ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 18
(Syllabi for Mechatronics Engineering Programme Courses)
(Revised on August 2024)

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

Engineering Science 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	21MHS201T	Course Name	THERMODYNAMICS AND HEAT TRANSFER	Course Category	S	ENGINEERING SCIENCE	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:	*evaluate the internal energy, work done and analyze the Coefficient of performance of heat engine, refrigerator and heat pump*
CLR-2:	*analyze the different properties of air using psychrometry chart and the working principle of different air conditioning and refrigeration systems*
CLR-3:	*apply the basic concepts of heat transfer and evaluate the conduction and convection heat transfer in plane wall, cylinder and sphere*
CLR-4:	*analyze the heat transfer effects in different electronics components*
CLR-5:	*study the mathematical modelling of different thermal systems and different cooling techniques of transformer and electric motor*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define and apply the concepts of first law and second law of thermodynamics in different real systems*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*define the psychrometry properties and evaluate the performance of refrigeration and air conditioning systems using psychrometry chart*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*recap the basics of heat transfer and demonstrate the application of conduction, convection and radiation in different real time systems*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*estimate the amount of heat generation in different electronic components and select the suitable cooling system*	*1*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-5:	*gain the knowledge of thermal system design modelling and different cooling methods of electrical machines*	*1*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Fundamentals of Thermodynamics	***9 Hour***
Thermodynamic concepts and definitions – System, Surroundings, Cycle, process, path and point function, Mechanical, thermal, chemical and thermodynamic Equilibrium - Laws of thermodynamics – Zeroth law, first law and second law – Application of first law of thermodynamics to non-flow process - Application of first law of thermodynamics to flow process - Second law of thermodynamics – Application of second law of thermodynamics in heat engine, refrigerator and heat pump - Entropy – Change in entropy for isobaric process, isochoric process and isentropic process	
Unit-2 - Psychrometry and Applications in Refrigeration and Air Conditioning	***9 Hour***
Psychrometry properties definition – Psychrometry chart – Psychrometry process – sensible heating, sensible cooling, humidification and dehumidification process – cooling and humidification, cooling and dehumidification, Heating and humidification, Heating and dehumidification - mixing of air streams - Refrigeration and air conditioning system – Fundamentals of refrigeration – vapour compression refrigeration and vapour absorption refrigeration system – types and working principle of window, split and centralized air conditioning system	
Unit-3 - Fundamentals of Heat Transfer	***9 Hour***
Modes of heat transfer – conduction, convection and radiation – one dimensional steady state heat conduction – heat transfer in plane wall, cylinder and spherical shell - heat transfer in composite wall, cylinder and spherical shell – Free convection and forced convection – Free convection over a horizontal plate - Free convection over a vertical plate, cylinder - Free convection over an inclined surface	

Unit-4 - Application of Heat Transfer in Electronics Systems	***9 Hour***
Heat generation in active devices – CMOS device – JFET – MOSFET, Heat generation in passive devices – Resistor – capacitor – Thermal Management system design for electronic systems – Cooling of electronic components with heat pipes	
Unit-5 – Application of Heat Transfer in Mechanical and Electrical Systems	***9 Hour***
Elements of IC engine – analysis of heat transfer in IC engine – elements of refrigeration system – modes of heat transfer in refrigeration system – thermos-electric effect – Seeback effect – Peltier effect – Thomson effect – thermoelectric cooler and heat pumps- cooling system and methods in transformer and electric motors – modelling of heat transfer systems	

Learning Resources	1. *Yunus A Cengel Michael A Boles, Thermodynamics, 8th ed., Tata McGraw-Hill, 2017* 2. *Nag.P.K., Engineering Thermodynamics, 6th ed., Tata McGraw-Hill, 2017* 3. *Yunus A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer - Fundamentals and Applications | 6th Edition, 2020*	4. *Upadhyay, K.G, Design of Electrical Machines, New Age International Publishers, 1st edition, 2018* 5. *Ralph Remsburg, Advanced thermal design of electronic equipment, Springer, 1998th edition, 2012* 6. *Dhar P.L, Thermal System Design and Simulation, Academic Press Inc., 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*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*15%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. K. Gopinath, Intel Technology India Pvt Ltd.,*	1. *Dr. M. Baskaran, Associate Professor, KSR College of Technology*	1. *Dr. S. Senthilraja, SRMIST*
2. *Mr. S. Senthilkumar, Grundfos Pumps India Pvt. Ltd.,*	2. *Dr. P. Ravichandran, Associate Professor, Kongu Engineering College*	2. *Mr. M. Thirugnanam, SRMIST*

ACADEMIC CURRICULA

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	21MHC201T	Course Name	ELECTRICAL ACTUATORS AND DRIVES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	21MHC202J	Progressive Courses	21MHE403T
Course Offering Department	Mechatronics Engineering	Data Book / Codes / Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	outline the concepts of DC and AC Electrical Machines
CLR-2:	gain knowledge on Stepper, Servo, BLDC Motors and their applications
CLR-3:	familiarize the different Power Electronic Devices and Converters
CLR-4:	illustrate the working of different DC Electrical Drives
CLR-5:	acquire the knowledge on AC Electrical Drives

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	examine the fundamentals of DC and AC Machines	3	3	2	-	-	-	-	-	-	-	-	-	-	-	2
CO-2:	apply the Special Machines for different actuations	3	2	2	-	-	-	-	-	-	-	-	-	-	-	2
CO-3:	describe the working principle of Rectifiers, Choppers and Inverters	3	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	summarize the working of Electrical Drives	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	disseminate the latest trends in applications of Electrical Drives	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - DC and AC Electrical Actuators	**9 Hour**
Overview of DC Machines, Single Phase Transformers, Three phase Induction Motors, Single Phase Induction Motors, Synchronous Motors, Characteristics, Speed Control, Starting and Braking of DC and AC Machines	
Unit-2 - Special Machines and Actuators	**9 Hour**
Overview of PMDC, Stepper, BLDC and Servo Motors, Robotic grippers, MEMS actuators, Introduction to solenoids, Solenoid operated fuel injection systems	
Unit-3 - Power Electronic Devices and Converters	**9 Hour**
Power semiconductor devices and their working -Power Diode, Power BJT, MOSFET, IGBT, SCR, Power Converters-Single Phase and Three Phase Rectifiers, Choppers, Buck, Boost and Buck boost converters, Three Phase Voltage Source Inverters, Voltage regulators, Cycloconverters	
Unit-4 - DC Electric Drives	**9 Hour**
Introduction to Electric Drives, Choice of electric drives - Status of DC and AC drives, Fundamental Torque Equations, Speed Torque Conventions and Multiquadrant Operation, Control of Electrical Drives, Speed Control methods - Armature Voltage Control and Ward Leonard Drives, Controlled Rectifier fed DC Drives, Chopper, Controlled DC drives, Traction Drives, Problems	
Unit-5 - AC Electric Drives	**9 Hour**
Speed Control of Three phase Induction Motors - Stator Voltage Control, Variable frequency Control, Voltage source inverter (VSI) Control, Cycloconverter control ,Rotor Resistance Control and Slip Power recovery schemes, Problems, BLDC motor Drives, Stepper Motor Drives and Battery powered Drives, Applications of Drives	

Learning Resources	1. *Bhimbra. Dr.P.S., "Power Electronics", Khanna Publishers, 2012.* 2. *Dubey.G.K., "Fundamentals of Electrical Drives", Narosa publishing house 2001.* 3. *Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, New Delhi, 2003.*	4. *Edward Hughes, John Hiley, Keith Brown, Ian McKenzie Smith, Hughes Electrical and Electronics Technology, Pearson Education, 12th ed., 2016.* 5. *B. L Theraja, A. K. Theraja, A text book of Electrical Technology, Volume II, S.Chand Publications, 2008* 6. *S. K. Bhattacharya, S. Chatterjee, Industrial Electronics and Control, TTTI, Chandigarh, Vol.II, 2017*

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. N. Gunavardhini, TANGEDCO, Salem, gunatneb1990@gmail.com*	1. *Dr.K.Sujatha,Dr.MGR Educational and Research Institute, sujatha.eee@drmgrdu.ac.in*	1. *Dr. M. Santhosh Rani, SRMIST*
2. *Ms.Joyce Sumathi, CMWSSB, sumathijoyce1968@gmail.com*	2. *Dr.G.R.Kanagachidambaresan, Vel Tech, kanagachidambaresan@gmail.com*	2. *Dr.R.Gangadevi, SRMIST*

Course Code	21MHC202J	Course Name	ANALOG AND DIGITAL ELECTRONICS	Course Category	C	PROFESSIONAL CORE	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:	outline the concepts of various semiconductor devices
CLR-2:	illustrate the working of amplifiers biasing and significance of amplifier for various wave shaping circuits
CLR-3:	gain knowledge on operational amplifiers and its applications
CLR-4:	familiarize the concepts of digital circuits
CLR-5:	acquire the knowledge on sequential circuits

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	analyze the characteristics of special semiconductor devices	3	1	1	-	-	-	-	-	-	-	-	-	-	2	-
CO-2:	analyze different types of amplifiers, oscillators and multivibrator circuits	3	3	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	design linear and non-linear applications of Op-amps	3	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	design various combinational digital circuits using logic gates	3	3	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	understand the concepts and applications of various sequential circuits	3	3	3	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Applications of PN Junctions — **12 Hour**

Operation and Vi Characteristics - Tunnel Diode, Varactor Diode, Photo Diode, Light Emitting Diode and Laser Diode, UJT. Diode Applications – Clippers, Clampers, Half Wave, Full Wave and Bridge Rectifier, with and without filter. Transistor Biasing – Overview (Concepts) of Fixed Bias, Emitter Bias with and without Emitter Resistance. Analysis and Design

Experiments:

1. Characteristics of Half Wave and Full Wave Rectifier With and Without Filter. 2. Characteristics of UJT

Unit-2 - Feedback Amplifiers, Oscillators and Multivibrators — **12 Hour**

Feedback Amplifiers: Concepts of Feedback – Classification of Feedback Amplifiers – General Characteristics of Negative Feedback Amplifiers – Effect of Feedback on Amplifier Characteristics – Voltage Series, Voltage Shunt, Current Series and Current Shunt Feedback Configurations – Simple Problems. Oscillators: Barkhausen Criterion for Oscillation – Types of Oscillators. Construction and Working Principle of RC and LC Oscillators. Multivibrators: Construction and Working Principle of Astable, Bistable and Monostable Multivibrator.

Experiments:

1. Design of Astable Multivibrator. 2. Design of RC Phase Shift Oscillator

Unit-3 - Operational Amplifier Applications — **12 Hour**

Basic Information About Op-Amps – Ideal Operational Amplifier – General Operational Amplifier Stages -And Internal Circuit Diagrams of IC 741, DC and AC Performance Characteristics, Slew Rate, Open and Closed Loop Configurations, Inverting and Non-Inverting Amplifier, Differential Amplifier, Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I And I-to-V Converters, Adder, Subtractor, Integrator, Differentiator, Logarithmic Amplifier, Antilogarithmic Amplifier, Comparators, Zero Crossing Detector, Schmitt Trigger, Precision Rectifier, Peak Detector, Clipper and Clamper.

Experiments:

1. Inverting and Non-Inverting Amplifiers Using Op-Amp. 2. Study of Half Wave and Full Wave Precision Rectifier

Unit-4 - Combinational Logic Circuits	**12 Hour**
Introduction to minterms and maxterms, Minimization of Boolean Expressions Using K – Map, Combinational Circuits -Design steps - Adder and Subtractor, Multiplexer and De-Multiplexer, Encoder and Decoder, Logic Diagram of Parallel Binary Adder/Subtractor, Code Converters, Magnitude Comparator. Programmable Logic Devices - PLA, PAL, Complex PLD *Experiments:* *1. Realization of Logic Circuits of Multiplexer and De-Multiplexer. 2. Realization of Logic Circuits of Encoder and Decoder. 3. Design of Code Converters*	
Unit-5 - Sequential Logic Circuits	**12 Hour**
Introduction to Latches and Flip-Flop, Triggering of Flip Flops, Truth Table, Characteristic Table, Excitation Table and Equations for Flip Flops, Conversion of Flip Flops, Master – Slave Flip-Flop, Design of Sequential Circuits - Synchronous and Asynchronous counters, Shift Registers - Serial in Serial Out, Serial In Parallel Out, Parallel In Serial Out and Parallel In Parallel Out *Experiments:* *1. Study of Flip Flop – SR, JK, T and D. 2. Design of Shift Registers using Flip-Flops. 3. Design of Synchronous Counter*	

Learning Resources	1. *Robert L. Boylestad and Louis Nasheresky, Electronic devices and circuit theory, Tenth edition, Pearson, 2013.* 2. *D Roy Choudhury and Shail Bala Jain, Linear Integrated Circuits, Fifth edition, new age International 2017.* 3. *Sergio Franco, Design with operational amplifiers and analog integrated circuits, Fourth edition, McGraw Hill, 2017.*	4. *M. Morris Mano and Michael D.Ciletti, Digital design, Pearson education, 2008.* 5. *Thomas L. Floyd, Digital Fundamentals, Tenth edition, Pearson education, 2011.* 6. *David A.Bell, Electronic Devices and Circuits, Fifth edition, Oxford University Press, 2008.* 7. *Adel S. Sedra and Kenneth C. smith, Microelectronic Circuits theory and applications, sixth edition, Oxford University Press, 2010.* 8. *Jacob Millman, Microelectronics, McGraw Hill, 2nd Edition, Reprinted, 2009.*

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*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*15%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	-	-	-	*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. *Subramani K.P,CTO, vTitan Corporation Pvt. Ltd.*	1. *Dr.R.Thiyagarajan, Indian Institute of Technology ,Tirupati, thiyagu@iittp.ac.in*	1. *Dr.V.Krithika, SRMIST*
2. *T.S.Srikanth, Principal Chief Engineer, CREAT UNO Minda Group*	2. *Dr.Sreejith.S, National Institute of Technology, Silchar(NITS),Assam, sreejith@ee.nits.ac.in*	2. *Dr.S.Vasanth, SRMIST*

Course Code	21MHC203J	Course Name	FLUID POWER SYSTEM AND AUTOMATION	Course Category	C	PROFESSIONAL CORE	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:	*get exposed to the fundamentals of fluid power principles and fluid power components*
CLR-2:	*explore various control valves and logics used in fluid power systems*
CLR-3:	*realize sequencing control of fluid power actuators for an application*
CLR-4:	*apply positioning control of fluid power actuators*
CLR-5:	*acquire knowledge on role of PLC in fluid power system automation*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*select fluid power system sources and actuators for an application*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*demonstrate competency in choice of control valves and logics based on application*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*design and implement any sequencing of actuations based on the application requirements*	-	*2*	*3*	-	*1*	-	-	-	-	-	-	-	-	*1*	*2*
CO-4:	*implement positioning control of cylinders using servo valve*	-	*2*	*3*	-	*1*	-	-	-	-	-	-	-	-	*1*	*2*
CO-5:	*develop PLC ladder logic programming control for fluid power circuits*	*2*	-	*3*	-	*1*	-	-	-	-	-	-	-	-	*1*	*2*

Unit-1 - Fluid Power Sources and Actuators	***12 Hour***
Introduction to fluid power system – Types, Advantages and Applications - Physics of fluid power - Pneumatic sources – Compressors and its types –Working principle, design and selection criteria - Hydraulic sources – Pumps and its types – Working principle, design and selection criteria - Types of fluid power actuators - Special cylinders – Design and selection criteria. *1. Study experiment on pneumatic components and their symbolic representation, 2. Experiment on direct and indirect control of fluid power actuators*	
Unit-2 - Control Valves in Fluid Power Systems	***12 Hour***
Direction control valves – Types, actuation techniques and neutral positions - Continuous reciprocation of single-acting and double-acting cylinder - Flow control valves, their needs and types-Speed control circuits - Pressure control valves, their needs and types - Logic valves – Actuator control with logic valves - Time delay valve, and Quick exhaust valve. *1. Experiment on continuous reciprocation of fluid power actuators, 2. Experiment on speed control circuits*	
Unit-3 - Design and Implementation of Fluid Power Circuits	***12 Hour***
Two-cylinder and three-cylinder sequencing – Pneumatic and electro-pneumatic implementation - Two-cylinder and three-cylinder sequencing with signal conflict – Pneumatic and electro-pneumatic cascading implementation - Timer and counter-based control of fluid power actuators. *1. Experiment on pneumatic and electro-pneumatic implementation of multiple actuator sequencing control with and without signal conflict* *2. Experiment on timer and counter-based control of pneumatic actuators*	
Unit-4 - Position Control of Fluid Power Actuators	***12 Hour***
Synchronization circuits - Accumulators and application circuits - Need for positioning control of fluid power actuators - Proportional valves – working, types and applications - Servo valves – working, types and applications - Servo pneumatic/Servo hydraulic positioning system - Application case studies. *1. Experiment on synchronization circuits, 2. Experiment on servo pneumatic position control*	

Unit-5 - Applications of PLC in Fluid Power Systems	***12 Hour***
Introduction to programmable logic controllers - Architecture and advantages of PLC - Ladder logic programming – Logic gates, start/stop operation with latching - Timers and counters - Interlocking - Continuous reciprocation circuit and sequential circuit implementation using PLC. *1. Experiment on basic ladder logic programming of PLC and continuous reciprocation of fluid power actuator using PLC* *2. Experiment on multiple actuator sequencing control using PLC*	

Learning Resources	1. *Anthony Esposito, "Fluid Power with applications", Prentice Hall International, 7th edition, 2014.* 2. *Majumdar .S.R., "Oil Hydraulics: Principle and Maintenance", Tata McGraw Hill Education, 2012.* 3. *Werner Deppert , Kurt Stoll, "Pneumatic Application", Vogel verlag, 1986*	4. *James L. Johnson, "Introduction to Fluid Power", Prentice Hall, 2004.* 5. *Andrew Parr, "Hydraulics and Pneumatics", Jaico Publishing House, 2003.* 6. *G. Dunning, "Introduction to Programmable Logic Controllers", Cengage Learning.*

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*	*5%*	-	-	*10%*	*5%*	-
Level 2	*Understand*	*15%*	-	-	*10%*	*15%*	-
Level 3	*Apply*	*15%*	-	-	*10%*	*15%*	-
Level 4	*Analyze*	*15%*	-	-	*20%*	*15%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. C. Elan Chezhian, Keyence Engineering, Chennai*	1. *Dr. D. Saravanakumar, VIT University, Chennai*	1. *Dr. T. Muthuramalingam, SRMIST*
2. *Mr. K. Elango, Sealed Air Company, Chennai*	2. *Dr. V. Mugendiran , MIT, Anna University, Chennai*	2. *Mrs. G. Madhumitha, SRMIST*

Course Code	21MHC204L	Course Name	ELECTRICAL ACTUATORS AND DRIVES LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	Co- requisite Courses	*21MHC201T*	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:	*apply the basic concepts of DC motor*
CLR-2:	*analyze the basic concepts of BLDC motor*
CLR-3:	*demonstrate their ability in selecting motors for particular application*
CLR-4:	*implement characteristics of semiconductor devices and converters*
CLR-5:	*illustrate the basic concepts of power converters*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement the functionality of DC motors*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply the knowledge on basic concepts in operating BLDC motors*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the Performance Characteristics of drives*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply the knowledge in selecting motors for different applications*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*illustrate characteristics of semiconductor devices and power converters*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1	***6 Hour***
1. Control of DC motor. *2. Control of stepper motor.*	
Unit-2	***6 Hour***
3. Control of servomotor *4. Control of BLDC motor*	
Unit-3	***6 Hour***
5.Light dimmer control *6. Relay-based control circuit*	
Unit-4	***6 Hour***
7.Rectifier-based control *8. Chopper-based control*	
Unit-5	***6 Hour***
9.Cycloconverter based control *10.Applications of DC,Stepper and Servo motors* *11. Development of a converter using power devices for drives*	

Learning Resources	1. *Bhimbra. Dr.P.S. "Power Electronics", Khanna Publishers, 2012.* 2. *Dubey.G.K. "Fundamentals of Electrical Drives", Narosa publishing house 2001.*	3. *Edward Hughes, John Hiley, Keith Brown, Ian McKenzie Smith, Hughes Electrical and Electronics Technology, Pearson Education, 12th ed., 2016* 4. *Lab Manuals.*

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. *Dr.N.Gunavardhini, TANGEDCO, Salem, gunatneb1990@gmail.com*	1. *Dr.K.Sujatha,Dr.MGR Educational and Research Institute, sujatha.eee@drmgrdu.ac.in*	1. *Dr. M. Santhosh Rani, SRMIST*
2. *Ms.Joyce Sumathi, MWSSB, sumathijoyce1968@gmail.com.*	2. *Dr.G.R.Kanagachidambaresan, Vel Tech, kanagachidambaresan@gmail.com*	2. *Mr. A. Lakshmi Srinivas, SRMIST*

Course Code	21MHC205T	Course Name	MICROCONTROLLER AND EMBEDDED SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	21MHC207L	Progressive Courses	21MHE412T
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 with the functionality of microprocessors and microcontrollers
CLR-2:	acquire knowledge of microcontroller programming in Mechatronics systems
CLR-3:	realize the fundamentals of embedded system design with real time systems
CLR-4:	assimilate the way to create and optimize programs
CLR-5:	incorporate the fundamentals of embedded systems design with real time system

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	evaluate and compare various embedded processors	3	-	-	-	1	-	-	-	-	-	-	-	-	1	-
CO-2:	implement the concepts of microcontroller to Mechatronics systems	3	-	2	-	2	-	-	-	-	-	-	-	-	-	2
CO-3:	apply the fundamentals of embedded system design with real time systems	3	-	-	-	1	-	-	-	-	-	-	-	-	-	2
CO-4:	appreciate the way programs are created and optimized	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-
CO-5:	build simple embedded applications	3	-	1	-	-	-	-	-	-	-	-	-	-	-	2

Unit-1 - Microprocessor and Microcontrollers	**9 Hour**
8-bit and 16-bit microprocessor - architecture - instruction set- addressing mode, Instruction cycle, 8-bit microcontroller – architecture - special function registers - instruction set - addressing mode, - interrupt handling	
Unit-2 - ARM Controller	**9 Hour**
ARM Controller - Architecture - Functional description - ARM state instruction - Thumb state instruction - Addressing modes - Operating modes	
Unit-3 - Introduction to Embedded System	**9 Hour**
Embedded System - Definition, Key Elements- Design Metric Challenges - Design technology - IC technology - Processor technology, Introduction to Arduino – Hardware interfacing - controlling embedded system based devices using Arduino - Arduino IDE - Introduction to Raspberry pi	
Unit-4 - Embedded System – Debugging & Development Environment	**9 Hour**
Debugging Techniques/ Challenges - Program Design and Analysis – Components for Embedded systems- Model of programs - DFG and CDFG - Assembly, linking and loading - Basic compilation techniques - optimization, Interrupts - Interrupt Latency, Embedded software architectures	
Unit-5 - RTOS Based Embedded System Design	**9 Hour**
Introduction to basic concepts of RTOS, Task, process & threads - Task management and scheduling - Interrupt servicing - Multiprocessing and Multitasking - Inter task Communication and data exchange - Synchronization between processes: Semaphores - Memory management - Issues in real-time system design - Design of Embedded Systems – Development of IoT Applications	

Learning Resources	1. *Muhammed Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems", Pearson Education, Second Edition, 2014.* 2. *Douglas V Hall, "Microprocessors and Interfacing", McGraw Hill Education, 3rd Edition (SIE), 2017* 3. *Frank Vahid and Tony Givargis, "Embedded system design: A unified hardware software approach", Pearson Education Asia, 3rd edition, 2009* 4. *Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design (The Morgan Kaufmann Series in Computer Architecture and Design)", 5th Edition, 2022*	5. *Andrew N Sloss, D. Symes, C. Wright, "Arm System Developers Guide", Morgan Kauffman/ Elsevier, 2006.* 6. *Michael McRoberts, " Beginning Arduino", Apress, Year: 2010* 7. *Massimo Banzi, "Getting Started with Arduino: The Open Source", Shroff Publishers & Distributors Pvt Ltd, 2014* 8. *M. A. Mazidi, S. Naimi, S. Naimi, The AVR Microcontroller and Embedded Systems Using Assembly and C, Pearson, 2015*

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%*	-
Level 2	*Understand*	*25%*	-	-	-	*25%*	-
Level 3	*Apply*	*30%*	-	*50%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*50%*	-	*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.Ravi,L&T GeoStructure Private Limited, Ravinagarajan@Intecc.com*	1. *Dr.BamaSrinivasan, Anna University, Guindy, Chennai,bama@annauniv.edu*	1. *Mrs.T.S.Rajalakshmi, SRMIST*
2. *Mr. SathiyaMoorthi, Broadcom Inc, sathiyamoorthi.chinnappan@broadcom.com*	2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	2. *Mrs.M.Nandhini, SRMIST*

Course Code	21MHC206T	Course Name	MECHANICS OF SOLIDS AND FLUIDS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	21MHC208L	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 behavior and properties of materials under external loading conditions, and Analyze the behavior of fluids using the concepts and equations
CLR-2:	analyze the beams and shafts under pure bending and torsion, Analyze the columns using the buckling effect
CLR-3:	identify types of beams and understand their deflection under different types of load
CLR-4:	understand the applications of Bernoulli's equation
CLR-5:	summarize the various losses in pipes

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	estimate the different types of stress induced in materials	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	evaluate the bending stress and shear stress under pure bending and torsion	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	calculate the maximum shear stress and bending moment at the critical section	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	determine the coefficient of discharge of different devices	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	estimate losses in pipes	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Mechanics of Materials and Fluids ***9 Hour***

Introduction-Stress, Strain and Displacement, Fundamental equations deformable body mechanics, Equilibrium, Determination of Internal Resultant Forces by Method of Joints and Method of Sections, Stress-strain relationship, Axially Loaded Bars, Elastic Constants, Poisson's Ratio, Stress-strain diagrams- Tension Test, Compression test, Mechanical properties of materials. Introduction- Fluid Properties, Types of Fluids, Types of Flow, Pressure and its measurement, Pressure measurement devices – Different types of manometers

Unit-2 - Pure Bending, Torsion and Columns ***9 Hour***

Pure Bending-Bending equation and its assumptions, Moment of Inertia for different cross sections, Bending Stress in beams- Torsion- Torsion Equation and its assumptions, Polar moment of inertia, Torsion in stepped and composite shafts- Columns-Buckling of slender column, Critical load, critical stress and effective length for a Column with pinned end, Column Fixed at the Base and Free at the Top, Column with Both Ends Fixed Against Rotation, Column Fixed at the Base and Pinned at the top.

Unit-3 - Beams and Shafts ***9 Hour***

Beams - Types of beams - cantilever, simply supported, fixed and continuous beam Types of loads, Sign conventions, Shear force and bending moment diagram – cantilever, simply supported and over hanging beams. Shafts- Equivalent twisting moment-Shaft with pulley and gear.

Unit-4 - Kinematics and Dynamics of Fluids ***9 Hour***

Fluid flow, Streamline-streak line-path line - stream function - Continuity equation and its application, Rate of flow, Derivation of Euler's equation, Bernoulli's equation and its assumptions, Application of Bernoulli's equation – Venturi meter, Orifice meter

Unit-5 - Flow Through Pipes ***9 Hour***

Introduction to losses in pipes, Types of losses, Darcy – Weisbach's equation, Friction factor, Analysis of Minor losses and Major losses in pipes- pipes in series and parallel, construction and working principle of centrifugal pump and reciprocating pump, Performance of pumps

Learning	1. R.K.Bansal, "Strength of Materials", 6th ed., Lakshmi Publications, 2022.	4. Bansal. R. K, "Fluid Mechanics and Hydraulic Machines", 11th ed., Laxmi publications (P)

Resources	2. *Ramamurtham S and Narayanan R, "Strength of Materials", 20th ed., Dhanpat Rai Pvt. Ltd., 2022.* 3. *Timoshenko. S. P., Gere .M. J, "Mechanics of Materials", 5th ed., Stanley Thornes (PUB) Ltd, 1999.*	*Ltd., 2022.* 5. *Kumar. K. L, "Engineering Fluid Mechanics", S Chand Publications, 2016.* 6. *John.M.Cimbala Yunus A.Cengel, "Fluid Mechanics: Fundamentals and Applications", 4th ed. Mc Graw Hill Higher Education, 2019.*

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. *Mr.G.Gopinath, R&D Manager, ZF, Chennai, Email ID: gopinath.gunasekaran@zf.com*	1. *Dr. D. Madesh, Professor, Dept of Mechanical Engineering, AMET University, Chennai, Email ID: madesh.d@ametuniv.ac.in.*	1. *Mr. M. Chandrasekaran, SRMIST*
2. *Mr. K.Maheshwaran, Assistant Manager , TAFE, Madurai, Email ID: maheshwaran@tafe.com*	2. *Dr. L. Ranganathan, Professor and Head, Dept. of Mechanical Engineering, Agni College of Technology, Chennai, Email ID: mechod@act.edu.in*	2. *Ms. D. Gayathiri, SRMIST*

Course Code	21MHC207L	Course Name	MICROCONTROLLER AND EMBEDDED SYSTEMS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co- requisite Courses	21MHC205T	Progressive Courses	21MHE412T
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 with the functionality of microprocessors and microcontrollers
CLR-2:	gain knowledge of microcontroller programming and embedded system
CLR-3:	assimilate the way programs are to be created and optimized
CLR-4:	apply the concepts of IoT and programming using open-platform
CLR-5:	incorporate the fundamentals of embedded systems design with real time system

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	evaluate and compare various embedded processors	3	2	2	-	2	-	-	-	-	-	-	-	-	1	-
CO-2:	analyze applications of IoT using Arduino	3	2	2	-	2	-	-	-	-	-	-	-	-	-	2
CO-3:	appreciate the way programs are created and optimized	3	2	2	-	2	-	-	-	-	-	-	-	-	-	-
CO-4:	design portable IoT using Raspberry Pi /open platform	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO-5:	design simple embedded applications	3	-	2	-	-	-	-	-	1	-	-	-	-	-	2

Unit-1 - Microprocessor and Microcontrollers	**6 Hour**
1. Microprocessor and Microcontroller programming for basic operations 2. Interfacing of motors of any type with Microprocessor and Microcontroller	
Unit-2 - Arduino Programming and Introduction to Embedded System	**6 Hour**
3.Basic Operations in Arduino Programming 4. Interfacing of motors and displays with Arduino	
Unit-3 - Embedded System – Debugging & Development Environment	**6 Hour**
5. Interrupt-based programs in microprocessor and microcontroller 6. Sensor and actuator interfacing with Arduino controller	
Unit-4 -	**6 Hour**
7. Basic operations in ARM controller 8. Interfacing of motors with ARM controller	
Unit-5 - RTOS Based Embedded System Design	**6 Hour**
9. Programs to explore the internal features of ARM controller. 10. Interrupts handling in ARM controller	

Learning Resources	1. *Muhammed Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, "The 8051 Microcontroller and Embedded Systems", Pearson Education, Second Edition, 2014.* 2. *Douglas V Hall, "Microprocessors and Interfacing", McGraw Hill Education, 3rd Edition (SIE), 2017*	3. *Andrew N Sloss, D. Symes, C. Wright, "Arm System Developers Guide", Morgan Kauffman/ Elsevier, 2006.* 4. *Laboratory Manuals*

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%*	-	*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. N.Ravi, L&T GeoStructure Private Limited, Ravinagarajan@Intecc.com*	1. *Dr.BamaSrinivasan, Anna University, Guindy, Chennai,bama@annauniv.edu*	1. *Dr.M.Mohamed Rabik, SRMIST*
2. *Mr. SathiyaMoorthi, Broadcom Inc, sathiyamoorthi.chinnappan@broadcom.com*	2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	2. *Dr.Cross T Asha Wise, SRMIST*

Course Code	21MHC208L	Course Name	MECHANICS OF SOLIDS AND FLUIDS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co- requisite Courses	21MHC206T	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 behavior and properties of materials under external loading conditions, and Analyze the behavior of fluids using the concepts and equations
CLR-2:	analyze the beams and shafts under pure bending and torsion, Analyze the columns using the buckling effect
CLR-3:	identify types of beams and understand their deflection under different types of load
CLR-4:	understand the applications of Bernoulli's equation
CLR-5:	summarize the various losses in pipes

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	estimate the different types of stress induced in materials	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	evaluate the bending stress and shear stress under pure bending and torsion	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	calculate the maximum shear stress and bending moment at the critical section	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	determine the coefficient of discharge of different devices	3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	estimate losses in pipes	3	2	2	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Basics of Mechanics of Materials and Fluids	**6 Hour**
Tensile test of metallic materials Deflection test on simply supported beam	
Unit-2 - Pure Bending, Torsion and Columns	**6 Hour**
Charpy / Izod impact test on a steel specimen Torsional test on mild steel rod Double Shear test on metallic materials	
Unit-3 - Beams and Shafts	**6 Hour**
Fatigue test Surface Hardness test on metallic materials Determine the coefficient of discharge of the orifice meter	
Unit-4 - Kinematics and Dynamics of Fluids	**6 Hour**
Verification of Bernoulli's theorem. Determine the coefficient of discharge of venturi meter	
Unit-5 - Flow Through Pipes	**6 Hour**
Determination of minor losses due to pipe fittings. Determination of pipe friction factor Performance test on centrifugal pump	

Learning Resources	1. *R.K.Bansal, "Strength of Materials", 6th ed., Lakshmi Publications, 2022.* 2. *Ramamurtham S and Narayanan R, "Strength of Materials", 20th ed., Dhanpat Rai Pvt. Ltd., 2022.* 3. *Strength of Material Lab Manual*	4. *Bansal. R. K, "Fluid Mechanics and Hydraulic Machines", 11th ed., Laxmi publications (P) Ltd., 2022.* 5. *Kumar. K. L, "Engineering Fluid Mechanics", S Chand Publications, 2016.* 6. *Fluid Mechanics Lab Manual*

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%*	-	*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. G. Gopinath, R&D Manager, ZF, Chennai, gopinath.gunasekaran@zf.com*	1. *Dr. D. Madesh, Professor, AMET University, Chennai, madesh.d@ametuniv.ac.in.*	1. *Mr. M. Chandrasekaran, SRMIST*
2. *Mr. K. Maheshwaran, Assistant Manager, TAFE, Madurai, Email ID: maheshwaran@tafe.com*	2. *Dr. L. Ranganathan, Professor and Head, Dept. of Mechanical Engineering, Agni College of Technology, Chennai, Email ID: mechod@act.edu.in*	2. *Mr. G. Balakumaran, SRMIST*

Course Code	21MHC209T	Course Name	PROJECT MANAGEMENT AND INDUSTRIAL PRACTICES	Course Category	C	PROFESSIONAL CORE	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:	*introduce the concepts and components of Project Management*
CLR-2:	*gain knowledge in the fundamentals project scheduling*
CLR-3:	*gain apply knowledge of time, cost and resource management*
CLR-4:	*introduce the concepts of new product development, productivity, reliability and Quality*
CLR-5:	*introduce modern industrial practice - digitization*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand main aspects of project management: time, money and resources*	-	-	-	-	-	-	-	-	-	-	*3*	-	-	-	-
CO-2:	*design project scheduling using Gant, CPM and PERT methods*	-	-	-	-	-	-	-	-	-	-	*3*	-	*2*	-	-
CO-3:	*apply project management technique for managing time, cost and resources*	-	-	-	-	-	-	-	-	-	-	*3*	-	-	-	-
CO-4:	*understand productivity and NPD in engineering*	-	-	-	-	-	-	-	-	-	-	*2*	-	-	-	-
CO-5:	*understand modern industrial practice system using digitization tools*	-	-	-	-	*2*	-	-	-	-	-	*2*	-	-	-	-

Unit-1 - Project, Program, and Project Life Cycle — ***9 Hour***

Project scope management, Work Breakdown Structure (WBS) and Responsibility Assignment Matrix (RAM), Project communications and documentation, Project evaluation: Benefit-Cost Ratio (BCR), Project performance and Earned Value Management (EVM), Professional project management organizations, Introduction to software project management

Unit-2 - Project Scheduling — ***9 Hour***

Project scheduling - Terms, terminologies, and definitions, Gantt Chart, Activity On Arc (AOA), Activity On Node (AON), CPM, PERT, Examples

Unit-3 - Project Time, Costing, Budget, Crashing — ***9 Hour***

Trade-offs in project-time and -cost, Project crashing with examples, Project cost estimation, budgeting, Actual Cost, Budgeted cost, Value of work done, Cost Performance Analysis (CPA), Resource constrained planning, Resource allocation, Resource loading, Resource levelling

Unit-4 - New Product Development (NPD) and Productivity — ***9 Hour***

New Product Development (NPD)– an industrial practice, Ideation, development, testing, launch and track – phases NPD, Value driven management, Innovation Driven management, Break-Even Analysis, Productivity, Reliability, Quality management, Process control, ISO9000.

Unit-5 - Digitization in Industry — ***9 Hour***

Modern industrial practice, Digital transformation and exponential growth, Work styles, Product- to service-oriented model, Digitization solutions- IT solutions, IOT, Industry 4.0, 3D printing, VR & AR, Wearables, Blockchain, Digitization in Automotive industry, Digital twins

Learning Resources	1. *Pradeep Pai, Project management, Pearson India, 2019* 2. *D.R.Kiran, Production planning and control – A comprehensive approach, BSP books pvt ltd-Elsevier, 2019* 3. *Juran, Gryna, Quality Planning and Analysis, McGraw-Hill, New York, 1993.*	4. *Lewis, R., Project Management, McGraw-Hill, 2006, ISBN 0-07-147160-X* 5. *Uwe Winkelhake, The digital transformation of the automotive industry- Catalysts, Roadmap, Practice, Springer, 2022* 6. *Phillips, J., PMP Project Management Professional Study Guide, McGraw- Hill, 2003.*

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%*	-
Level 2	*Understand*	*55%*	-	*50%*	-	*30%*	-
Level 3	*Apply*	*45%*	-	*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. *Dr Venkat Perumal, Ph.D., Sr. Principal Engineer, R&D, Stryker*	1. *Dr VeeraRagavan, Senior Lecturer, Monash University (Malaysia campus), Malaysia*	1. *Dr Madhavan Shanmugavel, SRMIST*
2. *Mr Koteswaran Srinivasan, Director, HCL Technologies Ltd, Chennai*	2. *Elango Natarajan, Associate Professor, Faculty of Engineering, Technology and Built Environment,, UCSI University, 56000 Cheras, Kuala Lumpur, Malaysia*	2. *Dr Senthilnathan, SRMIST*

Course Code	21MHC301T	Course Name	SYSTEM DYNAMICS AND CONTROL	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	21MHC304L	Progressive Courses	21MHE414T
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 electrical, mechanical, and electromechanical dynamic systems
CLR-2:	analyze a dynamic system using procedural methods
CLR-3:	construct the control systems in the time domain
CLR-4:	analyze control systems in the frequency domain
CLR-5:	develop a state space model

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	construct the basic dynamic systems	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	design a conventional controller for a dynamic system	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	analyze a controller based on time domain specifications	3	2	3	-	-	-	-	-	-	-	-	-	3	-	2
CO-4:	apply the procedure of frequency response plot to design a compensator	3	2	3	-	-	-	-	-	-	-	-	-	3	-	2
CO-5:	develop a controller using state space approach	3	2	3	-	-	-	-	-	-	-	-	-	3	-	2

Unit-1 - Modeling of Systems	**9 Hour**
Introduction to signals and their properties- Elementary Signals-Introduction to systems and properties- LTI system- Solving differential equation using Laplace transform -Transfer function/System function, poles and zeros-Modeling of mechanical, electrical, and electromechanical dynamic systems, and numerical examples on modeling.	
Unit-2 - Time Domain Specifications and Controllers	**9 Hour**
Introduction to open loop and closed loop control system, -Block diagram and signal flow graph reduction techniques, Response of I and II order systems and their time domain specifications- Steady state error constant of the system for type numbers and inputs-PID control-Analytical design for PD, PI, PID control systems- Design of PID controller using Model-based /Zeigler Nichols method	
Unit-3 - Concept of stability and Design	**9 Hour**
Stability of system- Routh-Hurwitz stability criterion- Root locus method, steps in obtaining a root-locus-Design of controllers using root-locus-Introduction to compensator - Compensator design using root locus-Cascade Lead, lag, and lag-lead compensation	
Unit-4 - Frequency Response Analysis and Design	**9 Hour**
Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Construction of Bode Plots and Polar Plots - Compensator design using Bode Plots -Cascade Lead, lag, and lag-lead compensation.	
Unit-5 - State Space Analysis and Design	**9 Hour**
State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability-Stability of linear systems-Full state feedback controller design-Full order observer design-Design examples.	

Learning Resources	1. B P Lathi, Principles of Linear Systems and Signals, 2nd edition, Oxford University Press, 2009. 2. J Nagrath, M Gopal, Control Systems Engineering, 5th Edition, New Age International, 2007.	3. Norman S Nise, Control Systems Engineering, 7th edition, Wiley, 2015. 4. Roland S. Burns, Advanced Control Engineering, Butterworth- Heinemann, First edition, 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	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. Dr. K. Karthikeyan Ph.D.,R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore	1. Dr.M.Mythili, Assistant Professor, Department of Electronics and Instrumentation Engineering, Anna University, Chennai - 600025.Email - mythilym@annauniv.edu	1. Dr.M.Mohamed Rabik, AP, SRMIST
2. Mr. Emmanuel Thangiah Director-Operations, E73 AI Innovations Pvt Ltd Email – emmanuel@73.ai	2. Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, MIT Campus, Anna University, Chennai- 600044. Email id:pkrthikeyan@mit.edu	2. Ms.D.Sasikala , AP, SRMIST

Course Code	21MHC302J	Course Name	DESIGN AND ANALYSIS OF MACHINE ELEMENTS	Course Category	C	PROFESSIONAL CORE	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:	formulate, design, and identify torque elements
CLR-2:	estimate the life of sliding and rolling contact bearings
CLR-3:	analyze the gear failure modes, and evaluate forces and stresses within a gear system
CLR-4:	construct flexible drive systems and design for light, medium, and heavy-duty applications
CLR-5:	summarize the basics of finite element formulation

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	design suitable shafts and coupling for particular engineering applications	3	3	2	2	3	-	-	-	-	-	-	-	2	2	-
CO-2:	analyze and select bearings and lubricants for various engineering applications	3	3	2	2	3	-	-	-	-	-	-	-	2	2	-
CO-3:	design and analyze various simple gear trains for various power transmission applications	3	3	2	2	3	-	-	-	-	-	-	-	2	2	-
CO-4:	design and select suitable flexible drive systems for power transmission applications	3	3	2	2	3	-	-	-	-	-	-	-	2	2	-
CO-5:	apply finite element formulations to solve one-dimensional and two-dimensional Problems	3	3	2	2	3	-	-	-	-	-	-	-	2	2	-

Unit-1 - Design of Power Transmission and Energy Storing Elements ***9 Hour***

Introduction to the design process, factors influencing machine design, selection of materials based on mechanical properties, Preferred numbers, fits, and tolerances. Design of rigid and flexible couplings, Keys, keyways, and splines, Various types of springs; design and optimization of helical springs; design of power screws.
Experiments:
Modeling of basic mechanical components using Solid Works Coupling and spring Modeling and Analysis (Solid works & Ansys)

Unit-2 - Design of Bearings ***9 Hour***

Design of Bearings (Ball Bearing, Roller Bearing & Sliding Contact Bearing) Sliding contact and rolling contact bearings – Hydrodynamic journal bearings, Sommerfeld Number, Raimondi and Boyd graphs, Selection of Rolling Contact bearings.
Experiments:
screw jack Modeling Simulation and Analysis (Solid works & Ansys)
Plummer Block Modeling Simulation and Analysis (Solid works & Ansys)

Unit-3 - Design of Gears and Gear Trains ***9 Hour***

Types of Gears, Gear materials, Gear Nomenclature, Design of spur gear based on Lewis and Buckingham equations: Helical Gear Nomenclature, Design of helical gear based on modified Lewis equations: Bevel Gear Nomenclature, Design of bevel gear based on Lewis and Buckingham equations. Gears and Gear trains, Design of Gears using Gear Life: Design of Gearbox.
Experiments:
Universal Coupling Modeling Simulation and Analysis (Solid works & Ansys)
Modeling, Simulation, and Analysis of Mechanisms (Four bar, Slider crank Mechanisms)

Unit-4 - Design of Flexible Drives	***9 Hour***
Types of Flexible Drives, Belt Materials and Constructions, Design of Flat Belt Drive & V- Belt Drive, Chain Drive: Types, Failures, Designation Selection of Chain Drive, Chain Lubrication Wire Rope - Types, Construction, Lays of Wire Rope, Selection of Wire Rope, Stresses in Wire Rope, Design of a Wire Rope Drive. *Experiments:* *Mode thermal analysis of Composite material Frequency analysis, Harmonic Analysis*	
Unit-5 - Finite Element Method	***9 Hour***
Finite element method: Introduction, types of elements, shape function, types of forces, elemental stiffness matrix, elemental force matrix, assembly, truss, introduction to 2-dimensional finite element method. *Experiments:* *Modeling, Simulation, and Analysis of a robotic arm*	

Learning Resources	1. *Bhandari.V.B, "Design of Machine Elements", 3rd ed., Tata McGraw- Hill, 2010.* 2. *Robert L. Norton, "Machine Design: An Integrated Approach", 5th ed., Prentice Hall, 2013.* 3. *Merhyle Franklin Spotts, Terry E. Shoup and Hornberger.L.E, "Design of Machine Elements", 8th ed.,, Prentice Hall,2003*	4. *Joseph Shigley and Charles Mischke, "Standard Handbook of Machine Design", 3rd ed., Tata McGraw Hill, 2004.* 5. *Richard G.Budynas, J.KeithNisbett, "Shigley's Mechanical Engineering Design", 10th ed., Tata McGraw-Hill, 2015.* 6. *PSG, "Design Data" [Data Book Of Engineers], Kalaikathir Achagam, 2016.* 7. *CAD Laboratory Manual.*

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*	*10%*	-	-	*20%*	*15%*	-
Level 2	*Understand*	*30%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*20%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*40%*	*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. R. Nirmal, Caterpillar India, Chennai*	1. *Dr. R Arvindraj, VIT vellore*	1. *Mr.G.Balakumaran ,SRMIST*
2. *Mr. R. DhineshBabu, Technofit, Malaysia*	2. *Dr. R. Senthilkumar, Mohamed Sathak A.J.College of Engineering*	2. *Mr.S.M. Vignesh SRMIST*

Course Code	21MHC303J	Course Name	MEASUREMENT, SENSORS AND INTERFACES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	21MHE401T, 21MHE410T
Course Offering Department	Mechatronics Engineering	Data Book / Codes / Standards		Nil	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	perceive the fundamental understanding of design, calibration, characterization and analysis of measuring systems and data acquisition
CLR-2:	gain knowledge of the working principle of sensors used for force and displacement measurement
CLR-3:	acquire the knowledge of the working principle of sensors for measurement of position, distance and acceleration
CLR-4:	explore the basic principles of pressure, flow, and temperature sensors
CLR-5:	comprehend different interfacing standards for sensors and their physical applications

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	implement the physical principles applied in measurement systems and data acquisition systems	3	2	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	analyze the sensors and their selection criteria for the measurement of force and displacement	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	evaluate the sensors for the measurement of position, distance and acceleration based on selection criteria	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	analyze the sensors and their selection criteria for the measurement of pressure, flow and temperature	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	acquire knowledge about different sensor interfaces and their real time applications	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Sensor Based Measurement Systems and Data Acquisition — ***12 Hour***

Sensor Classification - Static and Dynamic Characteristics of Measurement Systems - Errors in Measurement - Statistical Evaluation of Measured Data - Standard and Calibration - Amplification and Signal Conditioning - Digital Conversion - Elements of Data Acquisition Systems - Time Division and Space Division Channeling in Data Acquisition Systems

Experiments:

1. Design of instrumentation amplifiers. 2. Design of active filters

Unit-2 - Sensors for Force and Displacement Measurement — ***12 Hour***

Potentiometric Sensors - Capacitive Sensors - Working Principle of Strain Gauges - Quarter Bridge, Half Bridge and Full Bridge Configuration of Load Cell - Magnetic and Inductive Proximity Sensors - Working Principle and Applications of LVDT and RVDT - Tactile Sensors

Experiments:

1. Study of characteristics of load cell. 2. Study of characteristics of LVDT

Unit-3 - Sensors for Position, Distance and Acceleration Measurement — ***12 Hour***

Working Principle of Eddy Current Sensors - Hall Effect Sensors - Distance Measurement using IR and Ultrasonic Sensors - SONAR, RADAR, Optical Sensors - LIDAR - Optical Encoders - IMU

Experiments:

1. Distance measurement using IR. 2. Distance measurement using optical encoder

Unit-4 - Sensors for Temperature, Pressure and Flow Measurement	***12 Hour***
Piezoresistive Sensors - Working Principle and Applications of Bourdon Tube, Bellows and Diaphragm - Thermoresistive Sensors: Thermistor - RTD - Thermoelectric contact sensors: Thermocouple - Thermal Transport Sensors: Hot wire Anemometer Experiments: *1. Study of characteristics of pressure sensors. 2. Study of characteristics of temperature sensors*	
Unit-5 - Sensor Interfacing	***12 Hour***
Smart Sensor Systems – Role of sensors in IOT - Multichannel Sensor Interfacing - Standards - Integrated Circuit Bus (I2C) - Serial Peripheral Interface (SPI) - Controller Area Network (CAN) Bus - Universal Transducer Interface (UTI) - Case studies related to different Interfacing Standards Experiments: *1. Interfacing temperature sensor with data acquisition system. 2. Interfacing ultrasonic sensor with data acquisition system*	

Learning Resources	1. *Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 2015, 3rd edition, Springer, New York.* 2. *John G Webster, "Measurement, Instrumentation and sensor Handbook", 2014, 2nd edition, CRC Press, Florida.* 3. *Kirianaki N.V., Yurish S.Y., Shpak N.O., Deynega V.P., Data Acquisition and Signal Processing for Smart Sensors, John Wiley & Sons, Chichester, UK, 2002.*	4. *Ramon Pallas-Areny and John G Webster, Sensors and Signal Conditioning, 2012, 2nd ed., Wiley India Pvt. Ltd.* 5. *John Park and Steve Mackay, Practical Data acquisition for Instrumentation and Control, 2011, 1st ed., Newness publishers, Oxford, UK.* 6. *Paul P.L Regtien, "Sensors for Mechatronics", Elsevier publications, 1st edition, 2012.*

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*	*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. *Dr.S. Shaffath Hussain Shakir, Project lead,VIASAT*	1. *Dr.R.Thiyagarajan, Assistant Professor, Department of Mechanical Engineering, IIT,Tirupati.*	1. *Dr. S.Fouziya Sulthana, SRMIST*
2. *Mr.T.Sathish, Lead Engineer-Systems Engineering GE Power conversion.*	2. *Dr K. Navin sam, Assistant Professor , Department of Electrical and Electronics Engineering, NIT, Puducherry*	2. *Mr. J.Thiyagarajan, SRMIST*

Course Code	21MHC304L	Course Name	MODELLING AND CONTROL LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	Nil	Co- requisite Courses	21MHC301T	Progressive Courses	21MHE414T
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 electrical, mechanical, and electromechanical dynamic systems
CLR-2:	analyze a dynamic system using procedural methods
CLR-3:	construct the control systems in the time domain
CLR-4:	analyze a control systems in the frequency domain
CLR-5:	develop a state space model

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	construct the basic dynamic systems	2	2	3	-	2	-	-	-	-	-	-	-	3	-	-
CO-2:	design a conventional controller for a dynamic system	2	2	3	-	2	-	-	-	-	-	-	-	3	-	-
CO-3:	analyze a controller based on time domain specification	2	2	3	-	2	-	-	-	-	-	-	-	3	-	2
CO-4:	apply the procedure of frequency response plot to design a compensator	2	2	3	-	2	-	-	-	-	-	-	-	3	-	2
CO-5:	develop a controller using state space approach	2	2	3	-	2	-	-	-	-	-	-	-	3	-	2

Unit-1 - Modeling of Systems	**6 Hour**
1. Modelling of electrical and mechanical dynamic systems and validation using simulation software.	
2. Modelling of electromechanical systems and validation using simulation software.	
Unit-2 - Time Domain Specifications and Controllers	**6 Hour**
1. Determine the time domain specifications of I and II order systems.	
2. Performance comparison of open loop system and closed loop system with a PID controller.	
Unit-3 - Concept of Stability and Design	**6 Hour**
1. Experimentation of root locus method, gain determination, and stability analysis.	
2. Design of compensators using the root locus method.	
Unit-4 - Frequency Domain Analysis and Design	**6 Hour**
1. Experimentation on Bode plot method, calculation of gain, and phase margins with a suitable example.	
2. Design of compensators using Bode plot method.	
Unit-5 - State Space Analysis and Design	**6 Hour**
1. Experiment on state space representation of a system, conversions between transfer function and state space approaches.	
2. Design of full state feedback controllers with a suitable example using DC servo motor	

Learning Resources		
	1. Roland S. Burns, Advanced Control Engineering, Butterworth- Heinemann, First edition, 2001	3. Laboratory Manuals for Qube servo, and compensation circuit kits.
	2. J Nagrath, M Gopal, Control Systems Engineering, 5th Edition, New Age International, 2007.	

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	-	20%	-	-	-	15%	-	-
Level 2	Understand	-	25%	-	-	-	25%	-	-
Level 3	Apply	-	30%	-	50%	-	30%	-	-
Level 4	Analyze	-	25%	-	50%	-	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. M. Mythily Assistant Professor, Department of Electronics and Instrumentation Engineering, Email - mythilym@annauniv.edu	1. Dr.M.Mohamed Rabik, SRMIST

Course Code	21MHC305J	Course Name	MANUFACTURING PROCESSES	Course Category	C	PROFESSIONAL CORE	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 principle and process of different metal forming and metal cutting process*
CLR-2:	*impart knowledge on types and approaches of advanced manufacturing process*
CLR-3:	*gain knowledge in concept of computerized machine tool for metal cutting process*
CLR-4:	*understand the concept of automation in manufacturing process*
CLR-5:	*familiar in manufacturing metrology*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the process of different metal forming and metal cutting processes*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*distinguish the types and approaches of advanced manufacturing process*	*1*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*implement the concept of computerized machine tool for metal cutting process*	*2*	-	-	*2*	-	-	*1*	-	-	-	-	-	-	-	-
CO-4:	*understand the concept of automation in manufacturing process*	*1*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*acquire knowledge on manufacturing metrology*	*1*	*2*	*2*	*1*	-	-	*1*	-	-	-	-	-	-	-	-

Unit-1 - Conventional Manufacturing Process and Metal Cutting Theory ***12 Hour***

Introduction to casting process and mechanical working of metals- fundamentals of metal cutting process- types of cutting tools- Tool life- Prediction of tool life using tailors tool life equations- Cutting forces in orthogonal cutting, merchant circle analysis- Calculation of various forces involved during orthogonal cutting- finishing process and superfinishing process.

Experiments

**Multiple turning with grooving and thread cutting by applying canned cycle using CNC turning centre. *Multiple turning with axial drilling operation by applying canned cycle using CNC turning centre.*

Unit-2 - Advanced Manufacturing Process ***12 Hour***

Rapid Prototyping- Working Principles- Rapid tooling, Techniques of rapid manufacturing- Additive manufacturing: concept, types- Stereo Lithography, Laser Sintering, Fused Deposition Method, Applications and Limitations - Methods of micromachining- Abrasive jet, Ultrasonic, Abrasive water jet micromachining, Micro turning, Micro drilling.

Experiments

*1. Part Program for drilling and Peck drilling operation by applying canned cycle using CNC milling centre. 2. *Profile cutting using Wire cut Electrical Discharge Machine (WEDM)*

Unit-3 - CNC Machines and Its Architecture ***12 Hour***

Introduction to CNC machine tools – Classifications and Constructional feature of CNC turning and milling centre – Open loop and closed loop CNC systems- CNC controllers- Structural members of CNC machines: slide ways, linear motion - Automatic tool changer- fundamentals of part programming- Types of programming: manual part programming- Canned cycle and subroutines.

Experiments

1. CNC Part Program for Facing, Step turning, Tapper and Finish turning using ordinary cycle. 2. CNC Part Program for Facing, Step turning, Tapper and Finish turning using canned cycle.

Unit-4 - Automation in Manufacturing Process	***12 Hour***
Automation in Production systems- Components of a Manufacturing systems- Single Station Manned Workstations and Single Station Automated Cells- Manufacturing Operations- Cellular Manufacturing, Flexible Manufacturing Systems: FMS Components, FMS Applications, and FMS Planning. *Experiments* *1. Pocketing of Linear and Circular profile using CNC vertical machining centre. 2. Part Program for End milling and Drilling operation by applying canned cycle using CNC milling centre*	
Unit-5 - Advanced Inspection Technologies	***12 Hour***
Automated Inspection, Coordinate Measuring Machines Construction, operation & Programming, Software, Application & Benefits, Flexible Inspection System, Inspection Probes on Machine Tools, Machine Vision, contact and non-contact Optical Inspection Techniques & Non-contact Non-optical Inspection Technologies. *Experiments* *1. Profile cutting by applying Mirroring operation using CNC vertical machining centre*	

Learning Resources	1. *Sharma.P.C, "A textbook of Production Technology", Vol I and II, S. Chand and Company Ltd., New Delhi, 2007.* 2. *SeropeKalpakjian and Steven Schmid, "Manufacturing Engineering and Technology", Pearson Education, 7th edition, 2014.* 3. *Radhakrishnan.P, "CNC Machines", New Central Book Agency, 2000.* 4. *Pandey and H.S.Shah, "Modern Machining Process", Tata McGraw Hill Publishing Co., New Delhi, 2008.* 5. *Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", 3rd edition, World Scientific Publishers, 2010.*	6. *R. S. Khandpur"Printed Circuit Boards: Design, Fabrication, and Assembly" Tata McGraw Hill Publishing Co., New Delhi, 2010.* 7. *S.K. HajraChoudry, S.K.Bose, A.K. HajraChoudry , "Elements of Workshop Technology Vol II: Machine tools", Media promoters and Publishers Pvt Ltd, 2002.* 8. *Chapman.W.A.J, "Workshop Technology" Vol. I and II, Arnold Publisher, 1996.* 9. *Elanchezhian.C, VijayaRamnath.B and Sunder Selwyn, T., Engineering Metrology, Eswar Press, Chennai, 2004.* 10. *John A. Bosch, Giddings and Lewis Dayton, Co-ordinate Measuring Machines and Systems, Marcel Dekker, Inc, 1999* 11. *ZuechNello, Understanding and Applying Machine Vision, Marcel Dekker, Inc, 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*	*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.K.Balaguru, Deputy Manager, Hindustan Aeronautics limited, Structural Design, gurubala07@gmail.Com.*	1. *Dr.V. Senthilkumar , NIT Tiruchirappalli, Production department, vskumar@nitt.edu*	1. *Mr.Arivarasan J, SRMIST*
2. *.Mr.S.Hari bala manoj, Assistant Manager, Renault Nissan Technology, sbalamanoj@gmail.com*	2. *Dr.C.Velmurugan, IIIT Tiruchirappalli, Mechanical Engineering Department, velmuruganc@iiitt.ac.in*	2. *Mr.K.Saravanan, SRMIST*

Course Code	21MHC306T	Course Name	KINEMATICS AND DYNAMICS OF MECHANISMS	Course Category	C	PROFESSIONAL CORE	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:	appraise the fundamental concepts Mechanisms, degrees of freedom and inversions of different mechanisms
CLR-2:	analyze the forces of different machines under static and dynamic conditions
CLR-3:	acquire the knowledge about the principles of CAM and Gyroscopes
CLR-4:	explore the undesirable effects of balancing in different real time systems
CLR-5:	estimate the frequency of torsional, transverse and torsional vibrations under different loading conditions

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	comprehend the basic concepts of mechanisms and its inversions	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-
CO-2:	examine the forces and its impact on different machines under static and dynamic conditions	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-
CO-3:	understand the knowledge of CAM and gyroscope	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-
CO-4:	learn and implement the balancing techniques in different loading conditions	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-
CO-5:	gain the knowledge of vibrations and to estimate the frequency of different vibrations	1	2	-	-	1	-	-	-	-	-	-	-	-	-	-

Unit-1 - Elements of Mechanisms — **9 Hour**

Machine, mechanism, links, pair, Degrees of freedom, determining DOF using Kutzbach criteria - Grashoff law – 4 bar chain mechanism – inversions of 4 bar chain mechanism – single slider mechanism – inversions of single slider mechanism – position, displacement and velocity analysis – simulation of 4 bar chain mechanism

Unit-2 - Force Analysis of Machines — **9 Hour**

Static force analysis: Constraint forces and applied forces – Free body diagrams – Conditions for equilibrium – Equilibrium for two, three and four force members – Centroid and Moment of inertia – D – Alembert's principle – Principle of super position – Turning of moment diagram of flywheel – Fluctuation of energy – dimensions of flywheel

Unit-3 - CAMS and Gyroscope — **9 Hour**

CAMS: Classifications of cam and follower- Construction of cam profile when the follower moves with uniform velocity and simple harmonic motion - Construction of cam profile when the follower moves with uniform acceleration and retardation - Construction of cam profile when the follower moves in cycloidal motion- Gyroscope: Gyroscopic couple – Effect of gyroscopic couple on an aeroplane - Effect of gyroscopic couple on naval ship during steering and pitching – stability of a two-wheel vehicle

Unit-4 - Balancing of Rotating and Reciprocating Masses — **9 Hour**

Balancing of rotating masses: Static balancing – dynamic balancing – Balancing of several masses in single plane – balancing of several masses in different planes Balancing of reciprocating masses: Primary and Secondary unbalanced forces of reciprocating masses – Partial balancing of locomotives – Tractive force – Hammer blow – Swaying couple

Unit-5 - Vibrations — **9 Hour**

Types of free vibration – Natural frequency of free transverse and longitudinal vibration - Natural frequency of free transverse vibration due to single and multiple point load over a simply supported shaft - Natural frequency of free transverse vibration due to uniformly distributed load over a simply supported shaft – Critical speed of shaft – frequency of free damped vibration – frequency of underdamped forced vibration - Frequency of free torsional vibration of a single, two and three rotor system – Torsionally equivalent shaft

Learning	1. Ratan.S.S, Theory of Machines, 5th ed., Tata McGraw Hill, 2019	4. Dechev, Nikolai. Cleghorn, William L. Mechanics of Machines. Oxford University Press,

Resources	2. *R.L. Norton, Kinematics and Dynamics of Machinery, 1st ed., Tata McGraw Hill, 2017* 3. *Gordon R. Pennock & Shigley J.E John J Uicker, 4th ed., Theory of machines and mechanisms, Oxford university press, 2016*	*2nd edition, 2015.* 5. *Dukkipati, Rao V. Mechanism and Machine Theory. India: New Age International (P) Limited, 2nd edition, 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*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*15%*	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. N. Manojprabhakar.N, FLSmidth Private Limited, mnp-in@flsmidth.com*	1. *Dr. V. Muralidharan, Associate Professor,BS Abdur Rahman Crescent Institute of Science & Tech, muralidharan@crescent.education*	1. *Dr.S.Senthilraja, SRMIST*
2. *Mr. P. Thangadurai, Aditya Auto Components, thangadurai08@gmail.com*	2. *Mr. P. Nantha Kumar, Associate Professor, Sri Sai Ram Institute of Technology, nanthakumar.mech@sairamit.edu.in*	2. *Mr. M. Thirugnanam, SRMIST*

Course Code	21MHC307P	Course Name	MODEL BASED SYSTEMS ENGINEERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							1	2	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:	introduce systems engineering concepts for solving the problems in developing complex engineering systems
CLR-2:	familiarize the various modeling approaches and methodologies
CLR-3:	analyze stakeholders' expectations using stakeholders value network and capture systems requirements effectively
CLR-4:	create systems architecture for new or improved complex systems
CLR-5:	apply verification and validation techniques to evaluate the system design

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	familiarize the systems engineering concepts for solving the problems in developing complex engineering systems	3	3	-	1	-	1	-	-	-	2	-	-	2	2	2
CO-2:	develop various models for systems using SysML	3	3	-	2	2	-	-	-	-	-	-	-	1	1	1
CO-3:	analyze stakeholders' expectations using stakeholders value network and capture systems requirements effectively	3	3	3	1	1	2	-	-	2	3	2	-	3	3	3
CO-4:	develop systems architecture for new or improved complex systems	3	3	3	3	2	3	-	-	2	3	2	-	3	3	3
CO-5:	use verification and validation techniques to evaluate the system design	3	3	1	3	2	3	-	-	2	2	2	-	1	3	3

Unit-1 - Introduction to Systems Engineering — **9 Hour**

Definitions and concepts of system-system science and systems engineering, life cycle stages, definitions of requirement, architecture, design. System analysis, interface management, system integration, system verification, system transition, system validation, system operation, system maintenance, system disposal. Project planning, project management and control, decision management, risk management, configuration, Case studies: Refrigerator and Washing Machine.

Unit-2 - Introduction to MBSE and SysML Overview — **9 Hour**

Introduction to MBSE-MBSE concepts- MBSE Ontology-Introduction to Object Process modelling OPM- Object process language-Overview of SysML-Block definition diagrams-Internal block diagrams-Use case diagrams-Activity diagrams-Sequence diagrams-State machine diagrams-Parametric diagrams-Requirements diagram-package diagrams-Operational analysis modeling-functional analysis modeling-logical architecture modeling-Physical architecture modeling-architecture frameworks.

Unit-3 - Stakeholder Analysis and Requirements Definition — **9 Hour**

Stakeholder's identification, Concept of operations, Stakeholders value network analysis, Requirements: Purpose, Types, challenges, allocation and verification and validation and Volatility. Systems Requirements Review (SRR).

Unit-4 - System Design and Architecture — **9 Hour**

Architecture definition, architecture viewpoints, concept analysis, models and views of architecture (functional/behavioral/data/performance etc.) – Structure and behavior- Evaluating candidate architectures-System/subsystem analysis- tradeoff analysis- Architecture frameworks and standards-design progression-architecture domains (software/IT/ Manufacturing/social etc)-architecture heuristics- acquisition management-tailoring processes-industrial design-design for manufacturability- robustness design

Unit-5 - Verification and Validation	***9 Hour***
System verification-System validation-various approaches to system validation and verification-inspection/testing/analysis/demonstration-Generation of Test cases using the Markov Chain model-Writing verification/validation plans-introduction to formal methods-formal approaches to system validation/verification-focus on specialty areas (eg.. EMI/EMC)-test automation models (computation/timed automation)-simulation-model checking verification-verification validation activities prescribed in standards for safety critical systems	

List of Recommended Exercises in Tutorial
1. *Assign a case study to every batch (Washing Machine, Refrigerator, or any other equivalent systems), and ask them to identify characteristics of complex engineering systems and familiarize with complexity level*
2. *Analyze stakeholders associated with the system using SVN*
3. *Based on Stakeholder's analysis, develop requirements model for the system*
4. *Brainstorm and explore various possible concepts, choose the feasible concept for implementation based on trade-off study*
5. *Create an architecture based upon the chosen concept, mapping forms and functions.*
6. *Develop functional models for various functions and incorporate in the architecture*
7. *Perform model-based simulation by using various verification and validation strategies*
8. *Document the complete work carried out in this course*

Learning Resources	1. *National Aeronautics and Space Administration, "NASA Systems Engineering Handbook", (Rev 1, Dec 2007).* 2. *INCOSE, "Systems Engineering Handbook"* 3. *Kossiakof, Alexander and William N. Sweet; "Systems Engineering: Principles and Practice" Wiley, 2011*	4. *"SysML distilled: A brief guide to the Systems modeling language". Lenny Deligatti-Addison Wesley Professional, Ed 1, 2013* 5. *Rechtin, E., and M.W.Maier, "The art of Systems architecting", Boca Raton, FL: CRC Press, 2000* 6. *Engel, Avner, "Verification, Validation and Testing of Engineered Systems; John Wiley & Sons, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	-	-	-	-	-	-
Level 2	*Understand*	*40%*	-	-	-	-	-	-	-
Level 3	*Apply*	*20%*	-	-	*20%*	-	*20%*	-	-
Level 4	*Analyze*	-	-	-	*30%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	*30%*	-	*30%*	-	-
Level 6	*Create*	-	-	-	*20%*	-	*20%*	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Gaurav Dubey, Mathworks, India*	1. *Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	1. *Dr.K Sivanathan, SRMIST*
2. *Dr.Guna Surendra, Hitachi, Japan*	2. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	2. *Dr.T.Muthuramalingam , SRMIST*

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Volume – 18C
(Syllabi for Mechatronics Engineering (Autonomous Driving Technology) Programme 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

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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	21MHE437J	Course Name	COMPUTATIONAL TECHNIQUES FOR AUTONOMOUS VEHICLES	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:	*introduce mathematical principles and techniques essential for autonomous vehicles (AVs)*
CLR-2:	*provide the mathematical tools necessary to process sensor data, make real-time decisions, and navigate complex environments.*
CLR-3:	*understand the mathematical underpinnings that is crucial to develop robust and reliable autonomous systems*
CLR-4:	*equip students with the math skills needed to contribute effectively to the field of AVs.*
CLR-5:	*apply verification and validation techniques to evaluate the system design*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply linear algebra and geometry to perception, planning and control of AVs*	*1*	*2*	*2*	*2*	*2*		-	-	-	-	-	-	-	*2*	*1*
CO-2:	*utilize calculus for motion and trajectory planning*	*1*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*	*2*
CO-3:	*apply probability and statistics in processing sensors data*	*1*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*	*2*
CO-4:	*evaluate numerical methods for autonomous driving algorithms*	*1*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*	*2*
CO-5:	*analyze and apply graph theory for mapping and planning*	*1*	*2*	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*	*2*

Unit-1: Linear Algebra and Geometry for Autonomous Vehicles	***9 Hour***
Introduction, Importance of mathematical foundations for perception, planning, and control, Vector spaces and matrix operations, Coordinate systems and transformations. Eigenvalues and eigenvectors, Linear regression and least squares estimation, Geometric algorithms for localization and mapping, Point cloud processing and 3D geometry, Applications of linear algebra in sensor fusion and perception, Kalman filtering.	
Unit-2: Calculus and Optimization	***9 Hour***
Differentiation and integration for motion analysis, Optimal control and calculus of variations, Applications of calculus in motion planning and control, Path parameterization and curvature analysis, Trajectory generation and optimization, Derivatives, and gradients in optimization algorithms.	
Unit-3: Probability and Statistics	***9 Hour***
Probability distributions and random variables, statistical inference and hypothesis testing, Conditional Probability and Bayes' theorem, Statistical methods for uncertainty modeling and management, Applications of probability and statistical theory in perception and sensor fusion, Regression analysis and modeling, Gaussian processes and kernel methods, Hidden Markov Models (HMM) for state estimation, Probabilistic modeling for decision-making, Monte Carlo methods for localization and mapping.	
Unit-4:Numerical Methods	***9 Hour***
Numerical integration and differentiation, Root finding and interpolation techniques, Approximation methods for solving differential equations.	

Unit-5: Graph Theory and Network Analysis	***9 Hour***
Basics of graph theory (e.g., graph representation, connectivity, shortest paths), Graph algorithms for mapping and path planning, Graph-based SLAM and localization, Road network representation and analysis.	

Learning Resources	1. *Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics" MIT Press, 2005.* 2. *Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robotics", Second edition, The MIT Press, 2011* 3. *David C. Lay, Steven R. Lay, and Judi J. McDonald, "Linear Algebra and Its Applications", fifth edition, Pearson, 2015.*	4. *James Stewart, "Calculus: Early Transcendentals", eighth edition, 2015.* 5. *Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, and Keying Ye, "Probability and Statistics for Engineers and Scientists" ninth edition, Pearson, 2010.*

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*	*5%*	-	-	-	*5%*	-
Level 2	*Understand*	*10%*	-	-	*70%*	*10%*	-
Level 3	*Apply*	*75%*	-	-	*30%*	*75%*	-
Level 4	*Analyze*	*10%*	-	-	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Guna Surendra, Hitachi, Tokyo, Japan	*1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Mr.Elayaraj, apple, USA	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.R.Senthilanathan, SRMIST*

Course Code	21MHE438T	Course Name	FOUNDATIONS OF AUTONOMOUS VEHICLES	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:	*address Emerging Technological Trends*
CLR-2:	*understand of Autonomous Vehicles*
CLR-3:	*promote Ethical and Regulatory Awareness*
CLR-4:	*foster Problem-Solving Skills*
CLR-5:	*prepare for a Multidisciplinary Field*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the Fundamental Concepts of Autonomous Vehicle Technology*	-	-	-	2	-	2	-	-	-	-	-	-	-	2	1
CO-2:	*design and Implement Perception Systems for Autonomous Vehicles*	-	-	-	2	-	2	-	-	-	-	-	-	-	2	1
CO-3:	*create Decision-making and Planning Algorithms for Safe Navigation*	-	-	-	2		2	-	-	-	-	-	-	-	2	1
CO-4:	*analyze Vehicle Dynamics and Apply Control Systems*	-	-	-	-	2	2	-	-	-	-	-	-	-	2	1
CO-5:	*evaluate and Apply Safety Standards and Ethical Considerations*	-	-	-	-	2	2	-	-	-	-	-	-	-	2	1

Unit-1: Introduction to Autonomous Driving (Elementary Treatment only)	***9 Hours***
Overview of Autonomous Vehicle Technology, Historical Context and Evolution of Autonomous Driving, Levels of Automation (SAE J3016), Key Components of an Autonomous Vehicle System, Regulatory and Ethical Considerations, Evolution, Challenges, and Opportunities.	
Unit-2: Perception and Sensor Fusion (Elementary Treatment only)	***9 Hours***
Understanding the Environment for Autonomous Vehicles, Types of Sensors Used in Autonomous Vehicles (LiDAR, Cameras, Radar, etc.), Data Preprocessing and Feature Extraction, Object Recognition and Tracking, Sensor Fusion Techniques for Accurate Perception, Case Studies on Perception Systems in Autonomous Vehicles.	
Unit-3: Decision Making and Planning (Elementary Treatment only)	***9 Hours***
Behavior Planning and Decision-making, Path Planning Algorithms (e.g., A, RRT, etc.), Control Systems for Autonomous Vehicles (PID, MPC, etc.),Handling Complex Traffic Scenarios and Dynamic Environments, Simulation and Testing of Decision-making Algorithms.*	
Unit-4: Vehicle Dynamics and Control Systems (Elementary Treatment only)	***9 Hours***
Basics of Vehicle Dynamics (Kinematics, Kinetics), Tire Mechanics and Contact Forces, Control Systems (PID, LQR, State Feedback, etc.), Stability Control and Handling Characteristics, Integration of Control Systems with Autonomous Driving.	
Unit-5: Safety and Ethics in Autonomous Driving (Elementary Treatment only)	***9 Hours***

Safety Standards and Regulations for Autonomous Vehicles, Fail-safe Systems and Redundancies, Ethical Dilemmas in Autonomous Driving (Trolley Problem, etc.), Human Factors and Interaction with Autonomous Vehicles, Case Studies on Safety Incidents and Lessons Learned.

Learning Resources	1. *Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics" MIT Press, 2005.* 2. *Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robotics", Second edition, The MIT Press, 2011*	3. *Richard Szeliski, "Computer Vision-Algorithms and Applications", Spinger, 2011.*

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.K.Sridharan, Senior Engineer, GE Renewable Energy, Bangalore.*	1. *Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	1. *Dr.K Sivanathan, SRMIST*
2. *Dr.Srinivasan, Principal Engineer, Mahindra and Mahindra, Chennai.*	2. *Dr., P Karthikeyan, MIT, Anna University, pkarthikeyan@annauniv.edu*	2. *Dr.M.Mohamed Rabik, SRMIST*

Course Code	21MHE439T	Course Name	INTRODUCTION TO 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:	*realize the different coordinates of the vehicle*
CLR-2:	*identify the type of power train for a vehicle*
CLR-3:	*realize the factors affecting longitudinal control*
CLR-4:	*realize the factors affecting lateral motion for steering control*
CLR-5:	*familiarize the advance concepts in automotive technology*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the control on a proper coordinate control*	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-2:	*design a proper drive train for a vehicle*	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	*implement the control on longitudinal motion*	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*implement the control on lateral motion*	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*incorporate latest features in the vehicle*	-	-	2	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 : Introduction	***9 Hours***
Evolution and current trends in the industry, Coordinates and Notation for Vehicle Dynamics -Longitudinal, Lateral and vertical vehicle motions, Human Factors in Vehicle Automation, engine system, electric and electronic system overview	
Unit-2 : Power Trains and Drives	***9 Hours***
Engine, Electronic Transmission systems train management, Market Trends, Control of Automated shift transmission AST, Control of automatic transmissions, Control of continuously variable transmission, ECUs for electronic Transmission control, Electrical, Hybrid and Fuel cell vehicles	
Unit-3: Longitudinal Dynamics	***9 Hours***
Longitudinal dynamics - Forces and moments on vehicle, Equation of motion, Tire forces, rolling resistance, weight distribution, Tractive effort and Power available from the engine, Calculation of Maximum acceleration Braking torque, Braking Force, Brake Proportioning, Braking Efficiency, Stopping Distance, Prediction of Vehicle performance. ABS, stability control, Traction control	
Unit-4 : Lateral Dynamics	***9 Hours***
Lateral Dynamics - Steering geometry, Types of steering systems, Fundamental condition for true Rolling, Development of lateral forces. Steady-state handling characteristics. Yaw velocity, Lateral Acceleration, Curvature response and directional stability.	
Unit-5: Advanced Vehicle System	***9 Hours***
Advanced Driver Assistance Systems (ADAS): Sensors, Algorithms, and Safety Features, Overview of Intelligent Transportation Systems, Preventing collisions	

Learning Resources	1. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", 2013, Society of Automobile Engineers Inc., ISBN: 978-1560911999 2. Ali, Ulsoy, Huei_Peng, "Automotive control system", Cambridge University Press 2012 3. James D. Halderman - "Automotive Technology_ Principles, Diagnosis, and Service" (4th Edition) Prentice Hall. 2011.	4. Konrad Reif, "Automotive Mechatronics", Springer 2015 5. J. Y. Woung , "Theory of Ground Vehicles", John Willey & Sons, NY. 6. Rajesh Rajamani, "Vehicle dynamics and control", Springer publication.

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. K. Karthikeyan , R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore	1. Dr.K.Balasubadra, Professor, Electronics, RMD Engineering College, Chennai.	1. Dr.K Sivanathan, SRMIST
2. Dr.Srinivasan, Principal Engineer, Mahindra and Mahindra, Chennai.	2. Dr., P Karthikeyan, MIT, Anna University, pkarthikeyan@annauniv.edu	2. Dr.M.Mohamed Rabik, SRMIST

Course Code	21MHE440J	Course Name	PERCEPTION FOR AUTONOMOUS VEHICLES	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:	*provide a comprehensive understanding of the principles and techniques involved in designing perception systems for autonomous vehicles.*
CLR-2:	*identify the type of power train for a vehicle*
CLR-3:	*develop perception module that accurately interpret the environment of AV and make informed decisions.*
CLR-4:	*equip learners with the knowledge and skills necessary to develop robust perception modules that are crucial for the safe and reliable operation of autonomous vehicles.*
CLR-5:	*create systems architecture for new or improved complex systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*realize the significance of perception in Autonomous Vehicles*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-2:	*evaluate and select sensors for perception*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-3:	*apply image processing techniques for various perception tasks*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-4:	*integrate sensors data through sensor fusion techniques*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-5:	*design and analyze perception modules for AVs*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2

Unit-1: Introduction to Perception in Autonomous Vehicles	***12 Hour***
Overview of perception in autonomous driving systems, Importance of perception for safe navigation, Historical context, and evolution of perception technologies	
Unit-2: Sensors Technologies and Data Acquisition	***12 Hour***
Types of sensors used in autonomous vehicles (LiDAR, cameras, radar, etc.), Sensor characteristics, strengths, and limitations, Data acquisition and preprocessing techniques, Sensor calibration and synchronization.	
Unit-3: Image Processing and Vision	***12 Hour***
Image filtering, edge detection, and feature extraction, Object detection and recognition using classical computer vision techniques (e.g., Haar cascades, HOG), Feature matching and descriptor-based methods, Case studies on real-time object recognition.	
Unit-4: Sensors Fusion and Data Integration	***12 Hour***
Lidar point cloud processing and feature extraction, Segmentation and clustering for object identification, Ground plane estimation and removal, 3D object recognition and localization using Lidar data, Radar signal processing and target detection, Sensor fusion techniques (Kalman filtering, Extended Kalman Filter, Particle Filter), Multi-sensor fusion for robust perception, Case studies on sensor fusion in challenging environments.	
Unit-5: Object Detection, Tracking and Motion Estimation	***12 Hour***

Single and multi-object detection and tracking algorithms (e.g., Kalman Filter, Hungarian Algorithm), Localization techniques using object tracking information, Integration with other perception modules for global localization, Metrics for evaluating perception systems (precision, recall, F1-score), Real-world data collection and annotation.

Learning Resources	*1.Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics" MIT Press, 2005.* *2.Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robotics", Second edition, The MIT Press, 2011*	*3. Richard Szeliski, "Computer Vision-Algorithms and Applications", Spinger, 2011.*

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*	*10%*	-	-	*20%*	*5%*	-
Level 2	*Understand*	*30%*	-	-	*20%*	*10%*	-
Level 3	*Apply*	*30%*	-	-	*40%*	*75%*	-
Level 4	*Analyze*	*30%*	-	-	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Guna Surendra, Hitachi, Tokyo, Japan	*1.Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Dr.K.Sridharan, Senior Engineer, GE Renewable Energy, Bangalore.	*2. Dr. Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.M.Mohamed Rabik, SRMIST*

Course Code	21MHE441J	Course Name	LOCALIZATION AND STATE ESTIMATION	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:	*lay foundation for autonomous systems*
CLR-2:	*develop techniques for critical for safe and precise navigation*
CLR-3:	*address real-world challenges*
CLR-4:	*enable simultaneous localization and mapping (slam)*
CLR-5:	*equip students with industry relevance and innovation*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the Fundamentals of Localization and Estimation*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-2:	*implement Dead Reckoning and Odometry Techniques*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-3:	*apply Sensor-based Localization Techniques*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-4:	*design and Implement Simultaneous Localization and Mapping (SLAM) Algorithms*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-5:	*utilize Kalman Filtering and Bayesian Estimation for State Estimation*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2

Unit-1: Introduction to Localization and State Estimation	***12 Hour***
Overview of Localization in Autonomous Systems, Importance of State Estimation for Autonomous Vehicles, Probabilistic vs. Deterministic Approaches, Uncertainty Representation and Measurement Models, Bayesian Inference and the Bayes Filter	
Unit-2: Dead Reckoning and Odometry	***12 Hour***
Principles of Dead Reckoning, wheel Encoders and Odometry Data, Error Accumulation and Drift, Odometry-based Localization Techniques, Calibration and Error Reduction Strategies	
Unit-3: Sensor-based Localization	***12 Hour***
Sensor Types for Localization (e.g., GPS, IMU, LIDAR, Cameras), Sensor Fusion and Integration Techniques, Extended Kalman Filter (EKF) for Nonlinear Sensor Fusion, Particle Filter for Non-Gaussian Distributions, Case Studies on Sensor-based Localization in Real-world Scenarios	
Unit-4:Simultaneous Localization and Mapping (SLAM)	***12 Hour***
Fundamental Concepts of SLAM, EKF-SLAM and FastSLAM Algorithms, Graph-based SLAM Approaches, Visual SLAM and Monocular Camera Systems, SLAM Challenges and Current Research Trends	
Unit-5: Kalman Filtering and Bayesian Estimation	***12 Hour***
Understanding Kalman Filters, Predictive and Corrective Steps in Kalman Filtering, Extended and Unscented Kalman Filter, Applications of Kalman Filters in State Estimation, Bayesian Estimation and its Applications in Robotics	

Learning Resources	*1.Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics" MIT Press, 2005.* *2.Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robotics", Second edition, The MIT Press, 2011*	*3.Richard Szeliski, "Computer Vision-Algorithms and Applications", Spinger, 2011.*

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*	*10%*	-	-	*20%*	*5%*	-
Level 2	*Understand*	*30%*	-	-	*20%*	*10%*	-
Level 3	*Apply*	*30%*	-	-	*40%*	*75%*	-
Level 4	*Analyze*	*30%*	-	-	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Guna Surendra, Hitachi, Tokyo, Japan	*1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Mr.Elayaraj, apple, USA	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.R.Senthilanathan, SRMIST*

Course Code	21MHE442J	Course Name	MOTION PLANNING 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:	*obtain critical skillset for autonomous vehicle engineers*
CLR-2:	*address Real-world Challenges*
CLR-3:	*make integration of Perception and Decision-making*
CLR-4:	*learn Safety and Ethical Considerations*
CLR-5:	*have relevance to Cutting-edge Technology and Research*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design and Implement Effective Motion Planning Algorithms*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-2:	*integrate Behavior Planning for Complex Decision-making*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-3:	*apply Control Systems for Precise Vehicle Maneuvering*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-4:	*evaluate and Address Safety Considerations in Motion Planning*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-5:	*collaborate on Multidisciplinary Projects for Autonomous Systems*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2

Unit-1: Introduction to Motion Planning and Control for Self-Driving Vehicles	***9 Hour***
Overview of Motion Planning and Control in Autonomous Vehicles, Historical Context and Evolution of Motion Planning Algorithms, Challenges in Real-world Environments and Safety Considerations, Integration with Perception and Localization Systems, Ethical and Legal Aspects of Motion Planning for Autonomous Vehicles	
Unit-2: Path Planning	***9 Hour***
Principles of Path Planning and Trajectory Generation, Static and Dynamic Environments, Grid-based and Sampling-based Planning Algorithms (A, RRT, etc.), Heuristic Functions and Cost Functions, Real-time Path Planning and Dynamic Obstacle Avoidance, Algorithms and Techniques for Generating Safe and Optimal Trajectories*	
Unit-3: Behavior Planning	***9 Hour***
Behavior-based Systems for Autonomous Vehicles, Finite State Machines and Decision Trees, High-level Decision-making and Task Allocation, Collision Avoidance and Safe Navigation, Coordination of Multiple Agents in Complex Scenarios, Decision-Making Strategies for Navigating Complex Traffic Scenarios	
Unit-4: Control Systems for Autonomous Vehicles	***9 Hour***
Basics of Control Theory and Feedback Loops, Feedback Control and Stability Analysis, PID Controllers and State-space Control, Model Predictive Control (MPC), Nonlinear Control Techniques, Stability Analysis and Robust Control	
Unit-5: Motion Control	***9 Hour***
Low-level Motion Control Strategies, Trajectory Tracking and Following, Vehicle Dynamics and Kinematics, Vehicle Stability and Handling, Integration with Perception and Localization for Seamless Control, Techniques for Vehicle Maneuvering and Tracking Desired Trajectories	

Learning Resources	*1.Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics" MIT Press, 2005.* *2.Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robotics", Second edition, The MIT Press, 2011*	*3.Howie Choset and et al, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Bradford books, 2005.* *4.Bruno Siciliano, Oussama Khatib, "Spinger Handbook of Robotics", Springer, 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- Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	-	*20%*	*5%*	-
Level 2	*Understand*	*30%*	-	-	*20%*	*10%*	-
Level 3	*Apply*	*30%*	-	-	*40%*	*75%*	-
Level 4	*Analyze*	*30%*	-	-	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr.Guna Surendra, Hitachi, Tokyo, Japan	*Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Dr.K.Sridharan, Senior Engineer, GE Renewable Energy, Bangalore.	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.M.Mohamed Rabik, SRMIST*

Course Code	21MHE443T	Course Name	VEHICLE MECHANICS	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:	*critical skillset for vehicle mechanics*
CLR-2:	*optimizing vehicle performance in terms of stability, maneuverability and ride comfort*
CLR-3:	*safety and handling considerations*
CLR-4:	*integration of control systems knowing the vehicle mechanics*
CLR-5:	*equip students to address challenges in vehicle dynamics and control*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze vehicle motion and dynamics*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-2:	*navigate coordinate systems for vehicle motion*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-3:	*optimize tire performance*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-4:	*enhance vehicle handling and stability*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2
CO-5:	*design suspension systems for ride comfort*	-	-	2	2	2	-	-	-	-	-	-	-	2	1	2

Unit-1: Introduction to Kinematics and Dynamics of Vehicles	***9 Hours***
Basic Concepts and Terminology, Overview of Vehicle Kinematics and Dynamics, Forward and Inverse Kinematics, Analysis of Vehicle Motion in 2D and 3D Space, Vehicle Dynamics Equations and Constraints, Maneuverability and Turning Radius	
Unit-2: Vehicle Motion and Coordinate Systems	***9 Hours***
Modeling and Analysis of Vehicle Movement, Understanding Vehicle Motion Patterns (Translation, Rotation), Coordinate Systems for Vehicle Motion Analysis (Body-fixed, Earth-fixed), Transformation Matrices and Euler Angles, Velocity and Acceleration Analysis in Different Coordinate Systems, Trajectory Planning and Control.	
Unit-3: Tire Mechanics	***9 Hours***
Tire Characteristics and Properties (Traction, Grip, Rolling Resistance), Tire-terrain Interaction and Friction Models, Slip Ratio and Slip Angle Analysis, Tire Force and Moment Estimation, Tire Modeling for Vehicle Dynamics Simulations	
Unit-4:Vehicle Handling and Stability	***9 Hours***
Concepts of Vehicle Handling (Understeer, Oversteer), Cornering Forces and Weight Transfer, Lateral and Longitudinal Stability Analysis, Control Systems for Stability Control (e.g., ESC), Impact of Handling on Autonomous Driving Algorithms	
Unit-5: Suspension Systems and Ride Comfort	***9 Hours***
Concepts of vertical dynamics, Degrees of freedom of suspension system, Suspension system for autonomous vehicles, Control system for Suspension systems and Ride comforts.	

Learning Resources	*1.H.B. Pasjka, "Tire and Vehicle Dynamics", Butterworth-Heinemann Ltd; 3rd edition (2012).* *2.Rajesh Rajamani, "Vehicle Dynamics and Control", Springer New York, NY, 2011.* *3.Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics" MIT Press, 2005.* *4.Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robotics", Second edition, The MIT Press, 2011*	*5. Howie Choset and et al, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Bradford books, 2005.* *6. Bruno Siciliano, Oussama Khatib, "Spinger Handbook of Robotics", Springer, 2008*

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.Guna Surendra, Hitachi, Tokyo, Japan	*1. Dr.P.Karthikeyan, MIT Campus, Anna University, pkarthikeyan@annauniv.edu*	*1. Dr.K Sivanathan, SRMIST*
2. Mr.Elayaraj, apple, USA	*2. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*2. Dr.Mohamed Rabik, SRMIST*

Course Code	21MHE444J	Course Name	AI FOR PERCEPTION, PLANNING 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:	*obtain motivation for artificial intelligence and machine learning.*
CLR-2:	*get exposed to classical and convolutional neural networks and deep learning philosophy.*
CLR-3:	*realize various convolutional neural network architectures that are applied for computer vision tasks.*
CLR-4:	*develop and train deep neural networks for computer vision task*
CLR-5:	*explore the applications of reinforcement learning in planning and control tasks.*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define various terminologies and concepts in artificial intelligence and machine learning.*	*3*	-	-	-	*1*	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*express the concepts of classical and convolutional neural networks.*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*implement convolutional neural network architectures to various perception tasks.*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*demonstrate the applications of deep learning for planning and control tasks*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*conceive and defend legal and ethical aspects arising when humans and autonomous vehicles interact*	*3*	-	*2*	-	*1*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 : Introduction to AI and ML ***12 Hour***

Introduction to artificial intelligence - Intelligent agent - Categorization of AI - Overview of different forms of learning - Statistical decision theory - Machine learning - Feature selection and feature extraction - Training concepts in machine learning - Train-val-test split - Cross-validation - Generalization - Overfitting and Underfitting - Regularization techniques - Hyperparameters and tuning - Classification and Regression - Performance evaluation metrics for classification and regression algorithms - SDC sensors – Camera – RADAR - Ultrasonic sensors - Odometric sensors - LiDAR - Introduction to sensor fusion Experiments:

1. Implementation of classification algorithm and its performance evaluation.

2. Linear regression algorithm and computation of its performance metrics.

Unit-2 : Classical and Convolutional Neural Networks ***12 Hour***

Overview of biological neuro-system - Single layer perceptron - Learning rules - Multilayer perceptron - Types of gradient descent - Chaining derivatives -Backpropagation - Multilayer perceptron – Learning Boolean functions - Classical neural networks vs. deep learning - Convolutional neural networks - Activation functions - vanishing gradients - over-fitting and under-fitting - Optimization techniques- Applying trained networks for prediction - Image classification with multi-layer perceptron - Deep learning hardware.

Experiments:

1. Implementation of the backpropagation learning algorithm.

2. Implementation of gradient descent optimization algorithm.

Unit-3: CNN for Perception ***12 Hour***

Motivation for CNN - 1D, 2D and 3D convolutions - Convolutional neuron - Pooling layers and Initialization - Understanding Softmax Function - Image classification - LeNet, AlexNet architectures - CNN for Regression- Understanding the principle and Motivation for RNNs - RNN for Image Classification - LSTM Motivation and Principle Understanding *Experiments: 1. CNN for object detection, 2. RNN for Image Classification*
Unit-4 : Advanced Architectures and Embedded Implementations ***12 Hour***
ResNet and Inception - Key Aspects - Recent Image Classifications Architectures – Object Detection by RCNN and YOLO - Object Tracking by MOT and SORT- Semantic Segmentation -instance Segmentation- Panoptic Segmentation – Multi task Attention Network – SFA3D Object Detection – UNetXST camera to bird's eye view *Experiments: 1. Image panoptic segmentation network. 2. SFA3D for object detection*
Unit-5: Planning and Control ***12 Hour***
Markov decision process - Deep reinforcement learning – DRL for motion planning planning and control – CNN for End to End Learning of driving task – RNN for steering through time – DL for human centered semi-autonomous vehicles - implementation in end-to-end decomposition manner. *Experiments: 1. DRL for autonomous navigation of mobile robots in end-to-end manner, 2. DRL in planning and control of mobile robots.*

Learning Resources	*1. Bruno Siciliano, Oussama Khatib, "Handbook of Robotics", 2nd Edition, Springer, 2016.* *2. Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning", 1st Edition, MIT Press, 2016.* *3. Simon Haykin, "Neural Networks and Learning Machines: A Comprehensive Foundation", 3rd Edition, Pearson, 2011.*	*4. Timothy J Ross, "Fuzzy Logic with Engineering Applications", 3rd Edition, Wiley, 2011.* *5. Ranjan, Sumit, Senthamilarasu, Dr. S, Applied Deep Learning and Computer Vision for Self-Driving Cars: Build autonomous vehicles using deep neural networks and behavior-cloning technique, Packt Publishing, 2020*

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*	*10%*	-	-	*20%*	*5%*	-
Level 2	*Understand*	*30%*	-	-	*20%*	*10%*	-
Level 3	*Apply*	*30%*	-	-	*40%*	*75%*	-
Level 4	*Analyze*	*30%*	-	-	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Guna Surendra, Hitachi, Japan	*1.Dr. P. Karthikeyan, MIT, Anna University pkarthikeyan@annauniv.edu*	*1.Dr. K. Sivanathan, SRM IST*
2. Mr. Elayraj Jayaraj, Apple, USA	*2.Dr. R. Thiyagarajan, IIT Tirupati thiyagu@iittp.ac.in*	*2.Mrs.T.S.Rajalakshmi, SRMIST*

Course Code	21MHE445LQ	Course Name	CAPSTONE PROJECT	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:	*Engage in high-level work focusing on an area of specialization where immersive technologies may be applied.*
CLR-2:	*Bridge theory and practice and are aimed to have an impact on the professional life of students.*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering	Problem Analysis	Design/development	Conduct investigations	Modern Tool Usage	The engineer	Environment &	Ethics	Individual & Team Work	Communication	Project Mgt. &	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illuminate and bring new insight to one or more technologies involved in autonomous driving.*	*3*	*2*											*3*		-
CO-2:	*demonstrate a depth and breadth of knowledge and the application of this knowledge to scholarship and/or practice;*		*2*			*3*								*3*		-
CO-3:	*present a clearly articulated investigative framework, while situating projects within established academic practices and/or ideas;*		*2*			*3*									*3*	-

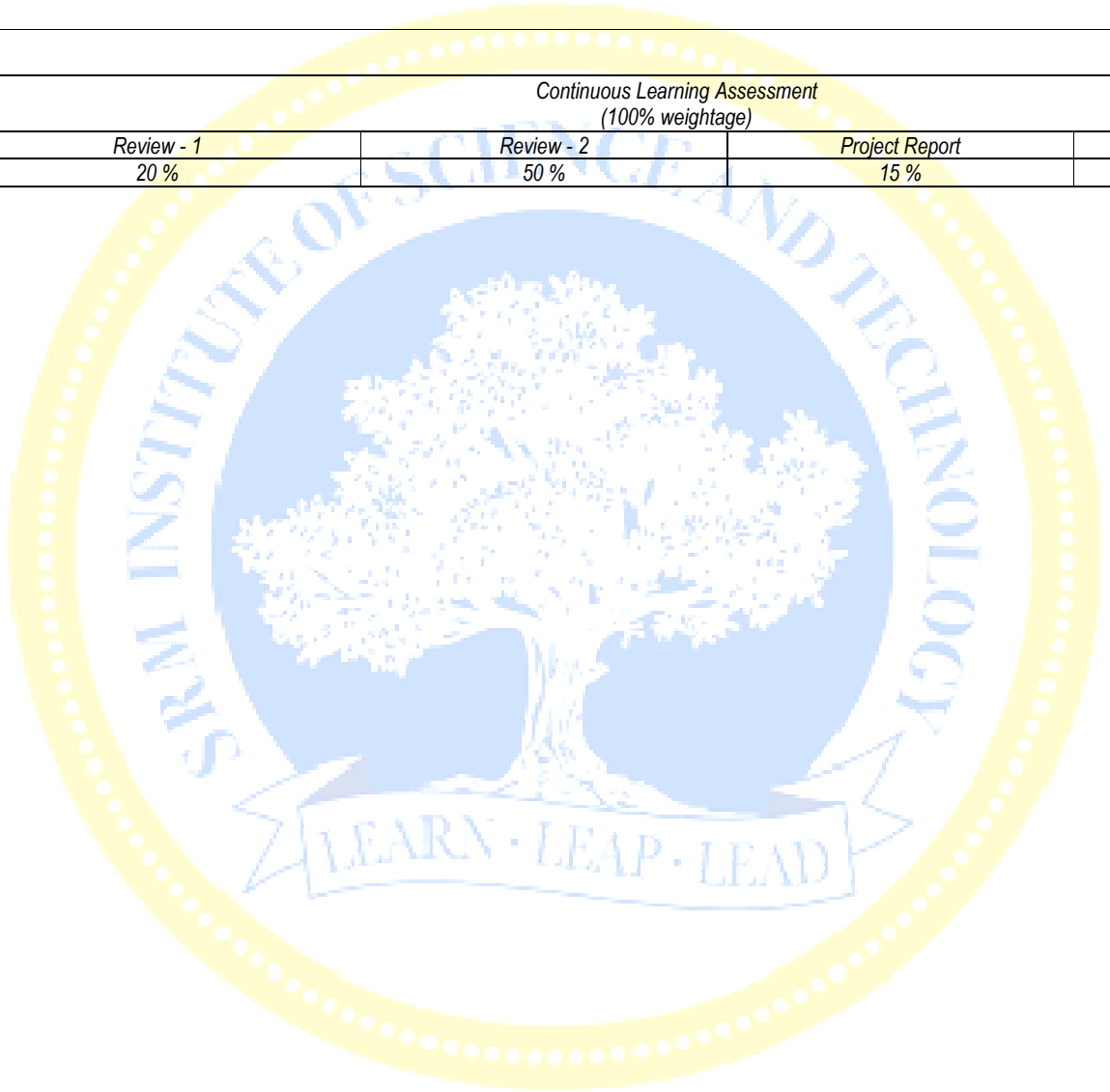
Nature of the Capstone Project

The following points describe the nature of the Capstone project course:

- *The Capstone Project provides an opportunity for students to engage in high-level work focusing on an area of specialization where Autonomous driving technology may be applied.*
- *Capstone projects (CP) will be inquiry and practice-centred.*
- *All Capstones aim to bridge theory and practice and are aimed to have an impact on the professional life of students.*
- *Students will identify the topics for their Capstone Project during the end of sixth semester study of the program.*
- *Capstone projects often take their inspiration from projects, papers, and experiences related to course work in the degree program. However, to ascertain students' abilities for independent work and their capacity for self directed inquiry, capstone projects must demonstrate in what ways individual graduate students have researched, developed, and extended, or applied the ideas and strategies under investigation.*
- *Capstone Projects encourage the application of knowledge gained on teaching and learning throughout the degree program.*
- *Additionally, the Capstone Project should demonstrate the depth and extent of knowledge of students.*
- *Capstone projects may take both only simulation works as well as hardware-involved work depending on the time, will and the needs involved in the chosen application. These may be, but are not limited to, the investigation of practices and educational ideas, the development of curricular materials, or teaching approaches which may utilize the autonomous driving technologies for better understanding of concepts.*
- *It may involve work, but not limited to, in one or more of following four broad modules namely*
  - *Perception*
  - *Localization and Mapping*
  - *Motion Planning*

➢ *Control*

	Continuous Learning Assessment (100% weightage)			
	Review - 1	*Review - 2*	*Project Report*	*Presentation*
Capstone Project	*20 %*	*50 %*	*15 %*	*15 %*



Course Code	21MHE446T	Course Name	CONNECTED VEHICLES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21MHE438T*	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:	*select a suitable communication module for a vehicle*
CLR-2:	*covert the communication modules as an intelligent transport system*
CLR-3:	*apply a suitable communication model for a specific application*
CLR-4:	*select the type of broadcasting method for information dissemination*
CLR-5:	*design a safe transport system in a cooperative way*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply a suitable wireless module for a specific application*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2-*	-
CO-2:	*design an intelligent transport system*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*fix a suitable communication model for an application*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*transmit and receive the broadcasting messages*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*design a safety standard for a group of vehicles in a cooperative way*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 : Introduction to Vehicle Communication	***9 Hour***
Adhoc Communications –Applications in Vehicle traffic Monitoring, Collision and congestion avoidance, Highway Lane reservation, Emission Control - Vehicle Frequency Utilization –AM Radio, Bluetooth, FM Radio, GPS, Short range RADAR, Wireless LAN - Intelligent Roadway-Infrastructure to vehicle and vehicle to vehicle communications - Evolving Smart Vehicle – ECU, Wireless Networking, Forward RADAR, Side RADAR, GPS, Cellular transmission and Event Recorder.	
Unit-2 : Vehicle Information System and Intelligent Transportation	***9 Hour***
Intelligent Transportation System (ITS) – Vision for ITS Communications-Multimedia communication in a car –Current ITS Communication Systems and Services-Vehicle to Vehicle and Road to Vehicle Communication Systems - Inter and Intra Vehicle Communication-VANETS-Devices-Optical Technologies and Millimeter Wave Technologies.	
Unit-3: V2X Communication Models	***9 Hour***
Communication models for V2X, Technical background of V2X-DSRC, Cellular V2X, Use cases.	
Unit-4 : Multi-Hop Broadcasting	***9 Hour***
Introduction, DSRC, Bio-inspired model of handover-Self-adaptive V2V communication system with DSRC, Cross-layer multi-hop broadcasting-Analytical model for 802.11broadcast service, multi-cast method for VANET	
Unit-5: Co-Operative Vehicular Safety Applications	***9 Hour***
Introduction, enabling technologies, cooperative architecture, Mapping for safety application, Safety application using active VANET, Case study any safety application using VANET	

Learning Resources	1. Gilbert Held "Inter and Intra Vehicle Communications", Auerbach Publications,2008. 2. Mohamed Kassab "Communication Technologies for Vehicles" Springer, 2015 3. Yue Cao · Yuanjian Zhang · Chenghong Gu ,"Automated and Electric Vehicle: Design, Informatics and Sustainability", Springer, 2023.	4. Yunpeng Wang, Daxin Tian, Zhengguo Sheng, Wang Jian - "Connected Vehicle Systems_ Communication, Data, and Control" CRC Press. 5. Hannes Hartenstein, Kenneth P Laberteaux "VANET: 6. Vehicular Applications and Inter-Networking Technologies" JohnWiley & Sons Ltd, 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%	-	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. K. Karthikeyan, R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore	1.Dr.K.Balasubadra, Professor, Electronics, RMD Engineering College, Chennai	1. Dr. K Sivanathan, SRMIST
2.Dr.Srinivasan, Principal Engineer, Mahindra and Mahindra, Chennai	2.Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, MIT Campus, Anna University, Chennai- 600044.	2. Dr. Mohamed Rabik, SRMIST

Course Code	21MHE447T	Course Name	SAFETY, ETHICS AND REGULATIONS FOR DRIVERLESS CARS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21MHE438T*	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:	*identify risks related to ethics in autonomous vehicles*
CLR-2:	*categorize the type of ethics for autonomous vehicles*
CLR-3:	*experiment with the trolley problem for the study of ethics*
CLR-4:	*balance the ethics and risks of autonomous vehicle design*
CLR-5:	*build structural assurance for ethics.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply ethics for risk balancing*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*design risk-balanced AVs based on the classification of ethics*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*apply the results of the trolley problem as ethics for AVs*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*design an AV with the balancing of risk and ethics*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*construct structural-based assurance for ethics*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 : Introduction to Ethics — ***9 Hours***

Ethics and risk distribution, Post trolley ethics, Moral uncertainty in Autonomous Vehicles, Broad social impacts-pandemic, possible hazards, risk in Town and ocean, Contaminated AV, Ethics of AV and discrimination

Unit-2 : Ethics Classification and Machine Learning — ***9 Hours***

Moral significance of classification, Moderate subjectivism for automated vehicles, From theory to practice toward a decision procedure, trolley optimism, machine learning basis for trolley Pessimism, Machine learning and autonomous vehicles, Objections-technological and Philosophical objections

Unit-3: Trolley Problem and Ethics in the Public Domain — ***9 Hours***

Trolley problem, experiment, implications of results for ethics, normative pluralism-the situation, The Predicament of Pluralism, Hostage Situation, Designer Ethics, Considerations of Value and the Type of Vehicle

Unit-4 : Ethics and Risk Balancing in the Design — ***9 Hours***

Engineering ethics and implemented ethics, AVs and ethical risk reduction, Perception of risks posed by AV and man, ethics and risk balance-As Low As Reasonably Practicable (ALARP). Ethical motivation for risk balancing, refinement of risk factors-area impact, exposed population, causes, profiles and ethical positions, risk profile selection guidance, Justification and implementation of risk profiles for various scenarios.

Unit-5: Structural Assurance for Ethical Principles and Safety Regulations — ***9 Hours***

Introduction, Principles of ethics assurance cases, Ethics assurance case templates, Business ethics and risk distribution in Hybrid traffic, Safety regulations-overview, Autonomous vehicle technology regulation, case studies on regulations and safety , US and UK safety standards

Learning Resources	1. Ryan Jenkins, David Cerny, Tomas Hribek - "Autonomous Vehicle Ethics_ The Trolley Problem and Beyond" Oxford University Press, 2022	2. Ryan Jenkins, David Cerny, Tomas Hribek - "Autonomous Vehicle Ethics_ The Trolley Problem and Beyond" Oxford University Press, 2022

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. K. Karthikeyan, R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore	1.Dr.K.Balasubadra, Professor, Electronics, RMD Engineering College, Chennai	1. Dr. K Sivanathan, SRMIST
2.Dr.Srinivasan, Principal Engineer, Mahindra and Mahindra, Chennai	2.Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, MIT Campus, Anna University, Chennai- 600044.	2. Dr. Mohamed Rabik, SRMIST

Course Code	21MHE448T	Course Name	INFRASTRUCTURE FOR SELF-DRIVING TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21MHE438T*	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:	*realize the guidelines of infrastructure for AVs*
CLR-2:	*realize the policies of infrastructure for AVs*
CLR-3:	*describe the framing mechanism for infrastructure.*
CLR-4:	*familiarize the impact of AV on infrastructure*
CLR-5:	*practice case studies*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement the infrastructure based on guidelines for AVs*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-2:	*implement the infrastructure based on policies for AVs*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*frame the infrastructure suitable for AVs*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*design of AV based on its impact on infrastructure*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*design an infrastructure as a case study*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 : Introduction and Guidelines of Infrastructure for AV-Enabled System	***9 Hours***
Key organizations linking automation and infrastructure, ways of infrastructure affecting AVs, Link for policy makers and infrastructure operators, Improving and maintaining physical infrastructure, Road facilities, Signage and line marking, operation, control, maintenance and communication networks	
Unit-2 : Digital Infrastructure and Framework	***9 Hours***
Vehicle and infrastructure communication technologies, satellite-based location, High-definition mapping, Managing data and infrastructure, Conservative (Mixed traffic), Moderate (Autonomous corridor), Aggressive (Separated Area)	
Unit-3: Institutional Framework	***9 Hours***
Changing the fundamentals of legal frame works, Institutional and stakeholder coordination, testing automated vehicles, updating laws and norms, Deploying automated vehicles,	
Unit-4 : Grading and Impact of AV on Infrastructure	***9 Hours***
Grading system, Key Factors-Safety, Efficiency, Accessibility Limitations, Geometric design, parking, Impact of truck platooning on bridges, emergency refugee areas, Traffic management, traffic signs and marking	
Unit-5: Case Studies	***9 Hours***
Case study on any local city/area to create an infrastructure for AVs	

Learning Resources	1. *Othman, Kareem. (2021). Impact of Autonomous Vehicles on the Physical Infrastructure: Changes and Challenges. Designs. 5. 40. 10.3390/designs5030040.* 2. *ITF research report "Preparing Infrastructure for Automated Vehicles"2023*	3. *Manivasakan, Riddhi Kalra, Steve O'Hern, Yihai Fang, Yinfei Xi, Nan Zheng, Infrastructure requirement for autonomous vehicle integration for future urban and suburban roads – Current practice and a case study of Melbourne, Australia, Transportation Research Part A: Policy and Practice,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*	*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. K. Karthikeyan, R &D Team Manager, Power Quality Products, Hitachi Energy, Bangalore	*1.Dr.K.Balasubadra, Professor, Electronics, RMD Engineering College, Chennai*	*1. Dr. K Sivanathan, SRMIST*
2.Dr.Srinivasan, Principal Engineer, Mahindra and Mahindra, Chennai	*2.Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, MIT Campus, Anna University, Chennai- 600044.*	*2. Dr. Mohamed Rabik, SRMIST*

Course Code	21MHE449T	Course Name	SOFTWARE ARCHITECTURE FOR SELF-DRIVING CARS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	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:	*equip students with practical skills that are directly applicable in the industry*
CLR-2:	*provide Hands-On Experience with Leading Platforms like Autoware*
CLR-3:	*develop a holistic understanding of autonomous vehicle software architecture*
CLR-4:	*learn to debug and optimize software components, an invaluable skillset*
CLR-5:	*prepare students for Future Innovations*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*setup and Navigate Autoware / Apollo Environments*		-	-	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*
CO-2:	*calibrate and Configure Sensors for Data Collection*		-	-	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*
CO-3:	*implement Data Processing and Sensor Fusion Algorithms*		-	-	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*
CO-4:	*create and Update Maps for Autonomous Driving*		-	-	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*
CO-5:	*design and Implement Path Planning and Control Algorithms*		-	-	*2*	*2*	*2*	-	-	-	-	-	-	-	*2*	*1*

Unit-1: Introduction to Autoware and Apollo	***9 Hour***
Overview of Autoware and Apollo Platforms, setting up Development Environments, Introduction to ROS (Robot Operating System) and ROS-based Development, Simulating Autonomous Vehicle Environments, Basic Autoware / Apollo Architecture and Components.	
Unit-2: Sensor Setup and Calibration	***9 Hour***
Types of Sensors Used in Autonomous Vehicles (LiDAR, Cameras, IMU, etc.), Sensor Calibration Techniques, Intrinsic and Extrinsic Calibration, Configuring Sensor Drivers in Autoware and Apollo, Data Collection and Dataset Management.	
Unit-3: Data Processing and Sensor Fusion	***9 Hour***
Preprocessing of Sensor Data (Filtering, Downsampling, etc.), Sensor Data Fusion Techniques, Object Detection and Tracking, Localization and Mapping with Fused Sensor Data, Debugging and Optimization of Data Processing Pipelines.	
Unit-4: Mapping and Localization	***9 Hour***
Creating and Updating Maps for Autonomous Driving, Techniques for SLAM (Simultaneous Localization and Mapping), Localization Methods (GPS, IMU, Visual Localization, etc.), Global and Local Localization Strategies, Handling Challenging Environments and Dynamic Changes.	
Unit-5: Planning and Control	***9 Hour***
Path Planning Algorithms (e.g., A, Dijkstra, RRT), Behavior Planning and Decision-making, Control Systems for Autonomous Driving (PID, Model Predictive Control, etc.), Integration of Perception and Planning Modules, Real-time Control and Adaptive Algorithms.*	

Learning Resources	1. *Sebastian Thrun, Wolfram Burgard, and Dieter Fox, "Probabilistic Robotics" MIT Press, 2005.* 2. *Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, "Introduction to Autonomous Mobile Robotics", Second edition, The MIT Press, 2011*	3. *Howie Choset and et al, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Bradford books, 2005.* 4. *Bruno Siciliano, Oussama Khatib, "Spinger Handbook of Robotics", Springer, 2008*

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.Guna Surendra, Hitachi, Tokyo, Japan	*1. Dr.Thiyagarajan, Indian Institute of Technology Tirupati, thiyagu@iittp.ac.in*	*1. Dr. K Sivanathan, SRMIST*
2. Mr.Elayaraj, apple, USA	*2.Dr. P. Karthikeyan, Assistant Professor, Department of Production Technology, MIT Campus, Anna University, Chennai- 600044.*	*2. Dr. Mohamed Rabik, SRMIST*

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

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

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