, Law of Total Probability and Bayes' rule, Independence of events, Random variables; Types of data, Descriptive statistics (measures of central tendency and variation), Graphical representation of data, Distribution functions, Expectation, variance, and moments of discrete & continuous random variables, Functions of random variables, Discrete Uniform, Bernoulli, Binomial, Poisson, and Geometric distributions, Continuous Uniform, Normal, and Exponential random variables; Measurement errors - accuracy and precision; Framing hypothesis statements (practical statement vs. statistical statement), Concept of statistical hypothesis tests; Type I Error, Type II Error, and p-value, Point estimation vs. interval estimation, Test of single mean, Test of comparison of two means (independent and paired t-tests), Test of single variance, Test of comparison of two variances, Test of comparison of more than two means (ANOVA), Test of independence of two discrete random variables (Chi-square), Correlation and covariance, Concept of Linear Regression. Estimation Theory, Bayes and Kalman filter. Introduction to SPSS/Minitab/Matlab for data Analysis.

TEXTBOOKS/REFERENCES:

Course Outcomes
CO1: Understand data analysis and statistics, Algebra of sets, Counting, Axioms of probability.
CO2: Apply Conditional probability, Law of Total Probability and Bayes' rule.
CO3: Apply Descriptive statistics.
CO4: Apply Discrete Uniform, Bernoulli, Binomial, Poisson, and Geometric distributions.
CO5: Analyze Concept of statistical hypothesis tests; Type I Error, Type II Error, and p-value.
CO6: Analyze Test of comparison of more than two means (ANOVA).

21RA712 HUMANOID ROBOTICS 3-0-2-4

The course aims at giving the students a basic understanding of the theory of humanoid robots, i.e. bipedal walking robots with an approximately humanlike shape, and a practical knowledge concerning humanoid robots, through a robot construction project. The contents of the course include Theory of humanoid robots, kinematics and dynamics. 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.

TEXTBOOKS/REFERENCES:

[4] Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators".

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.

21RA713 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.

21RA714 BEHAVIOURAL 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, sub-umption architecture.

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 sub-umption architecture.

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**21RA715 FRONTIERS OF BIOMECHATRONICS 3-0-2-4**

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:**


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**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 Nonlinear Programming.
CO5: Apply Unconstrained Nonlinear Programming.
CO6: Analyze Evolutionary Multi-Objective Optimization (MOO).


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.

21RA718                   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.

21RA719                   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.

21RA720 DESIGN FOR PEOPLE: PRINCIPLES AND PRACTISES OF HUMAN CENTERED DESIGN 3-0-2-4

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.

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.
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, magnetorheological elastomers, electrochemical actuators – motion transformation – linear transmission – rotational transmission (conventional reducers, cycloidal drives, strain wave drives) - flexible transmission (bowden cables, twisted string actuation). Challenges of designing robot mechanisms – technological constraints in actuators, speed reducers, structures – relative performance of robot mechanisms as compared to biomechanical systems.

TEXTBOOKS/REFERENCES:


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.

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.
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.

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.


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.
CO4: Apply Swarm Intelligence.
CO5: Apply Fuzzy systems: Concepts, Paradigms, Implementation, Hybrid systems.
CO6: Analyze CI application: case studies may include sensor networks, digital systems, control.

21RA734                                  MACHINE VISION      3-0-2-4


TEXTBOOKS/REFERENCES:


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.

**21RA735 ADVANCED AI FOR ROBOTICS 3-0-2-4**


**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.

**21RA736 VIRTUAL REALITY AND APPLICATIONS 3-0-2-4**

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.

21RA737 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.

21RA738  EXPERIMENTAL HAPTICS  3-0-2-4

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.

21RA739  UNMANNED AERIAL VEHICLES  3-0-2-4

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.

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.