COURSE STRUCTURE AND SYLLABI (NEP 2020)

FOR M. TECH. in MECHATRONICS (TWO YEARS COURSE)

School of Mechatronics and Robotics

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

June 2025

MASTER OF TECHNOLOGY

SPECIALIZATION: MECHATRONICS

First Semester

Sl. No.	Type	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	PC	Mechatronics System Design	MC5101N	3	0	0	3	3	100
2	PC	CAD/CAM for Product Development	MC5102N	3	0	0	3	3	100
3	PC	Control Systems for Mechatronics	MC5103N	3	0	0	3	3	100
4	PSE	Machines and Mechanisms	MC5121N	3	0	0	3	3	100
		Mathematics for AI	MC5122N						
		Electronic Design and Simulation	MC5123N						
		Industry 5.0	MC5124N						
5	OE/ESC	Product Design and Development	MC5161N	3	0	0	3	3	100
		Theory Sub-total		**15**	**0**	**0**	**15**	**15**	**500**
6	PC	Mechatronics Laboratory	MC5171N	0	0	3	2	3	50
7	PC	Automation and Robotics Laboratory	MC5172N	0	0	3	2	3	50
8	PC	Control Systems Laboratory	MC5173N	0	0	3	2	3	50
9	ESC Lab	Product Development Laboratory	MC5174N	0	0	3	2	3	50
		Practical Sub-total		**0**	**0**	**9**	**6**	**9**	**150**
		First Semester Total		**15**	**0**	**9**	**21**	**24**	**650**

Second Semester

Sl. No.	Type	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	PC	Robotics	MC5201N	3	0	0	3	3	100
2	PC	Machine Learning in Mechatronics	MC5202N	3	0	0	3	3	100
3	PC	Embedded Signal Processing	MC5203N	3	0	0	3	3	100
4	PSE	Biomechatronics	MC5221N	3	0	0	3	3	100
		Computer Vision	MC5222N						
		Biomedical Instrumentation	MC5223N						
		MEMS	MC5224N						
5	OE	Artificial Intelligence for Robotics	MC5261N	3	0	0	3	3	100
		Theory Sub-total		**15**	**0**	**0**	**15**	**15**	**500**
6	P	M.Tech. project/Term-paper	MC5291N	0	0	3	2	3	50
7	O	Seminar/Viva Voce	MC5292N	0	0	3	2	3	50
		Practical Sub-total		**0**	**0**	**6**	**4**	**6**	**100**
		Second Semester Total		**15**	**0**	**6**	**19**	**21**	**600**

Third Semester

Sl. No.	Type	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	P	M. Tech. Thesis	MC6191N				12	24	300
2	O	Progress Seminar and Viva-voce	MC6192N				6		100
3	I	Summer internship (6-8 weeks) evaluation	MC6193N				2		50
		Third Semester Total					**20**		**450**

Fourth Semester

Sl. No.	Type	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
				L	T	P			
1	VAC	Codes and Standards for Professionals	MC5262N	3	0	0	3	3	100
2	P	M. Tech. final thesis	MC6291N				22	30	400
3	O	Thesis Seminar and Viva-voce	MC6292N				8		200
		Fourth Semester Total					**33**		**700**

Course Code	MC5101N	**Course Name**	Mechatronics System Design	**Course Category**	PC	L	T	P
						3	0	0

Pre-requisite Courses	*None*	**Co-requisite Courses**	*None*	**Progressive Courses**	
Course Offering Department		***School of Mechatronics and Robotics***		**Data Book / Codes/Standards**	

Course Objective	The primary objective of mechatronics is to integrate the mechanical systems with electrical, electronics and computer systems and to provide a multidisciplinary approach to product development and manufacturing system design.

Module	**Syllabus**	**Duration (class-hour)**	**Module Outcome**
1	Electric Circuits and Components and Semiconductor Electronics	8	Kirchoff's laws, Thevenin and Norton theorems. Diodes and transistors and analysis of circuits containing these elements
2	Basic Mechanical Engineering, Hydraulic and Pneumatic System, Power and Motion Transmission Elements, Kinematics and Dynamics of dynamics of machines	8	Algebraic analysis of mechanisms. Equations of motion of mechanical systems. Analysis of gears, belts, cam and other motion transmission systems. Understanding design of hydraulic and pneumatic systems with circuit diagrams.
3	Modelling Techniques Modelling of Mechanical, Electrical, Electromechanical, Thermal, Hydraulic and Pneumatic systems. system modelling with structured analysis, Modelling paradigms for Mechatronic System, Block Diagrams, Mathematical Models, Systems of Differential-algebraic Equations, Response Analysis. Bond Graph	10	Modelling and simulation of dynamical systems connecting different domains. Bond graph techniques to formulate the state-equations of inter-connected dynamical systems.

4	Sensors and Actuators Different types of Sensors, Actuators: a comparative study, Selection criterion and calibration. Force/Torque sensor, shear sensor, gas sensor, EMG sensor, reaction force-sensing, transmitted force-sensing, electric SEA, cable-driven actuators, elastomeric actuators, Encoders, Hall sensors, gyroscopes, Transducers for Mechatronics Systems (Capacitance, Inductive, Ultrasound), Piezoelectric Sensors, Tactile Sensor. Vision sensors: monocular and stereo camera. Event camera. Hydraulic and Pneumatic actuators: Basic structure of Electro pneumatic and Electrohydraulic systems and controls. Series Elastic Actuators Electrical actuators: Stepper motors, Servo motors, brushless dc motors, Relay, Drive circuits for speed and position control (H-Bridge, DC-DC Converter, PWM Inverter etc).	10	Understand the working principles of sensors and selection of appropriate sensors for various industrial applications. Working principles of Hydraulic, pneumatic and electric actuators and their typical usage cases in mechatronics
5	Designing a Mechatronics System using available resources	6	Model and demonstrate Mechatronics systems like X-Y plotter, mobile vehicle or a Stewart platform

Course Outcome	1. Integrate mechanical, electrical, and software components into mechatronic systems. 2. Design and analyse mechanical systems for mechatronics. 3. Design and build a mechatronic system as part of a team.

Learning Resources	• Bolton, William. *Mechatronics: electronic control systems in mechanical and electrical engineering*. Pearson Education, 2003. • Boylestad, Robert L., and Louis Nashelsky. *Electronic devices and circuit theory*. Pearson Education, 2002. • Malvino, Albert, and David Bates. *Electronic principles*. McGraw-Hill, Inc., 2006. • Floyd, Thomas L. *Digital Fundamentals, 10/e*. Pearson Education India, 2011. • Karnopp, Dean C., Donald L. Margolis, and Ronald C. Rosenberg. *System dynamics: modeling, simulation, and control of mechatronic systems*. John Wiley and Sons, 2012. • Bishop, Robert H. *The Mechatronics Handbook-2 Volume Set*. CRC press, 2002.

Course Code	MC5102N	Course Name	CAD/CAM for Product Development	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	To learn the concepts of automation systems in manufacturing sector. To get familiarized with the basics of CAD/CAM and FE tool in dynamic problems in addition to intelligent machining operations.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction:** Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), Computer Aided Manufacturing (CAM), Computer Integrated Manufacturing (CIM), product cycle and automation in CAD/CAM, Need of CAD/CAM.	07	Understanding the product cycle and the need for CAD/CAM
2	**Modelling:** Introduction to transformation, plane and space curves, solid modelling, surface modelling, FEM, FEA, Structure analysis, motion analysis.	07	Solid modelling and FE analysis
3	**Process Planning:** Basic concepts of process planning, computer aided process planning (CAPP), Retrieval or variant and generative approach of CAPP, Implementation consideration of CAPP.	05	Understanding computer aided process planning
4	**Numerical Control of Machine Tools:** Principles of Numerical control (NC), Computer Numerical control (CNC), Direct Numerical control (DNC), comparison between conventional and CNC systems, Classification of CNC system, NC coordinate system, positional control, system devices; drives, ball screws, transducers, feedback devices, counting devices, signal converters, interpolators, adaptive control system.	09	Understanding CNC systems
5	**NC Part Programming:** Concept, format, codes, preparatory and miscellaneous coded, manual part programming, APT programming, macros, fixed cycles.	07	Codes to accomplish jobs using CNC machines
6	**Prototype Development**: Design and develop a prototype using existing laboratory facilities. Detailed guideline may be found in Product Development Laboratory (MC5174).	07	Prototype development using CNC

Course Outcome	1. Apply the concepts of machining for CNC milling and turning equipment 2. Create and validate NC part program data 3. Produce an industrial component by interpreting 3D part model / part drawings 4. Create and demonstrate the technical documentation for design 5. Design and develop a prototype

Learning Resources	• Radhakrishnan, Pezhingattil, S. Subramanyam, and V. Raju. CAD/CAM/CIM. New Age International, 2008. • Rao, Posinasetti Nageswara. CAD/CAM: principles and applications. Tata McGraw-Hill Education, 2004. • Groover, Mikell, and E. W. J. R. Zimmers. CAD/CAM: Computer-aided design and manufacturing. Pearson Education, 1983. • Groover, Mikell. Automation, production systems, and computer-integrated manufacturing. Prentice Hall Press, 2007. • Chang, Tien-Chien, and Richard A. Wysk. Computer-aided manufacturing. Prentice Hall PTR, 1997.

Course Code	MC5103N	Course Name	Control Systems for Mechatronics	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	This course develops expertise in analysis and synthesis of controllers based on classical, modern and advanced controller design techniques for mechatronic systems.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Digital Control:** Discrete time mathematics, z-transforms, sampling rates, zero and first order hold, time delays, discrete-domain state space realization, model predictive control	04	Real-time optimization and control MPC tuning and parameter selection
2	**Nonlinear Control:** Lyapunov stability analysis sliding mode control- Basics of sliding mode control; sliding surface; stability analysis; chattering; Robustness to uncertainties and disturbance rejection. Differential flatness and its application to designing robot controllers	07	Robust Controller design through sliding mode approach
3	**Geometric Control:** Basics of differential Geometry, Lie derivatives and brackets, vector fields and distribution, Relative degree and normal form, Feedback Linearisation techniques. Energy shaping, passivitiy based control design.	06	Feedback linearised controller design for robotic systems - Tracking and regulation
4	**Time Delay systems**: Lyapunov-Krasovskii functionals, Time-varying delays. Applications in and controller designs for teleoperated robots and Haptic interfaces.	06	Controller design for systems exhibiting time delays
5	**Adaptive Control:** Basic adaptive control schemes, Self-Tuning Regulators, Model reference adaptive control, Adaptive pole placement techniques.	06	Adaptive controller design for robotic system with modelling uncertainties and unmodelled dynamics

6	**Optimal Control:** State Observers; Kalman Filters as State Observers; Dynamic System LQ optimization – LQR design.	07	Optimal control design and Kalman filter implementation
7	**Design:** Case Studies in different Control Design Techniques on multi-degree of freedom serial and parallel manipulators;	06	Controller designs for robotic hardware developed in the laboratory

Course Outcome	1. Analyze nonlinear systems by phase-plane method, describing function method and Lyapunov method 2. Derive discrete-time mathematical models in both time domain and z-domain. 3. Design optimal, robust and intelligent controllers

Learning Resources	• I.J Nagrath, and M. Gopal,. Control Systems Engineering. New Age International Publishers, 6^{th} Edition, 2017. • Ogata, Katsuhiko. Modern control engineering. Upper Saddle River, NJ: Prentice Hall, 2009. • Ogata, Katsuhiko. Discrete-time control systems. Englewood Cliffs, NJ: Prentice Hall, 1995. • Hassan K. Khalil. Nonlinear Control, Pearson Education, 2015

Course Code	MC5121N	Course Name	Machines and Mechanisms	Course Category	PSE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	This course develops expertise in Kinematic Analysis, Mechanism Design and Synthesis, Dynamic Analysis, Gear Train analysis.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction to Mechanisms**: Definitions and basic concepts (kinematics, dynamics, mechanisms, machines), Types of motion (translation, rotation), Kinematic links, pairs, and chains, Degrees of freedom and mobility analysis (Grubler's criterion), Kinematic inversions.	05	Mobility analysis of single and multi-degree of freedom mechanisms
2	**Kinematic Analysis:** Displacement, velocity, and acceleration analysis, Graphical and analytical methods, Velocity and acceleration diagrams, Instantaneous centre of rotation, Coriolis acceleration.	06	Velocity and acceleration polygons. Algebraic techniques to analyse mechanisms
3	**Linkages:** Four-bar linkages, Slider-crank mechanisms, Quick-return mechanisms, Synthesis of linkages (graphical and analytical methods), Transmission angle and mechanical advantage.	06	Linkage synthesis techniques
4	**Gears and Gear Trains:** Gear terminology and classifications, Spur gears, helical gears, bevel gears, worm gears, Gear tooth geometry and kinematics, Gear trains (simple, compound, epicyclic), Gear ratios and velocity analysis.	06	Design and analysis of gear trains
5	**Cams and Followers:** Cam terminology and classifications, Follower motion profiles (displacement, velocity, acceleration), Cam profile design and synthesis, Types of followers.	05	Design and analysis of cam followers
6	**Dynamics of Machines:** Force analysis of mechanisms, Inertia forces and torques, Flywheels and governors, Balancing of rotating masses.	08	Familiarity with dynamic modeling: Dynamic models of machines and mechanisms, including mathematical

			modeling and simulation
7	**Special Mechanisms:** Universal joints, Intermittent motion mechanisms, Straight-line mechanisms.	06	Analysis and synthesis of straight line generators

Course Outcome	1. Understand the fundamental principles of kinematics and dynamics. 2. Analyse the motion of various machine elements and mechanisms. 3. Design and synthesize mechanisms for specific motion requirements. 4. Develop the ability to apply theoretical concepts to practical engineering problems

Learning Resources	• Rattan, S. S. Theory of Machines. 5th ed., Tata McGraw-Hill Education, 2014 • Amitabha Ghosh and Asok Kumar Mallick, Theory of Mechanisms and Machines, Reprint 2015, Affiliated East-West Press Private Limited • Norton, Robert L. Kinematics and Dynamics of Machinery. McGraw-Hill Education, 2017. • Norton, Robert L. Design of Machinery. McGraw-Hill Education, 2020. • Sandor, George N., and Arthur G. Erdman. Advanced Mechanism Design: Analysis and Synthesis. Vol. 1. Englewood Cliffs, NJ: Prentice-Hall, 1984.

Course Code	MC5122N	Course Name	Mathematics for AI	Course Category	PSE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		**Data Book / Codes/Standards**	

Course Objective	To provide the mathematical background behind various learning algorithms covering probability, statistics, optimization and calculus for a better understanding of the recent developments in the field of artificial intelligence.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Linear Algebra:** Vector spaces and operations, Matrices and matrix operations, Determinants and eigenvalues, Orthogonality and orthogonalization, Applications to computer vision and neural networks	5	Least squares and Singular value decomposition
2	**Introduction to probability theory:** Random variables and distributions, Bayes' theorem and conditional probability, Statistical inference and hypothesis testing Applications to machine learning and data analysis	5	Bayesian Inference, Uncertainty modelling, Decision theory
3	**Optimization:** Basic concepts of Constrained Optimization, Cost function; Feasible Solution Set; KKT method; Convex Optimization, Linear programming; LMI and BMI, Stochastic optimization and online learning, Applications to machine learning and deep learning	12	Gradient descent, Stochastic gradient descent, model training, hyper-parameter tuning, feature selection
4	**Multivariable calculus and partial derivatives:** Applications to machine learning and deep learning, Application to nonlinear root-finding and optimization. Multidimensional Newton and steepest–descent methods. Second derivatives, Hessian matrices, quadratic approximations, and quasi-Newton methods.	07	Jacobians and Hessians, Back-propagation, neural networks and logistic regression
5	**Differential geometry and Tensors:** Curves and surfaces, Tangent spaces and vector fields, Differential forms and integration, Lie Groups and Lie Algebras, exponential map, Applications to robotics and computer vision. Tensor products and direct sums. Tensor rank and decomposition, Symmetric and skew-symmetric tensors. Tensor fields and tensor-valued functions,	12	Application of differential geometry in motion planning and deep learning techniques

	Covariant and contravariant tensors. Tensor derivatives and gradients. Tensor Calculus - Tensor integration and differential equations.		

Course Outcome	1. Apply linear algebra in AI. 2. Use calculus for AI optimization. 3. Apply probability and statistics in AI. 4. Utilize optimization techniques in AI.

Learning Resources	• Geron, Aurelien. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow. O'Reilly Media, Inc., 2019. • James, Gareth. Introduction to Statistical Learning. Prentice Hall PTR, 1998. • Strang, Gilbert. Linear Algebra and Learning from data. Wellesley Publishers. • Manfredo Do Carmo. Differential Geometry of Curves and Surfaces. Prentice-Hall of India Pvt Ltd.

Course Code	MC5123N	Course Name	Electronic Design and Simulation	Course Category	PE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	This course develops expertise in Circuit Analysis and Design Fundamentals, Electronic Simulation Proficiency, Analog & Digital Circuit Design and Simulation, PCB Design and Implementation

Module	Syllabus	Duration (class-hour)
1	**Fundamentals of Electronic Circuits:** Basic electronic components (resistors, capacitors, inductors, diodes, transistors), Ohm's law, Kirchhoff's laws, AC and DC circuit analysis, Basic circuit configurations (series, parallel, voltage dividers).	05
2	**Introduction to Electronic Simulation Software:** Overview of popular simulation tools (e.g., SPICE, Multisim, LTSpice), Understanding the simulation environment. Creating and editing circuit schematics, setting up simulation parameters, Analyzing simulation results (voltage, current, waveforms).	06
3	**Analog Circuit Design and Simulation:** Operational amplifiers (op-amps) and their applications, Active filters (low-pass, high-pass, band-pass), Amplifier design, Oscillator circuits, Simulation of analog circuit behavior.	07
4	**Digital Circuit Design and Simulation:** Digital logic gates (AND, OR, NOT, XOR), Combinational logic circuits (multiplexers, decoders), Sequential logic circuits (flip-flops, counters, registers), Microcontroller basics, HDL (Hardware Description Language) basics, Simulation of digital circuit behavior.	07

5	**Printed Circuit Board (PCB) Design:** PCB design fundamentals, PCB layout software, Component placement and routing, PCB fabrication process, Introduction to Gerber files.	06
6	**Advanced Simulation Techniques:** Transient analysis, AC analysis, Noise analysis, Thermal analysis, Worst-case analysis.	05
7	**Applications and Projects:** Design and simulation of electronic circuits for specific applications, Project-based learning to reinforce concepts, Real world application of Electronic design.	06

Course Outcome	1. gain proficiency in electronic circuit design principles. 2. understand and utilize electronic simulation software. 3. develop the ability to analyze and troubleshoot electronic circuits. 4. design and simulate electronic circuits for various applications.

Learning Resources	• Sedra, Adel S., and Kenneth Carless Smith. Microelectronic circuits. Holt, Rinehart and Winston, 2015. • Boylestad, Robert, and Louis Nashelsky. Electronic devices and circuit theory. Prentice Hall, 2014. • Hayes, T.C. and Horowitz, P. Learning the Art of Electronics. 2016 • Rashid, Muhammad H. SPICE for Circuits and Electronics using PSpice. Prentice-Hall, Inc., 1994.

Course Code	MC5124N	Course Name	Industry 5.0	Course Category	PSE	L	T	P
						3	0	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		School of Mechatronics and Robotics		Data Book / Codes/Standards	Nil

Course Objectives	
	· **Introduce** core Industry 5.0 concepts and its societal relevance. · **Explore** key enabling technologies (AI, IoT, Cobots, Digital Twins). · **Apply** human-centric, sustainable, and resilient principles in industrial settings. · **Develop** solutions integrating Industry 5.0 technologies. · **Analyze** the ethical and socio-economic impact of Industry 5.0.

Module	Syllabus	Duration (class-hour)	Module Outcome
1	**Introduction to Industry 5.0 and its Foundations:** Defining Industry 5.0, Historical Context of Industrial Revolutions, Globalization and Emerging Issues	6	Introduce core Industry 5.0 concepts
2	**Key Enabling Technologies of Industry 5.0:** Human-Machine Collaboration (Cobots), Artificial Intelligence (AI) and Machine Learning (ML), Internet of Things (IoT) and Industrial IoT (IIoT), Big Data and Advanced Analytics, Digital Twin and Simulation, Augmented Reality (AR) and Virtual Reality (VR), Additive Manufacturing (3D Printing), Robotics Process Automation (RPA), Next Generation Sensors and Smart Materials	12	Explore key enabling technologies
3	**Core Principles in Practice:** Human-Centricity, Sustainability, Resilience	12	Application in Industry settings
4	**Applications and Impact of Industry 5.0:** Smart Factories and Smart Manufacturing, Industry-Specific Applications, Business	12	Practical solution development

	Model Transformation, Cybersecurity in Industrial Environments		

Course Outcome	1. **Analyze** the foundational principles and historical evolution of Industry 5.0, differentiating it from previous industrial revolutions and recognizing its societal implications. 2. **Evaluate** the role and interconnections of key enabling technologies (e.g., AI, IoT, Cobots, Digital Twins) in driving Industry 5.0 paradigms. 3. **Apply** the core principles of human-centricity, sustainability, and resilience to address contemporary industrial challenges and propose innovative solutions. 4. **Develop** conceptual frameworks for integrating Industry 5.0 technologies and principles within diverse industrial sectors to enhance productivity, well-being, and environmental stewardship. 5. **Assess** the ethical considerations, challenges, and opportunities associated with the implementation of Industry 5.0, contributing to responsible technological adoption and future-oriented decision-making.

Learning Resources	• Nidhya, R., Manish Kumar, S. Karthik, Rishabh Anand, and S. Balamurugan, eds. *Smart Factories for Industry 5.0 Transformation*. John Wiley & Sons, 2025. • Kaswan, Mahender Singh, Rajeev Rathi, and Jose Arturo Garza-Reyes, eds. *Industry 5.0: Concepts and Strategies for Digital Transformation*. CRC Press, 2025. • Elangovan, Uthayan. *Industry 5.0: The future of the industrial economy*. CRC Press, 2021. • Leong, Wai Yie, ed. *Industry 5.0: Design, standards, techniques and applications for manufacturing*, (2024).

Course Code	MC5161N	Course Name	Product Design and Development	Course Category	ESC	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		*School of Mechatronics and Robotics*		Data Book / Codes/Standards	

Course Objective	The course aims at providing the basic concepts of product design, product features and its architecture with a focus on the front end processes. At the end of this course the student is expected to have an understanding of the overview of all the product development processes and knowledge of concept generation and selection tools.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction:** Need for developing products – Strategic importance of Product development – integration of customer, designer, material supplier and process planner, Competitor and customer – Behavior analysis. Understanding customer – prompting customer understanding – involve customer in development and managing requirements – Organization – process management and improvement – Plan and establish product specifications.	05	Understand Product Development and process management
2	**Concept Generation And Selection:** Task – Structured approaches – clarification – search – externally and internally – explore systematically – reflect on the solutions and processes – concept selection – methodology – benefits.	05	Systematic Exploration and Effective Decision-Making
3	**Product Architecture:** Implications – Product change – variety – component standardization – product performance – manufacturability – product development management – establishing the architecture – creation – clustering – geometric layout development – fundamental and incidental interactions – related system level design issues – secondary systems – architecture of the chunks – creating detailed interface specifications.	08	Design Product Architecture and Develop Interface Specifications
4	**Industrial Design:** Integrate process design – Managing costs – Robust design – Integrating CAE, CAD, CAM tools – Simulating product performance and manufacturing processes electronically – Need for industrial design – impact – design process – investigation of for industrial design – impact – design process – investigation of customer needs – conceptualization – refinement – management of the industrial design process – technology driven products – user – driven products – assessing the quality of industrial design.	10	Create User-Driven Robust Design
5	**Design For Manufacturing And Product Development:** Definition – Estimation of Manufacturing cost – reducing the component costs and assembly costs – Minimize system	09	Project planning management and execution

	complexity – Prototype basics – principles of prototyping – planning for prototypes – Economic Analysis – Understanding and representing tasks – baseline project planning – accelerating the project – project execution.		for product development
6	**Advanced Manufacturing Techniques:** 3D Scanning and 3D Printing, Recent Trends in Micro Manufacturing	05	Improve Product Quality:

Course Outcome	1. Apply the principles of product design to modify existing engineering systems or to develop new artifacts. 2. Design a system taking into consideration the concepts of ease of production, maintenance, handling, installation etc. 3. Translate the concepts of economics in design, optimization of design and human factors approach to product design.

Learning Resources	• Eppinger, Steven, and Karl Ulrich. Product design and development. McGraw-Hill Higher Education, 2015. • Pugh, Stuart. Total design: integrated methods for successful product engineering. Addison-Wesley, 1991.

Course Code	MC5171N	Course Name	Mechatronics Laboratory	Course Category	PC	L	T	P
						0	0	3

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		*School of Mechatronics and Robotics*		Data Book / Codes/Standards	

Course Objective	To get accustomed with working of mechatronics systems and hands on experience on Mechatronics system design.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Development of Mechanism using Robot kits and Additive Manufacturing	06	Preparation of STL files and introduction to rapid prototyping
2	Microcontroller programming for motion control and path planning	06	Sensor interfacing for collision detection and collision free path planning for mobile robots
3	Design and Performance analysis of Mechatronics system using MATLAB / 20Sim / AMESim / Fusion 360	09	CAD Modeling and Simulation of mechatronic systems
4	Study of Hydraulic and Pneumatic System and programming using PLC	06	Design of hydraulic and pneumatic circuits and their programming using PLC
5	Study of Virtual Reality environment: programming language, interfacing Haptic devices.	04	Develop virtual reality environment using suitable software
6	Characterization of various Sensors, including Capacitive, Inductive and Strain Gauge	04	Interfacing sensors with mechatronic devices and extracting data using DAQs
7	Study of IoT Device for obtaining various Physiological Signals	07	Analyse physiological signals and access them in real-time remotely using IoT principles

Course Code	MC5172 N	**Course Name**	**Automation and Robotics Laboratory**	**Course Category**	PC	L	T	P
						0	0	3

Pre-requisite Courses	*None*	**Co-requisite Courses**	*None*	**Progressive Courses**	
Course Offering Department		***School of Mechatronics and Robotics***		**Data Book / Codes/Standards**	

Course Objective	To be familiarized with different Sensors, Signal Processing and Actuators for Robotics.

Module	**Syllabus**	**Duration (class-hour)**	**Module outcome**
1	Hardware configuration and Programming of PLC	06	Construction of ladder logics
2	Testing and validation of PLC programming related to motion control	06	Controlling electric actuators using PLC
3	Study on PLC controlled Actuator	06	Controlling hydraulic and pneumatic actuators using PLC
4	Interfacing of sensors with PLC and LabVIEW based HMI platform	03	Design of HMI for sensors
5	Study and demonstration of Automation based system	06	Study and operate industrial automation test benches
6	Hands on working and training on following robotics related hardware and test-beds: 6 - D.O.F. articulated robots.	03	Task planning and execution using 6-axis serial robots
7	Wheeled Mobile and Biped Mobile Robot (NAO) equipped with actuators and different sensors	06	SLAM and path planning using wheeled mobile robots. Operating in a cluttered environment. Task execution using humanoid robots.
8	Testing and validation of developed algorithms related to kinematics, dynamics, navigation, guidance, obstacle avoidance and control, using ROS, GAZEBO, RoboAnalyzer, ADAMS	06	Design navigation algorithms using robot operating systems

Course Code	MC5173 N	Course Name	Control Systems Laboratory	Course Category	PC	L	T	P
						0	0	3

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	To understand real-life control problems and have hands on experience on modeling and control of mechatronic systems.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Step, ramp and Impulse response of first order and second order systems, Time domain analysis for second order systems and identification of damping	06	Identify design parameters of first and second order systems
2	Stability analysis of linear systems using Routh-Hurwitz method and Root Locus	03	Plotting root locus using MATLAB. Analyse system response from root locus diagrams
3	Frequency response analysis using Bode Plot and Polar Plot	03	Study frequency response of first order and second order systems
4	Design of PID Controller for first order and second order systems	06	Design PID controller using MATLAB and study the system response
5	Design of Controller for speed control of DC Motor System, Flexible Beam Structure	06	Speed control of DC motors and single link flexible manipulator
6	Design of PID Based controller for Twin Rotor Multi Input Multi Output System	06	Modelling and control of twin rotor system
7	Design of Controller for stabilization of Rotary Inverted Pendulum	03	Modelling and control of rotary inverted pendulum
8	Temperature control of a Heat Chamber, disturbance study	03	Model dynamics and design controller for Heat Chamber
9	Servo Control of electric drive and pneumatic drive	06	Design controllers for electric and pneumatic drives

Course Code	MC5174N	Course Name	Product Development Laboratory	Course Category	PC	L	T	P
						0	0	3

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		*School of Mechatronics and Robotics*		Data Book / Codes/Standards	

Course Objective	The purpose of this exercise is to generate a knowledge-base among the students for development of mechatronics prototype, using theories studied and laboratories performed earlier. Here the students will have to design and develop a mechatronics system, using an integrated system design approach, from component level to assembly using various tools already available in the school and will submit a report. This will ensure development of knowledge regarding fabrication processes and assembly leading to manufacturing a prototype.

Module	Syllabus	Duration (class-hour)	Module outcome
1	Modelling in CAD Software. Developing 2D schematics for fabrication.	06	3D modelling in CAD
2	Designing driver circuits for actuator interfacing in CAD	06	Use of circuit design software to develop schematics for PCB fabrication
3	Introduction to Embedded programming on Arduino or Raspberry PI boards. Exercises on sensor interfacing and data logging	06	Sensor interfacing using Arduino or Raspberry Pi boards
4	Introduction to 3D printing. Generating STL files and printing parts.	09	Rapid prototyping planar and spatial mechanisms
5	Design and develop a product with proper documentation. Typical products may be: 1. Intelligent Mobile Robot (Wheeled/Hexapod) 2. Smart Orthotic / Prosthetic devices 3. X-Y plotter / Low cost 3D Printer 4. Automatic Vending Machine (using PLC/Arduino) 5. Bio-medical devices 6. Intelligent Gripper 7. Innovative Intelligent Product development 8. Precision motion control of mechanism 9. Vehicle model / Aero Model 10. Any other electro-mechanical intelligent innovative working model	15	A functional full-scale mechatronic device

Course Code	MC5201N	Course Name	Robotics	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		**Data Book / Codes/Standards**	

Course Objective	To introduce the modelling, simulation, and control of spatial multi-degree-of-freedom robotic manipulators. In particular, the student will study the kinematics and dynamics of robotic manipulators, and they will get awareness about the trajectory planning and control of robotic arms.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction:** History of the development of robots, basic components of robotic systems, Anatomy and structural design of robot, manipulation, arm geometry, Drives and control (hardware) for motions, End effectors and grippers.	02	Robot classification and its components
2	**Kinematics:** Translation, orientation of rigid bodies, Representation of links and joints, workspace, velocities, manipulator Jacobian, singularities of robots and mechanisms, Kinematics for serial and parallel manipulators, election of coordinate frames, Homogeneous transformation, DH parameters, Direct and Inverse kinematics: Two link planar serial robot, SCARA, PUMA 560, Stanford arm, and Stewart Platform.	07	DH parameters of a robot. Forward and inverse position analysis. Velocity Jacobians
3	**Dynamics of Robots**: Introduction to robot dynamics, Forward and inverse dynamics of robot manipulators, Rigid link Recursive Acceleration, Lagrange-Euler Dynamic formulation.	07	Forward and Inverse dynamics formulation and implementation in suitable software
4	**Trajectory Planning and Control:** Path planning, trajectory planning, Joint space trajectory planning, Cartesian space trajectory, planning, Continuous trajectory recording (Trajectory following), position, velocity and force control.	04	Task-space and Joint-space trajectory planning. PID and computed torque control of robots
5	**Advanced topics in Robotics:** Wheeled mobile robots, holonomic and non-holonomic constraints. Frenet-Serret frames of reference. SLAM: Localization, Planning, Graph SLAM, Implementing Constraints, Adding Landmarks, Matrix Modification, Untouched Fields, Landmark	10	SLAM and navigation of wheeled mobile robots

	Position, Confident Measurements, Implementing SLAM. Overview of aerial robotics.		
6	**Continuum Robots:** Bioinspiration and applications. Single-backbone, multi-backbone, and concentric-tube robots. Extrinsic and intrinsic actuation. Kinematic modeling: constant curvature assumption, piecewise constant curvature, and Cosserat rod theory. Transfer matrix method. Lagrangian dynamics, model-based and model-free control, static and dynamic control. - Sensing and Feedback - Position sensors: optical trackers, electromagnetic trackers, and embedded sensors - Shape estimation: permanent magnets and magnetic sensors, fiber Bragg grating sensors	07	Analysis and Design of Continuum robots.
7	**Virtual Reality and Haptics:** Virtual reality concepts, virtual world and real world, Interface to virtual world (inputs and outputs), Types of interaction, Applications, Definition of Haptics, Importance of Touch, Tactile Proprioception, Tactual Stereo genesis, Kinesthetic Interfaces, Tactile Interfaces, Human Haptics, Overview of existing applications.	05	Develop virtual reality environment. Analyse and develop haptic interfaces

Course Outcome	1. Identify and formulate the desired robotic design specifications for a particular application 2. Design and simulate the forward and inverse kinematic model 3. Develop and analyse the trajectory planning 4. Model robot dynamics for a given serial robotic manipulator 5. Apply the joint- and Cartesian-based schemes to control the manipulators in different applications. 6. Analyse mobile robot in virtual and real environment

Learning Resources	• Saha, S.K. *Introduction to Robotics, Third edition.* McGrawHill, 2024 • Ghosal, Ashitava. ROBOTICS: Fundamental Concepts and Analysis. Oxford University Press, 2013. • Fu, King Sun, Ralph Gonzalez, and CS George Lee. *Robotics: Control Sensing. Vis*. Tata McGraw-Hill Education, 1987. • Craig, John J. *Introduction to Robotics: mechanics and control, 3/E.* Pearson Education India, 2009. • Spong, Mark W., and Mathukumalli Vidyasagar. *Robot dynamics and control*. John Wiley and Sons, 2008. • Monkam, Gareth. Soft Robotics. Bentham Books.

Course Code	MC5202N	**Course Name**	**Machine Learning in Mechatronics**	**Course Category**	PC	L	T	P
						3	0	0

Pre-requisite Courses	*None*	**Co-requisite Courses**	*None*	**Progressive Courses**	
Course Offering Department		***School of Mechatronics and Robotics***		**Data Book / Codes/Standards**	

Course Objective	To provide an overview on recent developments in machine learning, which covers Supervised and Unsupervised learning techniques, Fuzzy, Neuro, Probabilistic Reasoning and Evolutionary Computation that has been applied in mechatronics.

Module	**Syllabus**	**Duration (class-hour)**	**Module outcome**
1	**Introduction to Machine Learning:** Preliminary of statistical methods, different machine learning techniques, Estimation diagnosis, computational advantages, Optimisation techniques for Machine learning	07	Mathematical preliminaries of machine learning
2	**Supervised learning:** Linear and Multilinear regression, Classification and regression using Support Vector Machines, Decision trees, Random forests **Unsupervised learning**: K-means clustering, Principal Component Analysis, Autoencoders	09	Conventional supervised and unsupervised learning algorithms
3	**Fuzzy Set Theory and Fuzzy Logic System:** Basic concepts in Fuzzy Set theory, Operations of Fuzzy sets, Fuzzy relational equations, Fuzzy inference, Fuzzification, Defuzzification, Decision making logic, Membership functions, Rule base.	06	Development of fuzzy logic controller for mechatronic systems
4	**Introduction to ANN:** Fundamentals of Neural networks, Neural network architectures, Learning methods, multilayer perceptrons, Back propagation algorithm and its variants, Different types of learning. Physics informed Neural Networks:	07	Design neural network based learning algorithms
5	**Reinforcement learning based control: -** Concepts of agents, environments, actions, rewards Markov Decision Processes (MDPs) - Definition and properties of MDPs - Value and policy iteration Dynamic programming: TD learning, Q-learning **- Function Approximation** - Linear function approximation - Deep reinforcement learning **- Least Squares Methods** - Least squares policy iteration - Least squares temporal difference learning	08	Reinforcement learning based controller design for complex dynamical systems

	- Deep Reinforcement Learning - Deep Q-Networks (DQN) - Policy gradient methods - Actor-critic methods		
6	**Implementation in Mechatronics Systems:** Control and learning, navigation, vision, multimedia, and several robotics implementation such as inverted pendulum, autonomous vehicles, and ping-pong robot.	05	Application of machine learning and reinforcement learning in robotic or mechatronics systems

Course Outcome	1. Apply supervised and unsupervised learning techniques to real world datasets for regression and classification 2. Frame optimisation problems on data sets and apply appropriate techniques to solve them 3. Design Fuzzy controllers for robotic systems 4. Use ANN for classification, control and optimization problem. 5. Apply AI techniques on robotic systems for autonomous navigation and control

Learning Resources	• Geron, Aurelien. *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*. O'Reilly Media, Inc., 2019. • James, Gareth. *Introduction to Statistical Learning*. Prentice Hall PTR, 1998. • Strang, Gilbert, Linear Algebra and Learning from data. Wellesley Publishers • Murphy, Kevin. Machine Learning - a Probabilistic Perspective. MIT Press, 2012 • Bishop, Christopher. Pattern Recognition and Machine Learning. Springer, 2006

Course Code	MC5203N	Course Name	Embedded Signal Processing	Course Category	PC	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		*School of Mechatronics and Robotics*		Data Book / Codes/Standards	

Course Objective	To impart knowledge about Microcontrollers, advanced embedded processors. Use Embedded Platform for Signal Processing

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction:** Introduction to Embedded Systems and Signal Processing, Basics of Computer organization.	02	Revision of signal processing and microprocessor
2	**Advanced Embedded Processor:** Overview of embedded computing platforms; ARM Processor, FPGA's and SoC's. GPU (CUDA)	06	Programming of ARM processor based boards and FPGAs
3	**Real Time Operating System:** Introduction to Real-time systems and Real-time Scheduling, OS tasks, different types of scheduling algorithm, Semaphore, Message Queues, Mail Boxes and pipes, Timer Functions, Events, Memory Management, Interrupt.	05	Memory management and real-time task scheduling and management in resource hungry systems
4	**Analog Signal Processing:** Continuous time filters; Single amplifier and multiple amplifier structures and filter parameter sensitivities. Cascade filter. Sampled data filter; Mixed signal circuits; Noise and Interference signals and their reduction; Logarithmic and exponential amplifiers; Voltage controlled oscillator, Phase locked loop.	07	Design of analog filters, amplifiers and phase-locked loops
5	**Digital Signal Processing:** Frequency domain sampling, properties of DFT, Linear filtering methods based on DFT, frequency analysis using DFT, FFT algorithms**;** Design of digital filters; Characteristics of filters, FIR filters, IIR filters from analog filters, DSP processors.	08	Design of IIR and FIR filters, Implementation on DSP processors

7	**Statistical Signal Processing:** Statistical modelling of signals; Spectral factorization; AR, MA and ARMA models; Estimating signal from a mixture; MMSE estimation; Weiner filtering; Least Squares filtering. Bayesian and Kalman filtering.	06	Develop AR, MA and ARMA prediction models
8	**Case Study:** Biomedical Signal Processing	03	Extract physiological signals and build diagnostic models based on various parameters

Course Outcome	1. Learn the programming concept, peripheral interface for embedded processors. 2. Implement the knowledge of processing concept for designing real time signal acquisition.

Learning Resources	• Vahid, Frank, and Tony Givargis. Embedded system design: a unified hardware/software introduction. John Wiley and Sons, Inc., 2001. • Kamal, Raj. Embedded systems: architecture, programming and design. Tata McGraw-Hill Education, 2011. • Liu, J. W.S. Real-Time Systems. Pearson Education, 2000. • Patranabis, D. Sensors and Tranducers. PHI Learning Pvt. Ltd., 2003. • Gajski, Daniel D., Frank Vahid, Sanjiv Narayan, and Jie Gong. Specification and design of embedded systems. Prentice-Hall, Inc., 1994. • Heath, Steve. Embedded systems design. Elsevier, 2002.

Course Code	MC5221N	Course Name	Biomechatronics	Course Category	PE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	To understand the intersection of biology and engineering and develop practical skills in biomechatronic system design.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction to Biomechatronics:** Definition and scope of Bio-mechatronics, Historical evolution and key milestones, Interdisciplinary nature and collaboration with other fields, Human physiology (relevant to biomechatronics), Emerging Trends and Future Directions, Safety, Ethics, and Regulations in Bio-mechatronics	04	Evolution and Emerging trends in biomechatronics
2	**Electronics for Biomechatronics:** Basics of analog and digital electronics, Sensors and actuators in bio-mechatronic systems, Signal conditioning and amplification techniques.	05	Amplification and filtering techniques for physiological signals
3	**Control Systems in Biomechatronics:** Introduction to control systems, Feedback control mechanisms, PID controllers and their applications in bio-mechatronic devices.	05	Control systems for bio-mechatronic systems
4	**Respiratory Aids:** Overview of respiratory aids in biomechatronics, Biomechanical considerations in designing respiratory support devices, Control strategies for optimizing respiratory assistance.	06	Design and control of respiratory support systems
5	**Heart Replacement:** Overview of artificial heart and cardiovascular bio-mechatronics, Biomechanical considerations in designing heart replacement devices, Control strategies for mimicking natural heart functions.	06	Cardio-vascular biomechatronics and design of heart replacement devices
6	**Active and Passive Prosthetic Limbs:** Overview of prosthetic limb technology, Case studies on myoelectric prostheses and biomimetic limbs,	06	Design of prosthetic devices

	Ethical considerations for accessibility and user-centered design.		
7	**Hearing Aids and Implants:** Overview of hearing aid technology and cochlear implants, Case studies on noise reduction algorithms, directional microphones, and wireless connectivity, Ethical considerations for accessibility and affordability.	05	Design of efficient hearing aids
8	**Sensory Substitution and Visual Prostheses:** Introduction to visual prostheses for the visually impaired, Case studies on retinal implants and cortical visual prostheses, Challenges in achieving naturalistic vision.	05	Understanding retinal implants and visual prostheses

Course Outcome	1. Understand application of engineering principles for biological systems. 2. Apply sensors and actuators for bio-interfaces. 3. Implement control for biomechatronic systems. 4. Integrate biomechatronic systems. 5. Evaluate biomechatronic applications.

Learning Resources	• Graham M. Brooker, *Introduction to Biomechatronics*, Institution of Engineering and Technology, 2012. • Jacob Segil, *Handbook of Biomechatronics*, Academic Press, 2018. • Marko B. Popovic, *Biomechatronics*, Academic Press, 2019. • Jorge Garza Ulloa, *Applied Biomechatronics Using Mathematical Models*, Academic Press, 2018.

Course Code	MC5222N	Course Name	Computer Vision	Course Category	PE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		*School of Mechatronics and Robotics*		Data Book / Codes/Standards	

Course Objective	To impart knowledge about foundation in computer vision, apply CV techniques to solve robotics problems, cover classical and deep learning approaches for robot perception.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**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.	08	Mathematical fundamentals of image processing
2	**Depth estimation and Multi-camera views:** Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.	08	Depth perception and calibration
3	**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.	08	Algorithms for feature extraction
4	**Image Segmentation:** Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.	09	Algorithms for image segmentation
5	**Pattern Analysis:** Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods.	09	Algorithms for pattern recognition from images

Course Outcome	1. Understand the challenges and constraints of applying computer vision in robotics. 2. Implement fundamental image processing techniques for robot vision tasks. 3. Apply classical computer vision methods such as feature detection and description, camera geometry, and 3D vision to solve robotics problems. 4. Design and train deep learning models for robot perception tasks, including image classification, object detection, and image segmentation. 5. Develop and implement computer vision solutions for specific robotics applications, including robot navigation, manipulation, and human-robot interaction.

Learning Resources	• Szeliski, Richard**.** *Computer Vision: Algorithms and Applications*. 2nd ed. London: Springer, 2022. • Forsyth, David A., and Jean Ponce**.** *Computer Vision: A Modern Approach*. 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2011. • Gonzalez, Rafael C., and Richard E. Woods**.** *Digital Image Processing*. 4th ed. Boston: Pearson, 2018. • Hartley, Richard, and Andrew Zisserman. *Multiple View Geometry in Computer Vision*. 2nd ed. Cambridge: Cambridge University Press, 2004. • Kaehler, Adrian, and Gary Bradski. *Learning OpenCV 3: Computer Vision in C++ with the OpenCV Library*. Sebastopol, CA: O'Reilly Media, 2016.

Course Code	MC5223N	**Course Name**	**Biomedical Instrumentation**	**Course Category**	PE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	**Co-requisite Courses**	*None*	**Progressive Courses**	
Course Offering Department		***School of Mechatronics and Robotics***		**Data Book / Codes/Standards**	

Course Objective	To impart knowledge about analysing bio-signals, Design biomedical systems, Select instrumentation, Evaluate device performance and Understand regulations & ethics.

Module	**Syllabus**	**Duration (class-hour)**	**Module outcome**
1	**Physiological Signals and Sensors:** Foundations of Biomedical Signals, Biosensors and Transducers, Biopotential and Bioimpedance Measurements, Sensor Calibration and Characterization	05	Fundamentals of biological signal measurement
2	**Biomedical Signal Processing:** Analog Signal Processing, Digital Signal Processing (DSP) Fundamentals, Feature Extraction and Pattern Recognition, Data Compression and Storage	07	Data compression and storage techniques for biological signals
3	**Biomedical Instrumentation Systems:** Data Acquisition Systems, Microcontroller-Based Biomedical Instruments, Patient Monitoring Systems, Medical Imaging Systems Introduction	08	Development of data acquisition systems and medical imaging techniques
4	**Therapeutic and Assistive Devices:** Cardiac Devices, Prosthetics and Orthotics, Drug Delivery Systems	09	Analysis of prosthetics and drug delivery systems
5	**Medical Imaging and Diagnostics:** Advanced Medical Imaging, Nuclear Medicine and Optical Imaging, Computer Aided Diagnostics	09	Advanced medical imaging techniques
6	**Safety and Ethical Considerations:** Electrical Safety and Biocompatibility, Regulatory Standards and Guidelines, Ethical Considerations	04	Understanding ethical guidelines related to medical devices

Course Outcome	
	1. Apply the principles of biomedical instrumentation to analyze and interpret physiological signals. 2. Design and implement biomedical instrumentation systems for diagnostic and therapeutic applications. 3. Evaluate and select appropriate sensors, transducers, and signal processing techniques for specific biomedical measurements. 4. Demonstrate an understanding of the safety and ethical considerations related to biomedical instrumentation. 5. Conduct research and development in the field of biomedical instrumentation.

Learning Resources	
	• Cromwell, Leslie, Fred J. Weibell, and Erich A. Pfeiffer. *Biomedical Instrumentation and Measurements*. Prentice Hall, 1980. • Webster, John G., and Clark, Malcolm. *Medical Instrumentation: Application and Design*. Wiley, 2022. • Khandpur, R. S. *Handbook of Biomedical Instrumentation*. McGraw Hill Education, 2014. • Reddy, D.C. *Biomedical Signal Processing: Principles and Techniques*. Tata McGraw-Hill, 2005. • Zhu, Yongmin. *Digital Signal Processing for Medical Imaging.* Academic Press, 2011.

Course Code	MC5224N	Course Name	MEMS	Course Category	PE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	To impart knowledge about foundational understanding of MEMS principles and microfabrication, introduce essential design and simulation tools, familiarize students with basic characterization techniques and to enable students to design and simulate a simple MEMS device.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction to MEMS and Microfabrication Fundamentals:** Introduction to MEMS: History, applications, scaling laws. Cleanroom basics, photolithography principles and materials, Etching techniques (wet and dry): fundamentals and process control, Thin film deposition (sputtering, CVD): principles and applications.	09	Fundamentals of MEMS, basics of material deposition
2	**Materials and Mechanics of MEMS:** Silicon, polymers, metals, and piezoelectric materials, Elasticity, stress, and beam theory, Vibration and resonance in microstructures, Fluid and thermal effects in micro-systems.	09	Mechanical analysis of MEMS
3	**MEMS Design and Simulation:** Introduction to CAD tools (e.g., simplified introduction to a tool), Finite element analysis (FEA) basics for mechanical simulations, Electrostatic actuator design and simulation, Sensor design principles and basic simulation.	12	MEMS based sensor and actuator design
4	**MEMS Characterization and Basic Applications:** Optical microscopy and SEM introduction, Basic electrical characterization, Introduction to MEMS sensor and actuator applications.	12	Electrical characterisation of MEMS devices and its applications as sensors

Course Outcome	1. Understand MEMS fundamentals and microfabrication. 2. Apply materials and mechanics principles to MEMS. 3. Design and simulate basic MEMS devices. 4. Perform basic MEMS characterization and understand applications.

Learning Resources	• Hsu, Tai-Ran. *MEMS & Microsystems: Design, Manufacture, and Nanoscale Engineering*. Hoboken, NJ: John Wiley & Sons, 2008. • Hsu, Tai-Ran. *Microfabrication and Micromachining*. New York: John Wiley & Sons, 2005. • Bao, Minhang. *Analysis and Design Principles of MEMS Devices*. Amsterdam: Elsevier, 2005. • Senturia, Stephen D. *Microsystem Design*. Boston: Kluwer Academic Publishers, 2001. • Masters, Barry P. *Practical MEMS Packaging*. Boston: William Andrew Publishing, 2010. • Wang, Wanjun. *BioMEMS*. Boca Raton, FL: CRC Press, 2006.

Course Code	MC5261N	Course Name	Artificial Intelligence for Robotics	Course Category	OE	L	T	P
						3	0	0

Pre-requisite Courses	*None*	Co-requisite Courses	*None*	Progressive Courses	
Course Offering Department		***School of Mechatronics and Robotics***		Data Book / Codes/Standards	

Course Objective	To provide an overview on recent developments in machine learning, which covers Supervised and Unsupervised learning techniques, Fuzzy, Neuro, Probabilistic Reasoning and Evolutionary Computation that has been applied in mechatronics.

Module	Syllabus	Duration (class-hour)	Module outcome
1	**Introduction to Machine Learning:** Preliminary of statistical methods, different machine learning techniques, Estimation diagnosis, computational advantages, Optimisation techniques for Machine learning	07	Mathematical preliminaries of machine learning
2	**Supervised learning:** Linear and Multilinear regression, Classification and regression using Support Vector Machines, Decision trees, Random forests **Unsupervised learning**: K-means clustering, Principal Component Analysis, Autoencoders	09	Conventional supervised and unsupervised learning algorithms
3	**Fuzzy Set Theory and Fuzzy Logic System:** Basic concepts in Fuzzy Set theory, Operations of Fuzzy sets, Fuzzy relational equations, Fuzzy inference, Fuzzification, Defuzzification, Decision making logic, Membership functions, Rule base.	06	Development of fuzzy logic controller for mechatronic systems
4	**Introduction to ANN:** Fundamentals of Neural networks, Neural network architectures, Learning methods, multilayer perceptrons, Back propagation algorithm and its variants, Different types of learning.	07	Design neural network based learning algorithms
5	**Re-inforcement learning based control: -** Concepts of agents, environments, actions, rewards Markov Decision Processes (MDPs) - Definition and properties of MDPs - Value and policy iteration Dynamic programming: TD learning, Q-learning **- Function Approximation** **-** Linear function approximation - Deep reinforcement learning **- Least Squares Methods** - Least squares policy iteration - Least squares temporal difference learning **- Deep Reinforcement Learning** - Deep Q-Networks (DQN)	08	Re-inforcement learning based controller design for complex dynamical systems

	- Policy gradient methods - Actor-critic methods		
6	**Implementation in Mechatronics Systems:** control and learning, navigation, vision, multimedia, and several robotics implementation such as inverted pendulum, autonomous vehicles, and ping-pong robot.	05	Application of machine learning and re-inforcement learning in robotic or mechatronics systems

Course Outcome	1. Apply supervised and unsupervised learning techniques to real world datasets for regression and classification 2. Frame optimisation problems on data sets and apply appropriate techniques to solve them 3. Design Fuzzy controllers for robotic systems 4. Use ANN for classification, control and optimization problem. 5. Apply AI techniques on robotic systems for autonomous navigation and control

Learning Resources	• Geron, Aurelien. *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*. O'Reilly Media, Inc., 2019. • James, Gareth. *Introduction to Statistical Learning*. Prentice Hall PTR, 1998. • Strang, Gilbert, *Linear Algebra and Learning from data*. Wellesley Publishers. • Murphy, Kevin. *Machine Learning a Probabilistic Perspective*. MIT Press, 2012. • Bishop, Christopher. *Pattern Recognition and Machine Learning*. Springer, 2006.

Course Code	MC5262N	Course Name	Codes and Standards for Professionals	Course Category	VAC	L	T	P
						3	0	0

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		School of Mechatronics and Robotics		Data Book / Codes/Standards	Nil

Course Objectives	
	1. Familiarize students with relevant industry codes and standards. 2. Enable students to apply code requirements to real-world scenarios. 3. Equip students to ensure compliance with codes and standards in their profession. 4. Train students to analyze the implications of codes and standards on design, implementation, and maintenance.

Module	Syllabus	Duration (class-hour)	Module Outcome
I	**Introduction to Codes and Standards:** History and Evolution of Standards, The Standards Ecosystem, Overview of Key Standards Organizations	6	Define and differentiate between various types of engineering standards.
II	**Standards Development and Harmonization:** The Standards Development Process, Principles of Good Standardization Practice, Harmonization and Mutual Recognition, Case Studies in Standards Development	8	Explain the importance and benefits of using standards in engineering practice.
III	**Types of Engineering Standards and Their Applications:** Quality Management Standards (ISO 9000 Family) , Environmental Management Standards (ISO 14000 Family) , Occupational Health and Safety Standards (ISO 45000 Family), Electrical and Electronic Standards, Mechanical Engineering Standards, Civil Engineering and Construction Standards,	12	Apply relevant standards to solve engineering problems and make informed design decisions.

	Software and IT Standards , Industry-Specific Standards e.g. Aerospace (AS9100), Automotive (IATF 16949), Medical devices (ISO 13485)		
IV	**Legal and Ethical Aspects of Standards:** Standards and the Law, Intellectual Property Rights and Standards, Ethics in Standards Application	8	Understand the legal and ethical implications of non-compliance with standards
V	**Practical Application and Future Trends:** Navigating and Interpreting Standards Documents, Standards in Design and Manufacturing, Emerging Trends in Standardization, Case Studies and Project Work	8	Navigate and effectively utilize standards documents and resources

Course Outcome	1. Apply relevant codes and standards to professional practice. 2. Ensure compliance with industry codes and standards in design, implementation, and maintenance. 3. Analyse the implications of codes and standards on professional decisions. 4. Develop solutions that meet code requirements and standards.

Learning Resources	1. Jawad, Maan H., and Owen R. Greulich. *Primer on engineering standards*. John Wiley & Sons, 2018. 2. Khan, Wasim Ahmed, and Abdul Raouf SI. *Standards for engineering design and manufacturing*. CRC Press, 2005. 3. BIS Web Resource