ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 25
Syllabi for School of Mechanical Engineering Programmes

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

School of Mechanical Engineering

Professional Core Course

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MAC501T	Course Name	COMPUTATIONAL METHODS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mathematics*	**Data Book / Codes / Standards**		*Statistical Tables*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the concept of one dimensional wave equations and diffusion equation*
CLR-2:	*construct Fourier series for periodic functions and transform technique to solve elliptic equation*
CLR-3:	*understand the concepts of Euler's equations*
CLR-4:	*identify numerical technique to solve algebraic transcendental equations, ODE and PDE*
CLR-5:	*infer the concepts of probability, correlation and regression*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain analytical solution of partial differential equation*	*3*	*3*	
CO-2:	*justify the solution of elliptic type PDE and periodic functions*	*3*	*3*	
CO-3:	*evaluate the solution of functional and vibrational problems*	*3*	*3*	
CO-4:	*adapt numerical solutions for algebraic, transcendental, ODE and PDE*	*3*	*3*	
CO-5:	*solve Statistical problems related to day to day life*	*3*	*3*	

Module-1 - Transform Techniques	***12 Hour***
Laplace transform - Fourier transform - One-dimensional wave equation using Laplace transform methods - Displacements in long string - Longitudinal vibration of an elastic bar - One -dimensional diffusion equation using Fourier transform methods – One-dimensional diffusion equation using Fourier sine transform methods – One-dimensional diffusion equation using Fourier cosine transform methods. .	
Module-2 - Fourier Series and Elliptic Equation	***12 Hour***
Fourier series representation of periodic functions - Fourier transform methods for Laplace equation.	
Module-3 - Calculus of Variations	***12 Hour***
Euler's Equations - Functional involving x, y, y' - Functional on higher order derivatives - Functional dependent on functions of independent variables - Rayleigh-Ritz method.	
Module-4 – Numerical Methods	***12 Hour***
Solution of algebraic and transcendental equations-Iteration method-Newton's method- solution to ODE- Runge Kutta method of 4th order- Milne's predictor corrector method. Solution to PDE- Solution to Laplace equation-Leibman's method- Solution to Poisson equation- Solution to Parabolic type PDE- Bender Schmidt method-Crank Nicholson method.	
Module-5 - Statistical Techniques	***12 Hour***
Random Variables –Discrete and continuous random variables-Mean, median, variance, Standard deviation, moments, skewness, kurtosis, correlation, regression, coherence, multiple and partial correlation.	

Learning Resources	1. *Sankara Rao, K., "Introduction to Partial Differential Equations", PHI, New Delhi, 3rd edition 2011.* 2. *B .V. Ramana, "Higher Engineering Mathematics", McGraw Hill Publication, 2017.* 3. *Elsgolts, L., "Differential Equations and Calculus of Variations", Mir Publishers, Moscow, 2013.*	4. *S. S. Sastry, Introductory Methods of Numerical Analysis, 5thEdition, PH1, 2012* 5. *S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 11th Edition, 2015.* 6. *S. Ross, A First Course in Probability, 8th Edition., Pearson Education India, 2010.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Madhan Shanmugasundaram, Infosys Technologies, madshan@gmail.com*	*1. Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in*	1. *Dr. V. Subburayan, SRMIST*
	2. *Prof. K.C. Sivakumar, IIT Madras, kcskumar@iitm.ac.in*	*2. Dr. P.Sambath. SRM IST*

ACADEMIC CURRICULA

Mechatronics Engineering

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MHC501J	Course Name	ADVANCED SYSTEM DYNAMICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*21MHE522J*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*model the different dynamics systems*
CLR-2:	*apply linearization on non-linear systems*
CLR-3:	*understand various conditions for stability of dynamic systems*
CLR-4:	*design fully state feedback control system*
CLR-5:	*impart knowledge on advanced controls*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*model any type of dynamics system*	2		3
CO-2:	*convert non-linear system into linear system*	2	2	3
CO-3:	*analyze the stability of system under different conditions*	2	3	
CO-4:	*design a control system in a state format*			3
CO-5:	*familiarize the advanced controls*			3

Module-1 – Modeling of the Systems	***15 Hour***
Modeling in time and frequency domain, Transfer function modeling, EOM of Mechanical, Electrical using force/torque balance, State space modeling, Different forms of state space modeling, Diagonal and Jordan Canonical Form, Model representation using Block Diagram, Signal flow graphs, EOM of Mechanical system using Lagrangian Mechanics	
Module-2 – Advanced Modeling and Non-Linear Systems	***15 Hour***
Introduction to system identification and concepts, Examples for parametric and non-parametric methods, Bias, consistency and model approximation, A degenerative experimental condition, the influence of feedback, Introduction to non-parametric methods and linear regression, linearization of non-linear system using graphical approach, Taylor Series and Jacobian Approach.	
Module-3 – Control System and Stability	***15 Hour***
Introduction to open loop and closed loop control system, order and type of system, PID control, Introduction to stability, Lyapunov stability criterion, Routh Hurwitz Criterion, Root Locus, Bode plot	
Module-4 – State Space Representation of Systems	***15 Hour***
State space representation of mechanical and electrical systems, Observability and controllability, Effect of condition number on controllability, Full state feedback (FSF) control, FSF using Pole placement, observer design, Pole placement using Ackermann's Formula	
Module-5 – Advanced Controls	***15 Hour***
Linear quadratic regulator, Kalman Filter and its types, Neural Networks, Artificial Neural networks. Fuzzy logic controllers.	

Learning Resources	*1. Dorf and Bishop, "Modern Control Systems", 12th Edition, Prentice Hall Publication* *2. Ogata, K., System Dynamics, 4th Edition, Prentice-Hall, 2004.* *3. Vu, Hung V, Ramin S. Enfandiari. System Dynamics, McGraw-Hill, 1997* *4. Mukherjee and Karmarkar, "Modelling and Simulation of Engineering Systems Through Bond graphs", Alpha Science Intranet Publisher, 2000.* *5. P. P. J. van den Bosch and A. C. van der Klauw, "Modeling, Identification and Simulation of Dynamical Systems", CRC Press, 1994.*	*6. Soder storm T and Peter Stoica, "System Identification", Prentice Hall International, 1989.* *7. Simon Haykin (Ed)," Kalman Filter and Neural Networks", John Wiley & Sons Publication, 2001.* *8.. Tsoukalas and Robert Uhrig, "Fuzzy & Neural Approach in Engineering", John Wiley* *9. "System dynamics and control Laboratory Manual", Mechatronics Engineering, SRMIST*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.. Dr. K. Karthikeyan, R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore	*1. Dr.KS Balamurugan, Professor and Head, Electronics and Communication Engg , Karpaga Vinayaga College of engineering and technology, Chengalpet. drksbalamurugan@kveg.in*	*1. Dr.M.Mohamed Rabik, SRMIST*
2. Dr.K.P.Srinivasan, Principal Engineering, Mahindra and Mahindra.	*3. Dr.Manikandan, Associate Professor, TCE.Madurai.*	*2. Dr.Fouziya Sulthana, SRMIST*

Course Code	21MHC502P	Course Name	ELEMENTS OF MECHATRONICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							1	0	6	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore various mechanisms and design principles*
CLR-2:	*acquire knowledge in the domain of electrical and electronic circuit design for control application*
CLR-3:	*attain knowledge in the domain of sensor integration and actuator control*
CLR-4:	*acquire knowledge in the area of microcontroller architecture, operation and programming*
CLR-5:	*understand the principles of control systems, system integration and their components*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply basic mechanical design principles.*	*3*		*3*
CO-2:	*apply the knowledge of electrical and electronics design for control of mechanisms*	*3*		*3*
CO-3:	*employ sensors and actuators in real-world mechatronics systems.*	*3*		*3*
CO-4:	*interface and program sensors and actuators with microcontrollers using various communication protocols*	*3*		*3*
CO-5:	*integrate, control and analyze mechatronics systems*	*3*		*3*

Module-1 – Fundamentals of Mechanical Systems	***8 Hour***
Introduction to mechanisms and types, Degree of freedom of mechanism, Mechanical components and transmission elements: gears, pulleys, cams, levers, belts etc., Manufacturing process, Motion analysis of mechanisms, Dynamics of mechanical systems (force, torque, motion equations), Mechanical Design principles: material selection and properties, safety factors and design criteria *Project Component: Design a simple mechanical system (e.g., a gear train or linkage mechanism) and analyze its kinematics and dynamics*	
Module-2 – Basics of Electrical and Electronics Systems	***8 Hour***
Basic electrical quantities (voltage, current, resistance, power), Ohm's Law and Kirchhoff's Laws, AC vs. DC circuits, Passive components: resistors, capacitors, inductors, Active components: diodes, transistors, operational amplifiers, Basic circuit configurations (series, parallel), Analog and digital circuits, Introduction to circuit simulation tools, Power supplies and voltage regulation, Motor drivers and control circuits *Project Component: Modelling systems using mechanical and electrical analogies, Design of an electronics control circuit for actuator control of the mechanism and its simulation*	
Module-3 – Sensors and Actuators	***10 Hour***
Introduction to Sensors: Types of sensors: position, velocity, acceleration, temperature, pressure, etc. , Sensor characteristics (sensitivity, range, accuracy, etc.), Interfacing and signal conditioning, Introduction to Actuators: Types of actuators: electric motors, hydraulic and pneumatic actuators, solenoids, Actuator characteristics (torque, speed, efficiency, etc.), Control methods and interfacing , Applications and Case Studies: Practical applications of sensors and actuators in mechatronics systems, Case studies of sensor and actuator integration *Project Component: Interface a sensor and actuator with a microcontroller and demonstrate a basic control system (defined for the selected mechanism)*	
Module-4 – Microcontrollers and Programming	***10 Hour***

Microcontroller Basics: Architecture and operation of microcontrollers, Overview of popular microcontrollers (Arduino, PIC, STM32, etc.), Programming Fundamentals: Basics of C/C++, python programming, Digital and analog I/O programming, Timer and interrupt programming, Communication Protocols: Serial communication (UART, SPI, I2C) Wireless communication (Bluetooth, Wi-Fi), Embedded Systems Development: Development environments (IDEs), Debugging and troubleshooting techniques
Project Component: Develop an algorithm to integrate the sensor and actuator for a defined mechanism control
Module-5 – Control Systems and System Integration ***9 Hour***
Introduction to Control Systems: Open-loop and closed-loop control, Transfer functions and block diagrams, Control System Components: Feedback sensors and controllers ,Actuators and control elements, PID Control: Proportional, Integral, Derivative control theory, Tuning and implementation of PID controllers, System Integration: Combining mechanical, electrical, and control elements, Interfacing hardware and software components , System Modeling and Analysis: Mathematical modeling of dynamic systems , Stability analysis, Simulation using MATLAB/Simulink
Project Component: Integrate, Implement and test a comprehensive mechatronics system

Learning Resources	1. *Godfrey C. Onwubolu, "Mechatronics: Principles and Applications", Butterworth-Heinemann, Year: 2005* 2. *David G. Alciatore and Michael B. Histand, "Introduction to Mechatronics and Measurement Systems, McGraw-Hill Education, 2012* 3. *Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall, 2010*	4. *Clarence W. de Silva, "Sensors and Actuators: Engineering System Instrumentation", CRC Press, 2015* 5. *Paul Horowitz and Winfield Hill, "The Art of Electronics", Cambridge University Press, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of unit test (20%)		CLA-2 Project Based Learning (60%)		Report and Viva Voce (20% Weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	20%	-	20%	-	-
Level 2	Understand	20%	-	-	20%	-	20%	-	-
Level 3	Apply	30%	-	-	30%	-	30%	-	-
Level 4	Analyze	30%	-	-	30%	-	30%	-	-
Level 5	Evaluate	-	-	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100%			

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Mohammed Sagheer, Wabco Technology Center, ohammedsagheer.musthafa@wabco-auto.com*	1. *Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	1. *Dr. Ranjith Pillai R, SRMIST*
2. *Mr. N. Ganesh Ram,Co-Founder and Director of Aerospace Division, Tunga Aerospace Industries Pvt. Ltd.*	2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2.Dr. Vimala Starbino ,SRMIST*

Course Code	21MHC503J	Course Name	DRIVES AND ACTUATORS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the fluid power actuators concepts for mechatronics systems design.*
CLR-2:	*incorporate control and regulating concepts in fluid power actuators to automate a process.*
CLR-3:	*translate and simulate a real time activity using modern concepts and tools.*
CLR-4:	*introduce the benefits of electrical and smart actuators in automation.*
CLR-5:	*identify suitable control methods for electrical actuators for the specific application.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*selection fluid power actuators concepts for automation.*		2	
CO-2:	*analyze suitable control and regulating concepts in fluid power actuators to automate a process.*		2	
CO-3:	*able to translate and simulate a closed loop control logic using modern tools*		2	
CO-4:	*analyze the benefits of electrical and smart actuators in automation.*		2	
CO-5:	*analyze suitable control methods for electrical actuators for the specific application.*		2	

Module-1 – Need and Concepts of Fluid Power Actuators	***15 Hour***
Need for automation - Block diagram representation of drives - Classification of hydraulics, pneumatics and electrical; Introduction to pneumatics, rotary compressor- Construction and principle of operation - Gear pump and piston pump; FRL Unit; Flow Control Valves - Simple and pressure compensated flow control valve - Speed control circuits concept - Meter-in, Meter-out, Bleed-off circuit - Selection of fluid power actuators - Cylinder specifications - check valve and one way flow control valve - Time delay valve and quick exhaust valve; Accumulators- Principle and applications; Types of accumulators *Lab 1: Introduction to Pneumatic lab components, software (Fluid SIM and Automation studio);* *Lab 2: Speed control circuits with direct and indirect control;* *Lab 3: Continuous reciprocation of single acting and double acting cylinder*	
Module-2 – Control of Fluid Power Actuators	***15 Hour***
3/2, 5/2, 5/3 direction control valves - Construction and principle of operation; Neutral positions - Direct control circuit for single and double acting cylinder - Indirect control circuit for single and double acting cylinder - Need for Electro pneumatics - Relay, Solenoids, Latching circuit - Sequencing circuit using pneumatics with application circuit - *Sequencing circuit using Electro-pneumatics with application circuit - Concepts of signal overlapping - Methods to overcome fighting signal - Cascading circuits for two groups using pneumatics with application circuit - Cascading circuits for two groups using electro pneumatics with application circuit - Cascading circuits for three groups using pneumatics - Cascading circuits for three groups using electro pneumatics* *Lab 4: Sequencing circuits for two and three cylinders using pneumatics* *Lab 5: Electro pneumatic solution for sequence circuit* *Lab 6: Cascading circuits for two groups using pneumatics*	

Module-3 - Design of Fluid Power Actuators	***15 Hour***
logical valves: Shuttle valve and dual pressure valve with application circuit - Simple Pressure relief valve and compound pressure relief valve - Pressure unloading and counter balance with application circuit - Pressure reducing valve with application circuit - Pressure compensated flow control valve with application circuit - Timers and counters application circuit - Proportional valve - Servo valve – Closed loop pneumatics with PID control and status controller - Design and selection of components of hydraulic machine tools - Design and selection of components of articulated mechanisms *Lab 7: Cascading circuits for three groups using pneumatics* *Lab 8: Cascading circuits for two groups using electro-pneumatics* *Lab 9: Closed loop servo pneumatics circuits*	
Module-4 – PLC and Electrical Actuators	***15 Hour***
Introduction to Programmable logic controller (PLC) - PLC advantages, applications - Architecture and parts of PLC - PLC I/O modules - Introduction to PLC programming – types Logic gates, timers and counters - Simulation with application - PLC interlocking with application circuit - Ladder logic Sequential circuits with simulation - Electrical actuators - Basic construction and principles - Basic construction of stepper, servo, PMDC and BLDC motor - Servo motor position and velocity control - Stepper motor position control *Lab 10: PLC Logic gates, timers and counters* *Lab 11: Developing PLC circuit for sequencing of pneumatic cylinder* *Lab 12: Real time PLC control*	
Module-5 – Control of Electrical Actuators	***15 Hour***
Selection of electrical drives - Drive specifications - Direction and Speed of control of DC electrical drives with application circuit - Speed of control of AC electrical drives with application circuit - Closed loop control of DC drives with application circuit - Closed loop control of AC drives with application circuit - V/F drives using PWM with application program - Slip power recovery system with application circuit - Position control for BLDC motor with application circuit - Position control for switched reluctance motor with application circuit *Lab 13: Stepper motor position and velocity control* *Lab 14: Servo motor position and velocity control* *Lab 15: Computerized control on electrical actuators*	

Learning Resources	*1. Anthony Esposito, "Fluid Power with applications", Pearson New International Edition, 7th edition, 2014.* *2. Majumdar .S.R., "Oil Hydraulics: Principle and Maintenance", Tata McGraw Hill Education, 2012.* *3. Thomson, "Introduction to Fluid power", Prentice Hall, 2004..*	*4. N.P. Bali and Manish Goyal, A textbook of Engineering Mathematics, Laxmi Publications, New Delhi, 10th edition,2016.* *5. Kandasamy P., etal. Engineering Mathematics, Vol.II & Vol.III (4th revised edition), S. Chand & Co., New Delhi,2000*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. K.P. Srinivasan, Mahindra and Mahindra, p.srinivasan2@mahindra.com	*1. Prof. M.R. Ramesh, NIT Surathkal, rameshmr@nitk.edu.in*	*1. Dr. T. Muthuramalingam, SRMIST*
2. Mr. C. Ellanchezhiyan, Keyence Microscope ellanchezhian@gmail.com	*2. Dr. P. Karthikeyan, MIT, Anna University, pkarthikeyan@mitindia.edu*	*2. Dr. M. Santhoshrani, SRMIST*

Course Code	21MHC504J	Course Name	MECHATRONICS SYSTEM DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the design challenges involved in multidisciplinary modern machines*
CLR-2:	*familiarize the mechatronics approach design process and its benefits*
CLR-3:	*understand the importance of modeling and develop model-based design framework*
CLR-4:	*develop models of different abstractions for various key elements of mechatronics systems and select them wisely*
CLR-5:	*understand and apply the real time mechatronics design approach for real systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recognize the integrated design issues associated with the multidisciplinary modern machines and systems and learn the mechatronics concepts, design processes and benefits*		2	
CO-2:	*develop and analyze the mathematical models of various key elements of mechatronics system and select them appropriately with a critical eye.*		2	
CO-3:	*develop a model-based framework for the concurrent design, analysis and integration of various subsystems and as a system overall and to arrive at an overall optimal synergistic design of system for further prototyping.*		2	
CO-4:	*conduct real-time analysis through RCP/HIL knowing its benefits*			3
CO-5:	*apply mechatronics design approaches for a product development*			3

Module-1 – Introduction to Mechatronics Design Process and MBSE	***15 Hour***
Definition of mechatronics, Evolution of electromechanical systems and issues - Multidisciplinary nature of modern machines and their design challenges - Traditional vs mechatronics approach - Mechatronics design process, Need for design tools integration - Concurrent development vs Model Based System Engineering (MBSE), Necessity of System Engineering - System engineering process - System lifecycle -Modeling and analysis of system requirements - System requirements Management. Structural/Architectural modeling - Behavioral Modeling -The detailed V-based mechatronics design process-integrated product design - The importance of modeling of systems at different abstraction levels through various development stages -Virtual/digital Prototyping -MIL, SIL, Real-time Hardware-In-Loop simulation (HIL) *Lab 1: Creating specifications, requirements, architectural and behavioral model of a system in system composer* *Lab 2: Developing a virtual prototype of Rotary Indexing table and validating the same by building actual prototype* *Lab 3: Developing physical models of systems from scratch and obtaining the physical model by importing the CAD model*	
Module-2 – Sensing and Data Acquisition Elements-Modelling and Selection	***15 Hour***
Detection and measurement elements-modeling and selection - Sensor performance characteristics - Measurement error types - Sensor sizing and selection procedure Analog measurement and detection instruments- position, velocity and acceleration measurement - Force and torque measurement - Flow measurement, Pressure and level measurement -Temperature measurement -Smart sensors and Nano sensors -Binary instruments- Limit switches -Photo electric, RFID based detection and pressure switches Signal conditioning -Signal conversion -Data transmission system *Lab 4: Mathematical modeling and analysis of sensing, data acquisition and transmission elements and selection of the same for a given system*	

Lab 5: Quadrature Decoding of an incremental encoder *Lab 6: Closed loop Control of mobile robot*
Module-3 - Drive and Actuating Elements- Modelling and Selection ***15 Hour***
Electrical driven actuating systems - DC motor dynamics and modeling - AC motor dynamics modeling - Stepper motor modeling - Electrical motor sizing and selection - Motion profile, load torque calculation, load torque speed characteristics and matching motor and load speed-torque curves- Modeling mechanical transmission elements - Modeling electro-fluidic transmission elements - Sizing of hydraulic of motion system components - Linear dynamic model of 1-axis hydraulic motion - Non-linear dynamic model of 1-axis hydraulic motion - Open center hydraulic system, force -speed modulation curves - Modeling of electro-thermal transmission elements - Control requirements of heating - Electrical binary actuators modeling *Lab 7: Mathematical modeling and analysis of drive and actuation elements for Active Suspension systems* *Lab 8: Mathematical modeling and analysis of drive and actuation elements for Antilock braking systems* *Lab 9: Model based design and control of One degree of freedom pitch control (VTOL) / One degree of rotary inverted pendulum / quad copter*
Module-4 – Model Based Concurrent Development ***15 Hour***
Concurrent development of both plant and ECU in a unified model-based framework - Overall system level modeling through virtual prototyping, topological/physical modeling Model-In-Loop simulation at different abstraction levels - Control technique selection criteria for the application at hand and its realization - Logic control, analog, linear, non-linear and optimal control techniques Selection criteria for physical controllers- Custom digital hardware, microprocessor/microcontroller/DSP, PLC, PAC and PC - Custom design of logic controller- design considerations - Design example - PLC based discrete control-design considerations - Design example - Analog and digital PID control- Introduction to optimization in control- constrained control, minimum time control - LQR, sliding mode control - Discrete control methods, Concluding remarks on model-based system design and optimization *Lab 10: Electro-fluidic motion control system with PLC in loop* *Lab 11: Introduction to hardware in loop simulation* *Minor project- Discussion and Review*
Module-5 – Real-Time Constraints and Analysis of Mechatronics Systems ***15 Hour***
Need for real-time interfacing and test methods in verification and validation - Real-time interfacing requirements- recap - Rapid Control Prototyping (RCP) - Need/requirements for RCP - Experimental set-up for RCP - Selection of appropriate control strategies through RCP - Selection of appropriate control strategies through RCP - Real-time Hardware-in-Loop (HIL) simulation - Testing in HIL - Practical considerations of HIL - System performance evaluation techniques - The final mechatronics design framework of selected case studies - Need for Test-cell and field testing - Product Life cycle management and optimization *Minor project- Discussion and Review* *Minor project- Final Submission, Competition and Evaluation*

Learning Resources	1. *Patrick Kaltjob, "Mechatronics Systems and Process Automation- Model-Driven Approach and Practical Design Guidelines", CRC Press, 2018* 2. *Sabri Centinkunt, "Mechatronics with Experiments", Second Edition, Wiley, 2015* 3. *Devdas shetty, Richard A.Kolk "Mechatronics Systems Design", Cengage Learning, 2011.* 4. *NI_mechatronics_machine_design_guide from ni.com.* 5. *Advanced model based systems design courseware from mathworks.com.* *6. Quanser QNET Practical Control Guide (available in Mechatronics Laboratory).*	*7. Quanser QNET VTOL Laboratory manual (available in Mechatronics Laboratory).* *8. Quanser QNET Rotary Inverted Pendulum manual (available in Mechatronics Laboratory).* *9. Laboratory manual for Mechatronics Laboratory, SRMIST* *10. Dennis M.Buede & William D.Miller., "The Engineering Design of Systems Models and Methods" 3rd Edition, Wiley, 2016*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. K.P. Srinivasan, Mahindra and Mahindra, p.srinivasan2@mahindra.com	*1. Prof. I. A. Palani, IIT Indore,*	1. *Dr. T. Muthuramalingam, SRMIST*
2. Mr. C. Ellanchezhiyan, Keyence Microscope ellanchezhian@gmail.com	*2. Dr. P. Karthikeyan, MIT, Anna University pkarthikeyan@mitindia.edu*	*2. Dr. M. Mohamed Rabik, SRMIST*

Course Code	21MHC505L	Course Name	REAL-TIME EMBEDDED SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	6	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the real time system concepts and basic microcontroller*
CLR-2:	*learn the programming concepts based on ARM and RTOS*
CLR-3:	*incorporate knowledge on the real time operating systems based implementation*
CLR-4:	*acquire knowledge in industrial real time controllers*
CLR-5:	*familiarize using PLC for different industrial applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify and need of real time system concepts and microcontroller*	3	-	2
CO-2:	*program Arm processors*	-	-	2
CO-3:	*build interfacing of FPGA based SOM controller for different industrial applications*	3	-	-
CO-4:	*selection and optimal usage of computer hardware in industrial real time controller*	3	-	-
CO-5:	*develop simulation using PLC for different industrial applications*	3	-	-

Module-1 – 8051 Controllers	***18 Hour***
Introduction to microcontroller, embedded system, real time system and real time operating system (RTOS), Microcontroller 8051 architecture, instruction set and addressing modes, Basic programming using basic instructions, Timer and counter programming, Interfacing of peripherals	
Module-2 – ARM Controllers	***18 Hour***
Introduction to ARM Cortex-M controllers, Cortex-M0, M3, M4, and M7 features and differences, Basic programming, Peripherals and Interfaces, GPIO, Timers, ADC, DAC, UART, SPI, I2C, CAN, Memory Architecture, Flash, SRAM, and peripheral memory mapping.	
Module-3 – RTOS Based Controllers	***18 Hour***
RTOS architecture, Task management and scheduling, Synchronization mechanisms, inter-task communications, RTOS timers and clock management, RTOS based programming for 8051, RTOS based programming for 8051, Getting started with FPGA based SOM and Basic Programming, Development methodologies, using pre-built FPGA acceleration, GPIO Access using FPGA, FPGA acceleration of Closed Loop Motor Control, Embedded-GPU (SOM-based) Acceleration for AI Inferencing, Time Performance Analysis	
Module-4 – Industrial Real-Time Controllers	***18 Hour***
Introduction to FPGA programming using high-level programming language, Modes of Using Reconfigurable Hardware – RT, FPGA and Scan Engine, Programmatic launching of applications, Communication between real-time microcontroller and FPGA – DMA FIFO, Communication between real-time microcontroller and FPGA – Interrupt Based, Timestamping in FPGA. Hardware Triggering for Image Acquisition, SPI Communication, I2C Communication. RS232/RS422/RS485 Using VISA. RS232/RS422/RS485 in FPGA, Hardware-in-loop Simulation with Real Time Controllers	
Module-5 – Programmable Logic Controllers	***18 Hour***

Introduction to PLC programming software and Hardware Connection Transport parts from Location A to Location B with Set and Reset, Working with analog inputs and output signals, Closed loop pneumatics using analog PID controller and Status Controller, Closed loop pneumatics using PLC, Filling tank with Timers, Basic Elevator, Advanced Elevator, Palletizer, Pick and place using XYZ Mechanism, Working with industrial communication interfaces.

Learning Resources	1. *Frank Vahid and Tony Givargis, "Embedded System Design: A Unified Hardware/ Software Approach", Pearson Education Asia, 3rd edition, 2009.* 2. *Steve Furber, "ARM System-on-chip Architecture", Pearson Education, India, 2000* 3. *Juan Jose Rodriguez Andina, Eduardo de la Torre, Maria Dolores Valdes, FPGAs Fundamentals, Advanced Features, and Applications in Industrial Electronics, CRC Press, 2020* 4. *Richard L. Shell and Ernest L. Hall, Handbook Of Industrial Automation, CRC Press, 2000.*	5. *Peng Zhang, Advanced Industrial Control Technology, William Andrew Publishing, 2010. Max Rabiee, Programmable Logic Controllers: Hardware and Programming, Goodheart-Willcox, 2017* 6. *Clyde coombs, Electronic Instrument Handbook, McGraw-Hill Professional, 1999.* 7. *Chanchal Dey, Sunit Kumar Sen, Industrial Automation Technologies, CRC Press, 2020.* 8. *Bruno, Frank, FPGA programming for beginners, Packt Publishing, 2021.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*25%*	-	*20%*	-	*25%*	-	-
Level 3	*Apply*	-	*30%*	-	*25%*	-	*30%*	-	-
Level 4	*Analyze*	-	*30%*	-	*25%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-	-	-
Level 6	*Create*	-	-	-	*5%*	-	-	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Shankar Bharathi, L&T Technology Services,*	1. *Dr. R. Thiyagarajan, IIT Tirupati, thiyagu@iittp.ac.in*	*1. Dr. R. Senthilnathan, SRMIST*
2. *Dr. K. Karthikeyan, R&D Team Manager, Power Quality Products, Hitachi Energy, Bangalore*	*2. Dr. G. Nagamanikandan, IIIT Hyderabad*	*2. Dr. M. Mohammed Rabik, SRMIST*

ACADEMIC CURRICULA

Mechatronics Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MHE521J	Course Name	INDUSTRIAL MANIPULATORS- KINEMATICS, DYNAMICS AND CONTROL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the concept of manipulator robotics and transformations*
CLR-2:	*acquire knowledge in the domain of kinematics*
CLR-3:	*acquire knowledge in the domain of differential kinematics and trajectory planning*
CLR-4:	*acquire knowledge in the domain of manipulator dynamics*
CLR-5:	*explore the methods of manipulator control*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the concept of transformation in robotics application*	3	2	
CO-2:	*apply the concept to compute the kinematic model of the manipulators*	3	3	
CO-3:	*apply the concept to compute the differential kinematic model of the manipulators*	3	3	
CO-4:	*apply the concept to compute the dynamic model of the manipulators*	3	3	
CO-5:	*familiarize the various control strategies applied for robot control*	3	1	

Module-1 – Introduction to Manipulator Robotics and Transformations	***15 Hour***
Basic terminologies in robotics, Anatomy of Robot , Basic configuration based on work volume, Description of point and body in space, Representing translation of body, Representing rotation of a body – Rotation matrix, Euler angle representation, Quaternions , Homogenous transformations, Importance of Transformations in Robotics – Mapping (Frame to frame) and operators, Numerical on transformations Lab 1: Basics of Linear algebra and vector transformations, Lab 2: Introduction to spatial transformations	
Module-2 – Introduction to Kinematics	***15 Hour***
Definition of Kinematics – Forward and Inverse Kinematics, Introduction to manipulator forward kinematics – Geometric and analytical method, Example of geometric method – 2R palanar and 3R spatial manipulator, Introduction to standard DH convention, DH matrix and transformation, Forward kinematics computation using standard DH – 2R manipulator, 3R spatial manipulator, RPY wrist, Introduction to Inverse kinematics and application, Inverse Kinematic computation: Closed form solution, conditions and steps in computation, Inverse kinematics computation using standard DH – 2R manipulator, 3R spatial manipulator, RPY wrist, Application of Inverse kinematics and transformations for a general pick and place application *Lab 3: Simulation of Forward kinematics model* *Lab 4: Simulation of inverse kinematic model*	
Module-3 – Differential Kinematics and Trajectory Planning	***15 Hour***
Introduction to Differential kinematics – Jacobian matrix and mapping, Velocity representations (Linear and angular velocity) and transformations – multi DoF rigid body, Steps in the computation of Jacobian matrix for multi DoF manipulators, Jacobian computation – 2R planar, 3R spatial and RPY wrist, Concept of singularity and its consequence, Computing singularity conditions for manipulators- 2R planar, 3R spatial and RPY wrist (Wrist singularity), Introduction to trajectory planning and its importance, Joint space trajectory planning (cubic polynomial and trapezoidal), Cartesian space trajectory planning. Lab 5: Velocity kinematics model and singularity simulation *Lab 6: Trajectory planning*	

Module-4 – Introduction to Manipulator Dynamics	***15 Hour***
Concept of Dynamics – Forward and Inverse dynamics, Dynamics computation method- Newton Euler (example of 2R planar manipulator), Recursive dynamics, Lagrangian method (example of 2R planar manipulator), Dynamics of 1R, and 3R spatial arm, Dynamics of pendulum over cart (transfer function and state space model) and its importance in control *Lab 7: Dynamics simulation I* *Lab 8: Dynamics simulation- II*	
Module-5 – Manipulator Control	***15 Hour***
Introduction to joint and cartesian control, Position and velocity control (P, PI and PID), Properties of PID control and tuning, Concept of partition control, Computed torque control, Introduction to force control, Hybrid force -position control and its control architecture, Concept of natural and artificial constraints, Example of Peg in Hole assembly *Lab 9: Closed loop control- PID* *Lab 10: Computed torque control- Simulation*	

Learning Resources	*1. John J.Craig, "Introduction to Robotics-Mechanics and Control" , Pearson Education, Fourth edition,2018.* *2. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, Fifth edition, 2003.* *3. Richard D.Klafter, Thomas A. Chmielewski and Michael Negin, "Robotics Engineering, An Integrated Approach" ,Prentice-Hall India,2009.*	*4. S.K Saha," Introduction to Robotics", McGraw Hill India, Second Edition,2014.* *5. K.S Fu, R.C Gonzalez and C.S.G Lee," Robotics-Control, Sensing, Vision and Intelligence" Tata McGraw Hill, Second reprint,2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr. Ranjith Pillai R, SRMIST*
2. Mr. N. Ganesh Ram,Co-Founder and Director of Aerospace Division, Tunga Aerospace Industries Pvt. Ltd.	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr. Madhavan Shanmugavel, SRMIST*

Course Code	21MHE522J	Course Name	MODERN CONTROL ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	21MHC501J	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*plot phase portrait for both linear and non linear systems*
CLR-2:	*describe the function for non linear systems*
CLR-3:	*model a dynamic system in discrete form*
CLR-4:	*study state space analysis in discrete form for any system*
CLR-5:	*know the advanced control schemes*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the dynamics systems using phase portraits*	2		3
CO-2:	*convert any non-linear into linear systems*	2	2	3
CO-3:	*convert continuous time system into digital system*	2	3	
CO-4:	*analyze the systems in digital domain*			3
CO-5:	*design modern control laws for control*			3

Module-1 –Non linear Systems and Phase Plane Analysis	***15 Hour***
Introduction to non-linear system, Common physical non-linearities, Methods of linearization, Concepts of phase portraits, Singular points, Limit cycles, Construction of phase portraits, Phase plane analysis of Linear and non-Linear systems, Isocline method.	
Module-2 – Describing function Analysis	***15 Hour***
Describing function fundamentals, Definitions and Assumptions, Computing Describing Functions, Common non-linearities, Nyquist criterion and its Extension, Existence of Limit Cycles, Stability of Limit Cycles	
Module-3 – Discrete System Modeling	***15 Hour***
Transforms of Z domains, Z transform-mapping between S and Z, Determination of the system equations, Open loop Hybrid sampled data control systems, Closed loop sample data control systems, Z transform method-response between sampling instants, stability of the Z modified plane, Jury's stability test, steady state error analysis for stable systems	
Module-4 – State Variable Model in Discrete Time	***15 Hour***
State descriptions of digital processors, Conversion of state variable models to transfer functions, Conversion of transfer function to canonical state variable models, Jordan canonical form, state description of sampled continuous, time plants, solution of state difference equations, Closed form solution, State transition matrix-Caley Hamilton Technique, concept of controllability and observability, Loss of controllability and absorbability due to sampling	
Module-5 – Modern Controls	***15 Hour***
Linear quadratic regulator, Adaptive control, Robust control, Model Predictive control, Extremum seeking control, Sliding surfaces, MIMO systems	

Learning Resources	*1.K.Ogata, "Modern Controls Engineering", Prentice Hall of India Pvt. Ltd., New Delhi, 2005.* *2. Jean Jacques Slotine and Weiping Li, "Applied Nonlinear Control", Prentice Hall Inc., 1991.* *3.Zoran Vukic, Ljubomir Kuljaca, Dali Donlagic and Sejid Tesnjak, "Nonlinear Control Systems", Marcel Dekker Inc, 2003* *4.Gopal M "Digital Control and State Variable Methods", Tata McGraw- Hill Ltd, New Delhi, 2003* *5.Wilfrid Peruquetti and Jean Pierre Barabot, "Sliding Mode Control in Engineering", Marcel Dekker Inc, 2002.*	*6.C.M. Houpis, G.B. Lamount, 'Digital Control Systems-Theory, Hardware, Software', International Student Edition, McGraw Hill Book Co., 1985.* *7. Simon Haykin (Ed),"Kalman Filter and Neural Networks", John Wiley & Sons Publication, 2001.* *8.. Tsoukalas and Robert Uhrig, "Fuzzy & Neural Approach in Engineering", John Wiley* *9.. "System dynamics and control Laboratory Manual", Mechatronics Engineering, SRMIST.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. K. Karthikeyan, R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore	*1. Dr.KS Balamurugan, Professor and Head, Electronics and Communication Engg , Karpaga Vinayaga College of engineering and technology, Chengalpet. drksbalamurugan@kveg.in*	*1. Dr.M. Mohamed Rabik, SRMIST*
2. Mr. C. Ellanchezhiyan, Keyence Microscope ellanchezhian@gmail.com	*2. Dr. P. Karthikeyan, MIT, Anna University pkarthikeyan@mitindia.edu*	*2. Dr. Sivanathan, SRMIST*

Course Code	21MHE523T	Course Name	MECHATRONICS APPLICATIONS IN SCIENCE AND ENGINEERING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*appreciate the applications of Mechatronics in Science and Engineering*
CLR-2:	*apply the concepts and principles of Mechatronics in Science and Engineering*
CLR-3:	*conduct preliminary analysis of performance of Mechatronics systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the principles of Mechatronics in engineering industries*	3	2	2
CO-2:	*apply Mechatronics principles applied to system monitoring and fault diagnosis*	3	2	2
CO-3:	*apply Mechatronics principles in materials, sensors and actuators*	3	2	2
CO-4:	*apply the role of Mechatronics in Medical science applications*	3	2	2
CO-5:	*apply the principles of Mechatronics in agriculture, foods & wastes and energy and clothing and home technologies*	3	2	2

Module-1 – Mechatronics in Manufacturing	***15 Hour***
Introduction to mechatronics in manufacturing, Numerical control, NC Positioning system – open loop, NC Positioning system – closed loop calculations, Metrics of positioning control – accuracy and repeatability, Mechatronics in automated assembly process, Mechatronics in Automated production line, Mechatronics in work cell design, Mechatronics in additive manufacturing, Modelling and Simulations and/or Experiments of Numerical control, production process, workcell simulation	
Module-2 – Fault Detection	***15 Hour***
Introduction to diagnosis and prognosis, Principles and Techniques for monitoring, Monitoring and techniques of fault diagnosis, Techniques of fault prognosis, Performance metric, Mechatronics in diagnosis and prognosis. Modelling and Simulations and/or Experiments of diagnosis and prognosis, monitoring, and performance metrics	
Module-3 –Microsystems	***15 Hour***
Principles of micro-mechatronics, Piezoelectric actuator, Magnetostrictive actuator, Magneto rheological fluid damper Induced-Strain Actuators - Electroactive Stacks, Inertial measurement Unit Microgripper. Modelling & Simulations and/or Experiments of micro-mechatronics – piezo, magnetostrictive actuators, MR damper, induced strain actuators, microgrippers, IMU	
Module-4 – Medical and Health	***15 Hour***
Patient monitoring system, Blood pressure measurement, Blood flow measurement, MRI and ultrasonic scanner, Haptics Technology, Wearable sensors. Modelling & Simulations and/or Experiments of Patient monitoring system, Blood pressure measurement, Blood flow measurement, MRI and ultrasonic scanner, Haptics Technology, Wearable sensors	
Module-5 – Sustainable Systems	***15 Hour***
Mechatronics in sustainability. Mechatronics in agriculture machinery, Precision farming, Drone technology in agriculture, Mechatronics in solid waste management, Mechatronics in wastewater treatment, Mechatronics in smart clothing, Mechatronics in smart homes Modelling and Simulations and/or Experiments of two or more systems of sustainability.	

Learning Resources	1. *Mikell P Groover, Fundamentals of modern manufacturing* 2. *George Vachtsevanos Frank L. Lewis Michael Roemer Andrew Hess Biqing Wu, "Intelligent Fault Diagnosis and Prognosis for Engineering Systems", John Wiley, 2006* 3. *Walt Boyes, "Instrumentation Reference Book", 4th Ed, Elsevier, 2010.* 4. *Stephanus Büttgenbach, Iordania Constantinou, Andreas Dietzel, Monika Leester-Schädel, Case Studies in Micromechatronics-From Systems to Processes, ISBN 978-3-662-61319-1, Springer (2020)*	5. *S. Pugalendhi, J. Gitanjali, R. Shalini and P. Subramanian, Handbook on Renewable Energy and Green Technology, CRC Press (2024)* 6. *Dr. John G. Webster (Editor), "Encyclopedia of Medical Devices and Instrumentation", John Wiley, 2006.* 7. *"Computers and Electronics in Agriculture" (Journal), Elsevier.* 8. *Robert H. Bishop, "The Mechatronics Handbook", 2nd Ed, CRC Press, 2007*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*30%*	-
Level 3	*Apply*	*50%*	-	*50%*	-	*50%*	-
Level 4	*Analyze*		-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. N. Ganesh Ram, Intel Labs, ganeshram.nandakumar@intel.com	*1. Dr Elango Natarajan, Department of Mechanical and Mechatronics Engineering, UCSI University, Malaysia, elango@ucsiuniversity.edu.my*	*1. Dr Madhavan Shanmugavel, SRMIST*
2. Mr. Mohammed Sagheer ,Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com	*2. Dr., P Karthikeyan, MIT, Anna University, pkarthikeyan@annauniv.edu*	*2. Dr Priya Esther, SRMIST*

Course Code	21MHE524J	Course Name	COMPUTER VISION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the various active methods of reconstruction techniques*
CLR-2:	*comprehend various basic image processing operations on digital image*
CLR-3:	*understand various recognition and segmentation algorithms*
CLR-4:	*develop algorithms for scene reconstruction and motion estimation from images*
CLR-5:	*understand deep learning techniques for computer vision tasks*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*appreciate the mathematics of basic computer vision principles*	3	2	-
CO-2:	*understand the active computer vision techniques*	3	2	-
CO-3:	*comprehend clustering and segmentation methods*	3	2	-
CO-4:	*understand recognition principles and basic mathematics of the same*	3	2	-
CO-5:	*implement deep learning for common computer vision tasks*	3	2	-

Module-1 - Image Formation	***15 Hour***
Introduction to Vision- Terminologies - Comparison of biological and computer vision- Specifications and limitations- Modelling of geometric image formation- Derivation- Camera calibration- methods of camera calibration- Estimation of projection matrix- Derivation- Experimental performance assessment in computer vision- Metrics and example usage- Scene constraints- Fundamentals of lighting- Optical Lens- Optical Filters- Image sensors- Comparison of Image Sensor Technologies- Specification of a Vision Camera- Hardware selection exercise	
Module-2 - Basic Image Processing	***15 Hour***
Vision software basics- Types and selection- Basics of digital image- Sampling, quantization effects- Point operations- 2-D convolution- Image smoothing in spatial domain- Image sharpening and Edge detection in spatial domain- Key point features- Harris Corner Detection- Scale Invariant Feature Transform (SIFT) key point descriptor- Matching Algorithms- Descriptor Matching and Gray-level matching-	
Module-3 - Stereo Vision and Optical Flow	***15 Hour***
Introduction to the multi-view geometry- Scene reconstruction and motion estimation problem- Geometry of a stereo vision system- Correspondence problem- Epipolar geometry- Estimation of fundamental and essential matrix- Epipolar constraint- Epipolar rectification- Metric reconstruction- Motion field of rigid objects- Aperture problem- Optical flow- Motion field- Brightness constancy equation- Estimating motion field - differential techniques- Estimating motion field - feature based techniques- Visual odometry - case study	
Module-4 - Segmentation, Recognition and Active Vision	***15 Hour***
Introduction to segmentation and recognition- K-means clustering- Principle and underlying mathematics- Numerical problem on k-means clustering- K-nearest neighbor algorithm- Principle and underlying mathematics- Numerical problem solving for a sample recognition using K-nearest- Principal component analysis (PCA)- Principle and underlying mathematics- Numerical problem solving for a sample recognition using PCA- Structured Light reconstruction- Principle, working and specifications- LIDAR, Types- Principle, working and specifications- LIDAR data processing	
Module-5 – Convolutional Neural Networks	***15 Hour***

Introduction to neural networks- Philosophy of learning and types of networks- Backpropagation- Multi-layer perceptron- Numerical example- Gradient descent optimization- Training concepts in neural network training- Conventional neural networks vs. Deep learning- Deep learning hardware for computer vision tasks- Convolutional neural networks- Layers and parameters- Popular CNN architectures For image classification- Challenges addressed and novelty- Popular CNN architectures for object detection- Challenges addressed and novelty- Applications of deep learning – semantic/ instance segmentation- Applications of deep learning

Learning Resources	1. *WileyForsyth and Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2015.* 2. *Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, 1st Edition, MIT Press, 2016.*	3. *Rafael C. Gonzales, Richard.E.Woods, "Digital Image Processing, 4th Edition, Pearson Education", 2018.* 4. *Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", 1st Edition, Prentice Hall, 1998 Edition.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. N. Ganesh Ram, Intel Labs, ganeshram.nandakumar@intel.com*	1. *Dr. R. Thiyagarajan, IIT Madras, thiyaguiitm@gmail.com*	1. *Dr. R. Senthilnathan, SRMIST*
2. *Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com*	2. *Dr. P. Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	2. *Dr. S. M. Vignesh, SRMIST*

Course Code	21MHE525J	Course Name	MACHINE LEARNING AND DEEP LEARNING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the fundamentals of Machine learning*
CLR-2:	*provide deeper understanding of various techniques for Machine learning algorithms*
CLR-3:	*review the basics deep learning philosophy*
CLR-4:	*construct CNN model for image-based applications*
CLR-5:	*provide various models in deep learning*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply specific supervised machine learning algorithm for a particular problem*	3	2	1
CO-2:	*choose and apply the appropriate unsupervised machine learning approach*	3	2	1
CO-3:	*develop neural networks for simple classification tasks*	3	2	1
CO-4:	*implement deep learning training concepts*	2	1	3
CO-5:	*implement deep recurrent neural networks and reinforcement networks for simple robot guidance tasks*	2	1	3

Module-1 - Introduction to Machine Learning and Supervised Learning	***15 Hour***
Introduction and motivation for machine learning; Examples of machine learning applications. Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification Models: Discriminant function – Perceptron algorithm, Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naïve Bayes, Maximum margin classifier – Support vector machine, Decision Tree, Random Forests *Experiments: 1. Support vector machine, 2. Naive Bayes clustering*	
Module-2 - Ensemble Techniques and Unsupervised Learning	***15 Hour***
Combining multiple learners: Model combination schemes, Voting, Ensemble Learning - bagging, boosting, stacking, Unsupervised learning: K-means, Instance Based Learning: KNN, Gaussian mixture models and Expectation maximization *Experiments: 1. Clustering analysis, 2.Discriminant based data classification*	
Module-3 Deep Networks Basics	***15 Hour***
Linear Algebra: Scalars — Vectors — Matrices and tensors; Probability Distributions — Gradient based Optimization – Machine Learning Basics: Capacity — Overfitting and underfitting -Hyperparameters and validation sets — Estimators — Bias and variance — Stochastic gradient descent — Challenges motivating deep learning; Deep Networks: Deep feedforward networks; Regularization — Optimization *Experiments: 1 Deep Learning . IMDB Dataset, 2. Deep Learning using the CIFAR Dataset*	
Module-4 - Convolutional Neural Networks	***15 Hour***

Convolution Operation — Sparse Interactions — Parameter Sharing — Equivariance — Pooling -Convolution Variants: Strided — Tiled — Transposed and dilated convolutions; CNN Learning: Nonlinearity Functions — Loss Functions — Regularization — Optimizers –Gradient Computation, CNN Architectures – Convolution – Pooling Layers – Transfer Learning – Image Classification using Transfer Learning Experiments: 1. CNN Implementation, 2. Deep Reinforcement Learning for Manipulators
Module-5- Recurrent Neural Networks and Reinforcement Learning ***15 Hour***
Unfolding Graphs – RNN Design Patterns: Acceptor – Encoder – Transducer; Gradient Computation – Sequence Modeling Conditioned on Contexts – Bidirectional RNN – Sequence to Sequence RNN – Deep Recurrent Networks – Recursive Neural Networks – Long Term Dependencies; Leaky Units: Skip connections and dropouts; Gated Architecture: LSTM, Reinforcement learning - Major components of RL *Experiments: 1. Reinforcement Learning Implementation, 2. : LSTM implementation for sequence modelling*

Learning Resources	1. *Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006. Tom Mitchell, "Machine Learning", McGraw Hill, 3rd Edition, 1997.* 2. *Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, "Foundations of Machine Learning", Second Edition, MIT Press, 2012, 2018.* 3. *Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016*	4. *Sebastain Raschka, Vahid Mirjalili , "Python Machine Learning", Packt publishing, 3rd Edition, 2019.* 5. *Navin Kumar Manaswi, "Deep Learning with Applications Using Python", Apress, 2018.* 6. *Joshua F. Wiley, "R Deep Learning Essentials", Packt Publications, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Mr.Kotesh, Director – Embedded/Edge Computing and Robotics Lab, ERS-CET-Technology Office,HCLTech	1. *.Dr Gunasekaran Thangavel, Engineering Department, University of Technology and Applied Sciences, Muscat, Sultanate of Oman.*	1. *Dr.S.Vani, SRMIST*
2.Dr.Ragav Menon, Senior Manager, Capegemini India Ltd	2. *.Dr.S.Srinivasan, Associate Dean and Vice Principal, Saveetha University,Chennai*	2. *Ms. Madhumitha .G,SRMIST*

Course Code	21MHE526T	Course Name	VETRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on components of automobile systems*
CLR-2:	*gain knowledge on sensors used in vehicle*
CLR-3:	*accrue the knowledge of different fuel injection and ignition system*
CLR-4:	*impart knowledge on digital control system and networks used in vehicle*
CLR-5:	*comprehend the knowledge on vehicle motion and stabilization system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the fundamentals of automotive system*	3	1	
CO-2:	*analyze the sensors into various automobile subsystems*	3		
CO-3:	*apply different fuel injection and ignition system*	3	1	
CO-4:	*analyze the different type of digital engine control*	3		
CO-5:	*incorporate the various vehicle motion control and stabilization system*	3		

Module-1 - Automotive System Fundamentals	***9 Hour***
Evolution of automotive electronics-Major automotive system components: Engine-Ignition System-Ignition timing-drivetrain-Suspension-Brakes-Steering system- Components of electronic engine management system-Solenoid –stepper motor- relays- 2 and 3 way catalytic converter.	
Module-2 - *Sensors and Instrumentation Systems*	***9 Hour***
Types of sensors: oxygen sensors- Crank angle position sensors - Fuel metering-vehicle speed sensor -detonation sensor- mass air flow sensor- Manifold absolute pressure (MAP) sensor- Throttle position sensors-Fuel quantity measurement-coolant temperature measurement –oil pressure measurement-vehicle speed measurement.	
Module-3 - Electronic Fuel Injection and Ignition Systems	***9 Hour***
Introduction- Feedback carburetor systems (FBC)- Throttle body injection and multi point fuel injection system- Types of solid-state ignition systems and their principle of operation- Electronic spark timing control – Power steering	
Module-4 - Digital Engine Control System and Networks	***9 Hour***
Open loop and closed loop control systems -Engine cranking and warm up control -Acceleration enrichment - Deceleration leaning and idle speed control. Distributor less ignition -Integrated engine control system- Exhaust emission control engineering- Wiring Harness- Limitations of Wiring Harness- Multiplex data bus- Basic principle of Networking Classification of automotive multiplex bus- Controller Area Network- Local Interconnect Network- FlexRay- Automotive Ethernet- Connected Cars.	

Module-5 – Vehicle Motion Control and Stabilization Systems	***9 Hour***
Introduction to Vehicle motion control - Adaptive cruise control-Electronic transmission control- Vehicle stabilization system - Antilock braking system- Traction control system- Electronic stability program-Low tire pressure warning system- Onboard diagnosis system-Automatic Transmission- Central locking- Electric mirrors- windows- Automatic Transmission- Electric vehicle- DC-DC Converters for EV, DC-AC Inverters for EV- Storage: batteries, Fuel cell- Telematics- Parking Assist Systems- Air bag system	

Learning Resources	1. *C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001* 2. *Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.* 3. *James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.* 4. *Fundamentals of Vehicle Dynamics, Thomas Gillespie, SAE Publication.* 5. *Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002* 6. *Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/Software introduction, Third edition, John Wiley & sons, 2010*	7. *R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009.* 8. *L. Ashok Kumar, S. Albert Alexander, "Power Converters for Electric Vehicles", CRC Press, Taylor & Francis Group, 2021* 9. *Automotive Industry Standards, India, 2015-2016* 10. *Barry Hollembeak, "Automotive Electricity, Electronics & Computer Controls", 1st Edition, Delmar Publishers, 2001*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Ms.S.Senthil kumar,Grundfos pums india(p) Ltd,senthel.s@gmail.com*	1. *Dr.M.Baskaran,Associate professor,KSR College of Technology,baskaranm@ksrct.ac.in*	1. *Dr.R.Gangadevi, SRMIST*
2.. *Dr. K. Karthikeyan Ph.D., R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore*	2. *Dr.KS Balamurugan, Professor and Head, Electronics and Communication Engg , Karpaga Vinayaga College of engineering and technology, Chengalpet. drksbalamurugan@kveg.in*	2..*Dr.Mohamed Rabik, SRMIST*

Course Code	21MHE527J	Course Name	AUTONOMOUS MOBILE ROBOTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*master the Fundamentals of Autonomous Mobile Robotics*
CLR-2:	*develop Skills in Robot Kinematics and Sensor Integration*
CLR-3:	*gain Expertise in Localization and Mapping Techniques*
CLR-4:	*proficiency in Path Planning and Navigation*
CLR-5:	*explore Advanced Control Systems and Future Trends*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*demonstrate a comprehensive understanding of the fundamental principles, historical development, and key applications of autonomous mobile robotics*		2	2
CO-2:	*analyze and model the kinematics of different types of mobile robots and effectively integrate various sensor technologies to enhance robot perception and navigation.*		2	2
CO-3:	*develop the ability to implement and evaluate localization algorithms and SLAM techniques, addressing practical challenges in real-world scenarios.*		2	2
CO-4:	*design, implement, and optimize path planning algorithms and develop strategies for efficient and safe navigation, considering uncertainties and dynamic obstacles.*		2	2
CO-5:	*apply advanced control methods to mobile robots and explore the latest trends and future directions in the field, including human-robot interaction and machine learning applications.*		2	2

Module-1 – Fundaments of Autonomous Mobile Robotics	***15 Hour***
Definition and scope of autonomous mobile robotics, Historical development and milestones, Applications in diverse industries (e.g., manufacturing, logistics, healthcare), Kinematic models of various mobile robots, Differential drive, omnidirectional drive, and Ackerman steering models, Non-holonomic constraints and their implications, Overview of key sensors: LIDAR, sonar, cameras, IMUs, and GPS, Sensor characteristics, calibration, and integration techniques, Introduction to sensor fusion methods	
Module-2 – Localization and Mapping Techniques	***15 Hour***
The localization problem and its challenges, Markov localization, Kalman filter and particle filter techniques, Fundamental concepts of SLAM, Graph-based SLAM, EKF-SLAM and FastSLAM methodologies, Occupancy grid mapping, Topological mapping, Semantic mapping approaches.	
Module-3 – Path Planning and Navigation	***15 Hour***
Classical algorithms: A, D*, Sampling-based algorithms: RRT, PRM, Optimization-based algorithms: Dijkstra, Bellman-Ford, Planning under uncertainty, Probabilistic roadmaps, POMDPs (Partially Observable Markov Decision Processes), Belief space planning techniques, Potential field methods, Vector field histogram, Dynamic window approach and its applications*	
Module-4 – Control of Autonomous Mobile Robots	***15 Hour***

PID control and its applications, Model predictive control (MPC), Introduction to fuzzy logic control, Adaptive control strategies, Robust control methods, Nonlinear control systems, Cooperative control of multirobot systems, Formation control algorithms, Swarm robotics principles, Distributed control techniques.
Module-5 – Emerging Trends and Future Prospects in Autonomous Mobile Robotics ***15 Hour***
Human robot interaction, Design of user interfaces for mobile robots, Social and collaborative robots, Ethical considerations and societal impacts, Reinforcement learning applications, Imitation learning techniques, Transfer learning in robotics, Advances in sensor technologies, Integration of AI and machine learning, Challenges and future applications

Learning Resources	1. *Siegwart, R., Nourbakhsh, I. R., & Scaramuzza, D, Introduction to Autonomous Mobile Robots. MIT Press,2011.* 2. *Thrun, S., Burgard, W., & Fox, D., Probabilistic Robotics. MIT Press, 2005.* 3. *Siciliano, B., & Khatib, O. (Eds.). Springer Handbook of Robotics. Springer, 2016*	4. *LaValle, S. M. Planning Algorithms. Cambridge University Press.,2006.* 5. *Corke, P. Robotics, Vision and Control: Fundamental Algorithms in MATLAB. Springer, 2017.* 6. *Sutton, R. S., & Barto, A. G, Reinforcement Learning: An Introduction. MIT Press,2018*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr.Murali Arunachalam, ZF CVCS, murali.arunachalam@zf.com*	1. *Dr. P.V. Manivannan, IIT Madras, pvm@iitm.ac.in*	1. *Dr. K. Sivanathan SRMIST*
2. *Guna Surendra, Hitachi, Japan*	2. *Dr. T. Asokan, IIT Madras, asok@iitm.ac.in*	2. *Dr. R. Ranjith Pillai, SRMIST*

Course Code	21MHE528J	Course Name	DIGITAL MANUFACTURING AND SMART FACTORIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts of digital manufacturing*
CLR-2:	*familiar in interfacing and intelligent control in digital manufacturing*
CLR-3:	*illustrate the fundamentals of IoT architecture, communication, and networking*
CLR-4:	*understand methods for data preparation and processing for big data analytics*
CLR-5:	*explore challenges and industrial applications of cloud computing in manufacturing*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*gain knowledge in fundamentals of digital manufacturing*		2	
CO-2:	*develop the concept of intelligent control in digital manufacturing*		2	
CO-3:	*apply IoT technology to build complete system for industrial applications*		2	
CO-4:	*develop big data solutions using Hadoop eco-system, environment for VR and AR applications*		2	
CO-5:	*recognize the industrial applications of cloud computing in manufacturing*		2	

Module-1 – Introduction to Digital Manufacturing	***15 Hour***
Introduction and concepts of digital manufacturing-digital networked manufacturing-new generation intelligent manufacturing- virtual environment for digital manufacturing- Application of virtual environm digital manufacturing system	
Module-2 – Modeling and Intelligent Control in Digital Manufacturing	***15 Hour***
Manufacturing computational model-Modeling theory of digital manufacturing-Introduction to reverse engineering-Methodologies and techniques for reverse engineering-Applications-Intelligent control-concept of intelligent multi information sensing and fusion-Multi agent manufacturing system	
Module-3 – Industrial Internet of Things	***15 Hour***
Introduction to internet of things (IoT)-IoT vs IIoT-M2M architecture-IoT Architecture-Sensing and actuation-wireless sensor networks-Basics of networking protocols-Transmission control protocol (TCP)-User datagram protocol (UDP)-Message Queueing Telemetry Transport (MQTT)	
Module-4 – Big Data Analytics and AR, VR for Industrial Application	***15 Hour***
Introduction to big data analytics-Data visualization methods- Types of digital data-big data analytics-History of Hadoop-design of HDFS-Hadoop file system interface- Data flow- Hadoop I/O tools. Introduction to immersive technologies-Design and implementation of an immersive user experience case study for AR and VR in industrial applications	
Module-5 – Cloud Manufacturing and Smart Factory Architecture	***15 Hour***
Introduction to cloud computing and manufacturing-cloud models-cloud service-architecture-cyber physical manufacturing-data security and cyber security-advanced automation and robotics: cobots-robotics in flexible manufacturing systems-integration of digital twin with IoT platform- edge computing -fog computing.	

Learning Resources	1. *Zude Zhou, "fundamentals of digital manufacturing science" Springer, 2012.* 2. *Alasdair Gilchrist "Industry 4.0: The Industrial internet of things", Apress 2017.* 3. *Erl, T.Khattak W " Big data fundamental: Concepts, drivers and techniques," Prentice hall press*	4. *Burdea, G.C, "Virtual reality Technology" second edition, Wiley- IEEE Press* 5. *Pradeep Tomar, "Integration and implementation of internet of things through cloud computing" 2021*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Mohammed sagheer, Wabco Technology center, mohammedsagheer.musthafa@wabco-auto.com*	1. *Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	1. *Dr. G. Murali, SRMIST*
2. *Mr. Singaram P, Senior engineer Eli Lilly, Email: pl_singaram@lilly.com*	2. *Dr. P. Karthikeyan, MIT Anna university, pkarthikeyan@annauniv.edu*	2. *Mr. J. Thiyagarajan SRMIST*

Course Code	21MHE529T	Course Name	INDUSTRIAL AUTOMATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize potential areas for automation and justify need for automation.*
CLR-2:	*understand different material handling and storage systems used in Modern Industries*
CLR-3:	*learn about different manufacturing systems adopted in Industries*
CLR-4:	*understand modern control technologies applied in modern industries*
CLR-5:	*learn about application computers in industries*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify potential areas for automation in modern industries.*		2	
CO-2:	*analysis different material handling and storage systems used in Modern Industries*		2	
CO-3:	*critically decide upon different manufacturing systems*		2	
CO-4:	*analyze and suggest modern control technologies for industries*		2	
CO-5:	*understand about application computers in industries*		2	

Module-1 – Introduction to Industrial Automation	***9 Hour***
Automation in Production System - Principles, strategies of Automation - Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, Flow lines Different level of Flow lines - Production economics: Cost in manufacturing - Break even analysis, unit cost of production - Lead time and work in process - Production concepts and Mathematical models - Types of plant layouts - Case Study	
Module-2 – Material Handling and Storage	***9 Hour***
Overview of Material Handling Systems, Principles of Material Handling Systems - Design Consideration of Material Handling Systems - Material Transport Systems, Introduction of Storage Systems - Different types of storage system - Automatic storage and Retrieval system - Work in process storage - Storage system performance - Material Identification Methods	
Module-3 – Automated Manufacturing Systems	***9 Hour***
Overview of Manufacturing Systems - Classification of Manufacturing Systems - Introduction of Manufacturing Cells - Introduction of GT, Cellular Manufacturing - Case studies - Overview and classification of FMS, FMS and its Planning and Implementation - Lean and Agile manufacturing system - Design for automated assembly, types of automated assembly system - Parts feeding devices - Analysis of single station and multi-station assembly machine	
Module-4 – Control technologies in Automation	***9 Hour***
Industrial Control Systems - Process Industries and Discrete-Manufacturing Industries - Continuous Versus Discrete Control - Computer Process control - Case study Sequence Control: Programmable Logic Controllers, Relay Ladder Logic, Programming - Supervisory Controllers: Functionally of Supervisory Control Level - Process Optimization - Recipe Management Material. Tracking - Man-machine interfaces - Case Study	
Module-5 – Computer based Industrial Control	***9 Hour***

Automatic Process Control - Building Blocks of Automation Systems: LAN - Analog Digital I/O Modules , Digital I/O Modules -SCADA Systems and RTU - Case study Distributed Control System - Functional Requirements - Configurations and some popular Distributed Control Systems - Industrial Communication Systems: Characteristic features of industrial networks - Low level networks and their features, Field bus architecture - Performance aspects of Industrial Automation Systems - Case Study – Internet of Things based industrial control - Case Study

Learning Resources	1. *M.P.Groover,"Automation, Production Systems and Computer Integrated Manufacturing", 5 th Edition, Pearson Education, 2009.* 2. *John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.* 3. *Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.*	*4. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw- Hill,New York, 2016.* *5. Dorf and Bishop, "Modern Control Systems", 12th Edition, Prentice Hall Publication* *6. Ogata, K., System Dynamics, 4th Edition, Prentice-Hall, 2004.* *7. Vu, Hung V, Ramin S. Enfandiari. System Dynamics, McGraw-Hill, 1997* *8. Mukherjee and Karmarkar, "Modelling and Simulation of Engineering Systems Through Bond graphs", Alpha Science Intranet Publisher, 2000.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. K.P. Srinivasan, Mahindra and Mahindra, p.srinivasan2@mahindra.com	*1. Prof. A. Gnanavelbabu, CEG, Anna University dr.agbabu@gmail.com*	1. *Dr. T. Muthuramalingam, SRMIST*
2. Mr. C. Ellanchezhiyan, Keyence Microscope ellanchezhian@gmail.com	*2. Dr. P. Karthikeyan, MIT, Anna University pkarthikeyan@mitindia.edu*	*2. Mr. J. Thiyagarajan, SRMIST*

Course Code	21MHE530T	Course Name	SMART MATERIALS AND SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamental concepts and types of smart materials.*
CLR-2:	*acquire knowledge in the design and selection of smart materials for mechatronics application*
CLR-3:	*understand the principles of controlling smart material systems.*
CLR-4:	*acquire knowledge in the integration of smart materials for real world mechatronics application*
CLR-5:	*explore advanced and emerging smart materials, their fabrication, control and applications.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explore different smart materials and their applications in mechatronics systems*	3		
CO-2:	*apply criteria for selecting appropriate smart materials for specific applications*	3		1
CO-3:	*design and implement control algorithms for smart actuators with sensor integration for real-time feedback*	3		3
CO-4:	*design prototypes incorporating smart materials for specific applications and evaluate the performance in real-world applications*	3		3
CO-5:	*identify future trends and challenges in smart material systems*	3		

Module-1 – Introduction to Smart Materials	***8 Hour***
Overview of Smart Materials: Definition and characteristics of smart materials, Historical development and applications, Types of Smart Materials: Piezoelectric materials, Shape memory alloys, Magnetostrictive materials, Electroactive polymers, Smart fluids (magnetorheological and electrorheological fluids), Properties and Behavior: Material properties (mechanical, electrical, thermal, etc.) Phase transformations and hysteresis, Applications in Mechatronics: Use cases in sensors, actuators, and transducers	
Module-2 – Design and Selection of Smart Materials	***8 Hour***
Material Selection Criteria: Mechanical, electrical, and thermal properties, Environmental considerations, Cost and availability, Design Considerations: Design methodologies for incorporating smart materials (to the mechanism as sensor / actuator), Integration with traditional materials, Case studies of smart material integration, Simulation and Modeling: Finite element analysis (FEA), Computational tools for material behavior prediction and control.	
Module-3 – Control of Smart Material Systems	***10 Hour***
Control Principles: Basics of control theory relevant to smart materials, Feedback and feedforward control systems, Actuation Mechanisms: Control of piezoelectric actuators, Shape memory alloy actuation, Magnetostrictive and electroactive polymer control, Sensors and Feedback: Integration of smart sensors, Real-time monitoring and control, Signal processing techniques, Control Algorithms: PID control, Adaptive control, Intelligent control strategies (fuzzy logic, neural networks)	
Module-4 – Application of Smart Materials in Mechatronics	***10 Hour***
Automotive Applications: Adaptive suspension systems, Vibration control and noise reduction, Aerospace Applications: Morphing wings and control surfaces, Health monitoring systems, Biomedical Applications: Smart prosthetics and orthotics, Biomedical sensors and actuators, Robotics and Automation: Soft robotics, Adaptive grippers and manipulators	

Module-5 – Future trends and advancement in smart material application	***9 Hour***
Emerging Smart Materials: Nano-smart materials, Bio-inspired smart materials, Advanced Fabrication Techniques: 3D printing of smart materials, Nanofabrication methods, Integration with IoT and AI: Smart materials in IoT systems, AI-driven smart material systems, Challenges and Opportunities: Technical and economic challenges, Future research directions	

Learning Resources	1. *M. V. Gandhi and B. So Thompson, "Smart Materials and Structures", Springer,1992* 2. *Michelle Addington and Daniel L. Schodek, "Smart Materials and Technologies: For the Architecture and Design Professions", Architectural Press, : 2005* 3. *A. V. Srinivasan and D. Michael McFarland, "Smart Structures: Analysis and Design", Cambridge University Press,2000* 4. *Walter Heywang, Karl Lubitz, and Wolfram Wersing, "Piezoelectricity: Evolution and Future of a Technology", Springer, 2008*	5. *D. C. Lagoudas, "Shape Memory Alloys: Modeling and Engineering Applications", Springer, 2008* 6. *Yoseph Bar-Cohen, "Electroactive Polymer (EAP) Actuators as Artificial Muscles: Reality, Potential, and Challenges", SPIE Press, 2004* 7. *Mirza Bichurin and D. Viehland, "Magnetoelectric Composites: Materials and Applications", Wiley, 2014* 8. *Ajit Behera, "3D Printing of Smart Materials: Applications in Robotics, Biomedicine, and Space", CRC Press, 2020*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Mohammed Sagheer , Wabco Technology Center, mohammedsagheer.musthafa@wabco-auto.com*	1. *Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	1. *Dr. G Murali, SRMIST*
2. *Mr. N. Ganesh Ram,Co-Founder and Director of Aerospace Division, Tunga Aerospace Industries Pvt. Ltd.*	2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2.Dr. Ranjith Pillai R, SRMIST*

Course Code	21MHE531J	Course Name	X-REALITY AND HAPTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain skills in 3D modeling, and texturing to create interactive X-reality environments*
CLR-2:	*explore the principles and intricacies of user interactions in virtual reality environments*
CLR-3:	*investigate user interaction techniques and AR devices to interact with augmented reality content*
CLR-4:	*acquire knowledge to design intuitive user interactions in MR*
CLR-5:	*learn how to develop immersive user interfaces with haptic feedback*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*interpret the various geometrical transformations and math involved in computer graphics.*	-	2	-
CO-2:	*analyze VR technologies*	-	2	-
CO-3:	*develop interactive AR applications*	-	2	-
CO-4:	*explain tracking in MR systems*	3	-	-
CO-5:	*demonstrate haptic perception, including tactile and kinesthetic sensations.*	3	-	-

Module-1 - Introduction to Immersive Technologies	***15 Hour***
History of Immersive technologies, Evolution, Formal definitions of key terminologies, Modelling 3D geometry, Coordinate systems, Primitives, and fragments, Vertex transforms, Spatial descriptions: Operators and mapping, Homogeneous transformation matrices, Vector and normal transforms, View transform, Projection transform, Perspective projection and Orthographic projection, polygonal representations, the graphics pipeline, Vertex processor, Rasterization / Scanline interpolation, Fragment processor, Lighting: Phong model and Physically based rendering, Shaders	
Module-2 – Virtual Reality – Interactions and Interfaces	***15 Hour***
Virtual reality components, Position tracking methods- outside-in/inside-out room-scale, rotational tracking, Navigation - Travel techniques, User-centered wayfinding, Environment-centered way-finding, motion controllers - Data gloves and gesture control-Direct user interaction - Touch, gesture and proximity-based interaction, Virtual controls - buttons, dials, sliders, steering wheels, menus, Locomotion techniques - teleportation, walking, flying, Selection - Hand and Gaze based, Techniques for object grabbing and manipulation, Scaling objects, Multimodal interfaces, Visual interface, Tracking interface-head and eye tracking, Auditory interface	
Module-3 – Augmented Reality - Devices and Techniques	***15 Hour***
AR technology, Types - Marker-based AR, Markerless AR, Projection-based AR, Superimposition-based AR, Outlining-based AR. AR devices- Smartphones and tablets-ARKit and ARCore, AR glasses, Head-Mounted displays, Smart Eyewear, Multimodal interaction techniques - Touch gestures, Hand gestures and tracking, voice commands, physical controllers, Registration- Geometric and Photometric, Special AR Interaction Techniques: Interaction by navigation, gaze-based interaction, tangible user interface.	
Module-4 – Foundations of Mixed Reality	***15 Hour***
I/O devices - Cave Automatic Virtual Environment, Head-Up display, Head-mounted display, Holograms, Algorithms in mixed reality, Calibration, Object Recognition, Object tracking, Applications of Mixed Reality, Depth sensing, Mesh generation, Simultaneous Localization and Mapping (SLAM), Scene objects, Scene components - Quads and Meshes, bounding boxes, collision meshes, metadata	

Module-5 – Haptic Technology	***15 Hour***
Taction and haptics - definitions, Human touch system - tactual stereognosis, Cutaneous senses, Kinesthetic senses, Tactile and Kinesthetic devices - Specifications and principles, Haptic sensors, and actuators - types, Principles, and comparison, Elements of a Haptics software, Haptic rendering, The Haptic Loop, Rendering Specific Haptic Effects, - texture Rendering of virtual spring and wall, Rendering of virtual damper, 3D Haptic rendering, Inside and Outside a box, Inside and Outside a circle.	

Learning Resources	1. *Marschner, Shirley "Fundamentals of Computer Graphics", 5th Edition, CRC Press, 2021.* 2. *Steven M. LaValle, Virtual Reality, Cambridge University Press, 2023.* 3. *Ralf Doerner and et al., Virtual Reality and Augmented Reality (VR/AR): Foundations and Methods of Extended Realities (XR), Springer, 2022*	4. *Yuichi Ohta, Hideyuki Tamura, Mixed Reality: Merging Real and Virtual Worlds, Springer-Verlag, 2013.* 5. *Weir D. W and Colgate J. E Stability of haptic displays. In M. C. Lin and M. Otaduy, Eds., Haptic Rendering: Foundations, Algorithms, and Applications. AK Peters, 2008.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. Sathyanarayanan, NIOT*	1. *Dr. P.V. Manivannan, IIT Madras, pvm@iitm.ac.in*	1. *Dr. R.Senthilnathan, SRMIST*
2. *Dr. Jai Nareesh, HP*	2. *Dr. P. Karthikeyan, MIT Chennai, pkarthikeyan @mitindia.edu*	2 *Dr. S. Anitha Kumari, SRMIST*

Course Code	21MHE532L	Course Name	ROBOT PROGRAMMING LABORATORY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							0	0	6	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart knowledge in RAPID programming for Industrial Manipulators*
CLR-2:	*introduce the concept and fundamentals of Robot Operating system*
CLR-3:	*impart knowledge in programming manipulators for various application*
CLR-4:	*impart knowledge and skills in the implementation of perception and localization algorithms*
CLR-5:	*impart knowledge and skills in the implementation of planning and motion control algorithms*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the skills to program Industrial Robot using RAPID*		2	
CO-2:	*learn the fundamentals and concepts of Robot Operating System*		2	
CO-3:	*gain the skill set in programming manipulators for various application*		2	
CO-4:	*implement the algorithms for mobile robot perception and localization*		2	
CO-5:	*implement the algorithm for mobile robot motion planning and control*		2	

Unit-1 - Industrial Robot Programming Using RAPID	***15 Hour***
Getting started with GUI of Robot programing software, Foundations of robot programing language, Programming with Flexpendant / Virtual Flex Pendant Create, Add, Edit, Save and Run. Understanding Routines, Modules, Program Pointer and Motion Pointer, creating a solution with station and a robot controller Creating frames, solids, setting-up local origin- Creating work object, target, empty path - Synchronize virtual controller with Robot controller to run a basics movement program, Modelling Functions and Measuring, Action Programming, Smart Component Usage, Working with I/O signals	
Unit-2 - Introduction to ROS	***15 Hour***
Installation of ROS, Workspace and Package, Exploring ROS Filesystem IDE, ROS Node creation, Publisher and Subscriber, Understanding roslaunch, rosbag, Understanding ROS Topics and rqt, Understanding Services and Parameters, Understanding rcl, rclpy with Turtlesim , Implementing Topics, Service, Parameters, Visualization Tools: rviz and Gazebo , Spatial descriptions in ROS , Wandering robot, Follower Robot	
Unit-3 - Industrial Manipulator Programming	***15 Hour***
Installing ROS Packages for ABB Yumi, Network Setup, Firmware setup and Setup of Yumi Controller, Griper Setup , Setup YuMi ROS Interface through TouchPendant, Running Task and Handling errors , Introduction to programming and simulation using Robot studio, Control Interfaces – Position Control, Gripper Control , Starting RAPID Scripts, Live Nodes and MoveIt Vision Based Closed Control of Single arm for Pick and Place Task , Vision Based Closed Control of Single arm for Pick and Place Task, Dual arm manipulation for an assembly task , Dual arm manipulation for an assembly task , Interfacing Dobot-Magician manipulator to ROS, Understand service-programming and creating a server and client in ROS for Dobot magician , Programming for Point-to-Point motion – 1, Programming for Point-to-Point motion – 2, Programming for Continuous motion – 1 , Programming for Continuous motion – 2 , Programming for Continuous motion – 3	
Unit-4 - Mobile Robot Perception and Localization	***15 Hour***

Wheel Odometry, PID heading control of the robot, PID longitudinal control of the robot, Camera modelling and homographs, Camera calibration Lane marking detection, Visual servo control for lane following, Map building, Visual odometry, Interfacing of range sensor and IMU, Understanding Kalman Filter Sensor fusion with EKF, Visual inertial odometry, Object detection
Unit-5 - Mapping, Motion Planning and Control ***15 Hour***
Map Considerations, Types, Access -, Global Path Planning – A , Global Path Planning – PRM, Global Path Planning – RRT , Control in Obstacle-free Environment Map update environmental objects with manual jogging , Local planning -Bug Algorithm Variants, Local planning – VFH , Motion Planning and Control in Dynamic Environment, Reinforcement learning based navigation*

Learning Resources	1. *ABB Yumi Manual* 2. *ABB Robot studio* 3. *Dobot studio*	4. *Dobot manual* 5. *Robot Operating System (ros.org)* 6. *RAPID Programming*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*15%*	-	*15%*	-	*15%*	-	-
Level 2	*Understand*	-	*25%*	-	*20%*	-	*25%*	-	-
Level 3	*Apply*	-	*30%*	-	*25%*	-	*30%*	-	-
Level 4	*Analyze*	-	*30%*	-	*25%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-	-	-
Level 6	*Create*	-	-	-	*5%*	-	-	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Mohammed Sagheer, ZF commercial vehicle control systems Pvt. Ltd*	1. *Dr. G Nagamanikandan, IIIT Hyderabad*	1. *Dr. Ranjith Pillai R, SRMIST*
2. *Mr. Shankar Bharathi, Larsen & Toubro Technology Services*	2. *Dr. R Thiyagarajan, IIT Tirpuati*	2. *Dr. K Sivanathan , SRMIST*

Course Code	21MHE533T	Course Name	MECHATRONICS IN ELECTRIC VEHICLE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on types of electric vehicle and modelling*
CLR-2:	*gain knowledge on motors used in EV*
CLR-3:	*accrue the knowledge of different power converters used in EV*
CLR-4:	*impart knowledge on controllers, battery management and charging system*
CLR-5:	*comprehend the knowledge on advanced driver assistance system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the evolution of electric vehicle*	3		1
CO-2:	*analyze the benefits of electrical motors used in EV*	3	2	
CO-3:	*apply different power converters in EV*	3	1	
CO-4:	*analyze the different type of controllers and battery management system in EV*	3	1	
CO-5:	*incorporate the various types of advanced driver assistance system*	3		

Module-1 - Electric Vehicle Components, Architecture and Modelling of EV	***9 Hour***
History of Electric Vehicles -Automobile power Train-Architecture of Electric Vehicles -Types of Electric Vehicles- Break down of key components in EV, Efficiency, Capital and operating cost. Vehicle Dynamics Modelling- Battery Modeling, Thermal Management Modeling.	
Module-2 - Electrical Motors for EV	***9 Hour***
Induction to Motors -Permanent Magnet Brushless DC motor -Switched reluctance motor -Permanent magnet synchronous motor and their controllers -Regenerative Braking-Integration with Vehicle Systems	
Module-3 - Power Electronics Converters for EV	***9 Hour***
Power Semiconductor devices- Rectifiers- DC -DC converters-Inverters -Bidirectional Chargers.	
Module-4 - Embedded Controllers, Battery Management Systems (BMS) and Electric Vehicle Charging for EV	***9 Hour***
Vehicle Control Unit -Controllers used in EV, Batteries -Types of Batteries- Battery packs- Energy Density and Range- Battery Degradation and Lifetime-Functions of a BMS-State of Charge (SoC) -State of Health-Temperature Management- Cell Balancing- Charging Control-Sensors-Battery Management Systems -User Interface and Communication, ON Board chargers -Off board chargers- Level 1 Charging -Level 2 Charging -DC fast Charging-Charging Connectors- Range and Efficiency.	
Module-5 – Advanced Driver Assistant Systems and Electric Vehicle standards	***9 Hour***
Driver Monitoring Systems-Gesture Control and Voice Recognition- Automatic Emergency Braking-Lane change detection -Traffic Sign Recognition-sensors for ADAS- Vehicle Safety Standards- Government incentives and policies	

Learning Resources	1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001 2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003. 3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003. 4. Fundamentals of Vehicle Dynamics, Thomas Gillespie, SAE Publication. 5. Electric vehicle battery systems by Sandeep Dhameja, Newnes Publishing, 2002	6. Frank Vahid and Tony Givargis, Embedded system design: A unified hardware/Software introduction, Third edition, John Wiley & sons, 2010 7. R. Krishnan, "Electric Motor Drives - Modeling, Analysis & Control", PHI Learning Private Ltd, 2009. 8. L. Ashok Kumar, S. Albert Alexander, "Power Converters for Electric Vehicles", CRC Press, Taylor & Francis Group, 2021

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Ms.S.Senthil kumar, Grundfos pums india (p) Ltd,senthel.s@gmail.com	1. Dr. M. Baskaran, Associate professor,KSR College of Technology, baskaranm@ksrct.ac.in	1. Dr.R.Gangadevi, SRMIST
2. Dr.N.Gunavanthini,TANGEDCO,Salem,gunatneb1990@gmail.com	2. Dr. S.S. Dash, Government college of Engineering, Keonjhar,Odisha,munu_dash_2k@yahoo.com	2. Dr.M.Santhosh Rani,SRMIST

Course Code	21MHE534T	Course Name	AUTOMOTIVE SOFTWARE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain a comprehensive understanding of automotive electronics, embedded systems, and the role of software in vehicles.*
CLR-2:	*develop skills to design and implement robust automotive software architectures using industry-standard tools and methodologies.*
CLR-3:	*learn to create and manage automotive control systems and diagnostic tools, including advanced driver assistance systems (ADAS).*
CLR-4:	*acquire proficiency in testing, validating, and verifying automotive software, focusing on reliability, safety, and security.*
CLR-5:	*stay ahead with insights into autonomous vehicles, connectivity, electrification, and other future technologies in the automotive industry.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the fundamentals of automotive software and embedded systems.*		2	
CO-2:	*design and implement automotive software architectures.*		2	
CO-3:	*develop and test automotive control systems and diagnostics.*		2	
CO-4:	*apply testing, validation, and verification techniques to automotive software.*		2	
CO-5:	*explore emerging trends and future directions in automotive software technology.*		2	

Module-1 - Introduction to Automotive Software and Embedded Systems	***9 Hour***
Overview of Automotive Software Systems: Introduction to automotive electronics, Role and importance of software in modern vehicles, Trends in automotive software development. Embedded Systems in Automotive Applications: Basics of embedded systems, Microcontrollers and microprocessors used in automotive, Sensors and actuators in vehicles. Software Development Lifecycle for Automotive Applications: Requirements engineering, Software design methodologies, Implementation and testing. Standards and Protocols: Overview of AUTOSAR (Automotive Open System Architecture), Communication protocols (CAN, LIN, FlexRay, MOST, Ethernet)	
Module-2 – Automotive Software Design and Architecture	***9 Hour***
Software Architectures for Automotive Systems: Layered architecture, Component-based architecture, Service-oriented architecture, Real-Time Systems and Operating Systems: Real-time operating systems (RTOS), Scheduling algorithms, Memory management, Model-Based Design (MBD): Introduction to MBD and its advantages, Tools and techniques (MATLAB/Simulink), Case studies and practical examples, Software Development Tools and Environments: Integrated Development Environments (IDEs), Compilers, debuggers, and simulators, Version control systems	
Module-3 - Automotive Control Systems and Diagnostics	***9 Hour***
Control Systems in Automobiles: Basics of automotive control systems, Engine control units (ECUs) and their functions, Vehicle dynamics control. Diagnostics and Fault Tolerance: On-board diagnostics (OBD) systems, Fault detection and isolation techniques, Redundancy and fail-safe systems. Advanced Driver Assistance Systems (ADAS): Overview of ADAS functionalities, Sensors and data fusion in ADAS, Software algorithms for ADAS. Case Studies and Applications: Anti-lock braking systems (ABS), Electronic stability control (ESC), Adaptive cruise control (ACC)	
Module-4 - Software Testing, Validation, and Verification	***9 Hour***

Testing Methodologies: Unit testing, integration testing, system testing, Static vs. dynamic testing, Test-driven development (TDD). Validation and Verification, Verification techniques, Validation processes, Compliance with automotive standards (ISO 26262). Software-in-the-Loop (SIL) and Hardware-in-the-Loop (HIL) Testing: Concepts and benefits of SIL and HIL, Setup and execution of SIL and HIL tests, Tools and platforms for SIL and HIL. Safety and Security in Automotive Software: Functional safety concepts, Cybersecurity threats and mitigation, Safety-critical software design
Module-5 – Emerging Trends and Future Directions ***9 Hour***
Autonomous Vehicles and Artificial Intelligence: Levels of vehicle autonomy, AI and machine learning in autonomous driving, Software challenges in autonomous vehicle development, Connectivity and IoT in Automotive: Vehicle-to-everything (V2X) communication, IoT applications in automotive, Cloud computing and big data analytics, Electrification and Energy Management: Software for electric and hybrid vehicles, Battery management systems (BMS), Energy-efficient driving strategies, Case Studies and Future Perspectives: Case studies on cutting-edge automotive software projects, Future trends and research directions in automotive software

Learning Resources	1. *Navet, N., & Simonot-Lion, F. (2008). Automotive Embedded Systems Handbook. CRC Press.* 2. *Schäuffele, J., & Zurawka, T. (2016). Automotive Software Engineering: Principles, Processes, Methods, and Tools. SAE International.* 3. *Jiménez, M., Palomera, R., & Couvertier, I. (2013). Introduction to Embedded Systems: Using Microcontrollers and the MSP430. Springer.*	4. *Kiencke, U., & Nielsen, L. (2005). Automotive Control Systems: For Engine, Driveline, and Vehicle. Springer.* 5. *Mueller, M., Hoeffgen, K., & Birkhofer, A. (2015). Automotive SPICE in Practice: Surviving Implementation and Assessment. Springer*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr.Murali Arunachalam, ZF CVCS, murali.arunachalam@zf.com*	1. *Dr. P.V. Manivannan, IIT Madras, pvm@iitm.ac.in*	1. *Dr. K. Sivanathan, SRMIST*
2. *Mr. Guna Surendra, Hitachi, Japan*	2. *Dr. T. Asokan, IIT Madras, asok@iitm.ac.in*	2. *Ms. M. Nandhini, SRMIST*

Course Code	21MHE535T	Course Name	AUTOMOTIVE TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechatronics Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart the knowledge about automobile components and power generation systems*
CLR-2:	*study the basic concepts of automobile power transmission systems*
CLR-3:	*understand the principle of steering, suspension and braking systems*
CLR-4:	*gain the basic knowledge of automobile electrical systems*
CLR-5:	*learn the basic concepts automobile safety systems and instruments*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*comprehend the basics elements of automobile and principle of IC engines*		2	
CO-2:	*familiarize the principle of power transmission systems*		2	
CO-3:	*acquire the knowledge and applications different steering, suspension and braking systems in automobile*		2	
CO-4:	*appraise the fundamental concepts and terminologies of automobile electrical systems*		2	
CO-5:	*explore the concepts automobile safety systems and instruments*		2	

Module-1 - Components of Automobile and Power Generation System	***9 Hour***
Elements of automobile – Types and parts of Engine - Principle of Diesel engine – Fuel Injection system and types – Principle of SI engine – Combustion of fuels in SI engine – combustion chamber design - Detonation and scavenging	
Module-2 – Transmission System	***9 Hour***
Transmission requirements – manual and automatic transmission system – Dual clutch transmission system – Continuously variable transmission system – Toroid transmission system – Drive system – four wheel and all wheel drive system	
Module-3 - Steering, Suspension and Braking System	***9 Hour***
Principle of steering system – Hydraulic and electrical power steering system - Types of suspension system – mechanical, pneumatic, hydraulic adaptive suspension system – Types of braking system – Pneumatic, hydraulic and electronic brake control system	
Module-4 - Automobile Electrical System	***9 Hour***
Battery system – Types of batteries – selection of batteries – Testing of batteries – Starting system – Types of starting motors - Starting system layout – Charging system – purpose and components of charging system – Ignition system – components and types of electronic ignition system – lighting and vehicle accessories systems	
Module-5 – Instrumentation and Safety Systems	***9 Hour***
Sensors and display units in automobile – Global positioning system – Telematics – Anti lock braking system – stability and traction control system – Air bag system – Tire pressure monitoring system – Automatic parking system - Automatic dimming mirrors – obstacle avoidance system	

Learning Resources	1. *Kirk VanGelder, Kirk T. VanGelder, Fundamentals of Automotive Technology, Jones & Bartlett Learning, 2022.* 2. *Patrick Hossay, Automotive Innovation the Science and Engineering Behind Cutting-Edge Automotive Technology, CRC Press, 2019* 3. *Tom Denton, Automobile Electrical and Electronic Systems, Taylor & Francis, 2013*	4. *Konrad Reif, Fundamentals of Automotive and Engine Technology, Standard Drives, Hybrid Drives, Brakes, Safety Systems, Springer Fachmedien Wiesbaden, 2014* 5. *S Sheeba Rani, P Subha Hency Jose, P Rajalakshmy, Automotive Electrics and Instrumentation Electrical Systems of AutoMotives, Educreation Publishing, 2019*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
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Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. P. Thangadurai, Aditya Auto Components, thangadurai08@gmail.com*	1. *Prof. P. SathishKumar, NIT Karaikal, Sathish.p@nitpy.ac.in*	1. *Dr. S. Senthilraja, SRMIST*
2. Mr. G, Vijayaram, TAFE, vijayaram@tafe.com	2. *Prof. V. Muralidharan, Associate Professor, BS Abdur Rahman Crescent Institute of Science & Tech, muralidharan@crescent.education*	*2. Mr. J. Thiyagarajan, SRMIST*